REPORTS

OF THE

CAMBRIDGE ANTHROPOLOGICAL EXPEDITION

TO

TORRES STRAITS.

VOLUME II.

PHYSIOLOGY AND PSYCHOLOGY.

PART I.

INTRODUCTION AND VISION.

CAMBRIDGE:
AT THE UNIVERSITY PRESS.
1901

Price Nine Shillings net

London: C. J. CLAY AND SONS,
CAMBRIDGE UNIVERSITY PRESS WAREHOUSE
AVE MARIA LANE,
AND
H. K. LEWIS,
136, GOWER STREET, W.C.

Glasgow: 50, WELLINGTON STREET.
Leipzig: F. A. BROCKHAUS.
New York: THE MACMILLAN COMPANY.
Bombay: E. SEYMOUR HALE.

REPORTS

OF THE

CAMBRIDGE ANTHROPOLOGICAL EXPEDITION

TO

TORRES STRAITS.

VOLUME II.

PHYSIOLOGY AND PSYCHOLOGY.

CAMBRIDGE:
AT THE UNIVERSITY PRESS.
1901

Cambridge:

PRINTED BY J. AND C. F. CLAY,

AT THE UNIVERSITY PRESS.

PREFACE.

During the years 1888–89 I spent some eight months in Torres Straits investigating the marine zoology of that district, and having become interested in the natives I devoted my spare time to recording many of their present and past customs and beliefs. Some of the results of these studies have already been published. Later I proposed to publish a Memoir on the Ethnography of the Islands of Torres Straits, but on going over my material I found it was too deficient to make into a satisfactory monograph. I then determined to go once more to Torres Straits in order to collect more data, with a view to making, with the aid of colleagues, as complete a study of the people as was practicable.

I had long realised that no investigation of a people was complete that did not embrace a study of their psychology, and being aware of the paucity of our knowledge of the comparative physiology and psychology of primitive peoples, I determined that this branch should be well represented. I was able to secure Dr W. H. R. Rivers as a colleague, and I gladly left all the arrangements of this important section of our work to him. We obtained the cooperation of Messrs C. S. Myers and W. McDougall, who undertook special branches of experimental psychology. Some assistance in this department was also given by Mr C. G. Seligmann.

Perhaps a few words are necessary to explain why we visited a district apparently so insignificant as Torres Straits. As explained above, I had a good deal of unpublished material on the ethnography of the people and it would naturally take less time to gain a good insight into the life of a people about whom a fair amount was known than to begin afresh on a new people. From what I knew of my old friends and acquaintances I was sure that we could at once get to work instead of having to lose more or less time while entering into friendly relations with a people who, after all, might prove to be suspicious and refractory. Our experience fully justified the good impression I had formed of the willingness of the Torres Straits islanders to impart information and to render personal assistance.

For the special work we had to do it was necessary to visit a people who were amenable and with whom communication was easy; but, on the other hand, who were not far removed from their primitive past. This peculiar combination was found in these people.

This region has some ethnological importance as it is on the frontier between two large land areas inhabited respectively by Papuans and Australians, and it was a matter of some interest to determine whether any mixture had taken place there and also to endeavour to find out if any traces could be found in the islands or on the adjacent coast of New Guinea of a migration of the Australian stock from North to South. The islanders are as a matter of fact distinctly Papuan.

The Murray Islands were selected for the most prolonged and detailed study on account of the difficulty in getting there. They lie out of the track of what little commerce there is, neither are they frequented by pearl-shellers nor bêche-de-mer fishermen, consequently the natives have not mixed so much with Europeans and other alien races as has been the case at Erub (Darnley Island) and the western group of islands. On the other hand, the islands have been subject for a quarter of a century to missionary influence and teaching, with the result that most of the natives are professed Christians, and for about ten years English has been taught to the children. The foreign cult and civilization have undoubtedly had some effect, but experience proved that they were not detrimental for many of the purposes of the expedition. Perhaps it would not be easy to find a more favourable spot for the study of a simple and primitive people.

The reports of the expedition will consist of several volumes, each of which will contain memoirs on related subjects. It is proposed to publish the various reports as they are completed.

A. C. HADDON.

JULY, 1901.

The Series will probably consist of the following volumes:

Vol. I. Physical Anthropology.
Vol. II. Physiology and Psychology.
Vol. III. Linguistics.
Vol. IV. Technology.
Vol. V. Sociology.
Vol. VI. Religion.

The following is the system of spelling which has been adopted in these memoirs:

a as in "father"	*ŏ* as in "on"
ă as in "at"	*ö* as German *ö* in "schön"
e as *a* in "date"	*ò* as *aw* in "law"
ĕ as in "debt"	*u* as *oo* in "soon"
i as *ee* in "feet"	*ŭ* as in "up"
ĭ as in "it"	*ai* as in "aisle"
o as in "own"	*au* as *ow* in "cow"

The consonants are sounded as in English:

ng as in "sing"	*ngg* as in "finger"

PART I.

INTRODUCTION BY W. H. R. RIVERS.

VISION. BY W. H. R. RIVERS.

1. PHYSICAL CHARACTERS AND DISEASES OF THE EYES.
2. VISUAL ACUITY.
3. COLOUR VISION.
4. VISUAL SPATIAL PERCEPTION.

APPENDIX BY C. G. SELIGMANN.


MAP OF
TORRES STRAITS
Statute Miles
0 10 20 30 40 50
BRITISH
NEW
GUINEA
FLY RIVER
Tagota
Odagositia
Daumori I.
Sumai
Kiwai
Turutu
Wabuda
Bonu R.
Iasa
Mibu I.
Saguane
Old Mawatta
Parama
Daru
Bobo
Tureture
Mawatta
MASINGARA
DAUDAI
Mabudauan Hill
Kussa
Kawa
Mata Kawa
Boigu
Saibai
Dauan
Masaramkoer
Garboi
Kerget
Uga
Erub
Damut
Buru
Igabu
Umaga
Kodal
Masig
Gaba
Tut
Maua
Mukwa
Giaka
Yam
Mabuiag
Aurid
Murray Is
Dauar
Mer
Waier
Sasi
Paremar
Suaragi
Saddle I.
Burar
Halfway I.
Badu
Moa
Getulai
Waraber
Nagir
Guijar
Wara
Nalgi
Keriri
Maurura
Waiben (Thursday I.)
Narupai
Mari
C. York
Muralug
Pabaju
Somerset
Jardine R.
QUEENSLAND
142 E
143
144
8
9
10
11

INTRODUCTION.

By W. H. R. RIVERS.

The work to be described in this volume of the Reports of the Cambridge Anthropological Expedition is the result of an attempt to study the mental characteristics of the natives of Torres Straits and the Fly River district of British New Guinea by the methods of experimental psychology.

This attempt was due to the initiation of Dr Haddon, and I should like to take this opportunity of saying how much those engaged in this work owe to his guidance and assistance. In our work in Murray Island we also owed much to the assistance of Mr John Bruce, who was in charge of the native school on that island, and the work during our short stay in Kiwai was similarly much helped by Mr Chalmers, who was in charge of the missionary station at Saguane.

The full account of the islands on which we worked and of the general characters of their natives will be given by Dr Haddon in other volumes of the Reports. Only so much will here be said as bears directly on the psychological work.

The chief part of our work was done on Murray Island by Messrs McDougall, Myers and myself. We lived on this island, which is about five miles in circumference, with a population of about 450, for four months. During the greater part of this time the other members of the expedition were travelling on the mainland of New Guinea. We had taken out with us the equipment of a small psychological laboratory, and the disused missionary house in which we lived was fortunately large enough to enable us to fit up the more complicated apparatus, especially that for reaction-times, in one room, while other parts of the house and verandah were used for different purposes. After four months' work, Messrs McDougall and Myers went on to Borneo. The remaining members of the expedition stayed for about a week in Kiwai and for about a month in Mabuiag, in which islands the psychological work was done by myself with assistance from Mr Seligmann.

We were able during our four months' stay in Murray Island to cover a fairly wide field in our work. The subjects, which were investigated, included visual acuity and sensibility to light difference; colour vision, including testing for colour-blindness, colour nomenclature, the thresholds for different colours, after-images, contrast, and the colour vision of the peripheral retina; binocular vision; line-dividing; visual illusions, some of which were investigated quantitatively; acuity and range of hearing; discrimination of tone-difference; rhythm; smell and taste; tactile acuity and localization: sensibility to pain: temperature spots; discrimination of weight and illusions of weight; reaction-time, including auditory and visual simple reaction-time and choice-time: estimation of intervals of time; memory; mental fatigue and practice; muscular power and motor accuracy; drawing and writing; blood-pressure changes under various conditions, etc.

In some cases observations were made on a fairly large number of individuals; in other cases, little more could be done than to make a few observations with the object of ascertaining the most satisfactory methods in work of this kind. In some of the latter cases, though we can bring forward no positive results, I hope that we may furnish contributions to method which may be useful in future work.

Our stay in Kiwai was very short, and little more could be done than to examine as many individuals as possible in a few subjects such as visual acuity and colour vision.

In Mabuiag, in which island we made a longer stay, the work was limited in extent owing to the fact that most of the apparatus had been taken on to Borneo. The subjects investigated included visual acuity, colour vision, auditory acuity, smell, tactile acuity, writing and drawing.

There were in the island of Mabuiag a number of Polynesian and Melanesian natives as well as some Australians, and a few observations were made on them. A few half-castes, chiefly with Torres Straits mothers and Polynesian or Melanesian fathers, were also examined. The account of these observations and of some made by Mr Seligmann in New Guinea will also be included in this volume.

It will be impossible to give any general resumé of the work and its results until all our data have been worked out, and until other data have been collected for purposes of comparison with those derived from Torres Straits. Nearly all the methods used by us were modified in some way to meet the special conditions, and others were either entirely new or had not been employed on any large number of individuals. Consequently much of our work is at present in the form of mere facts which will only acquire interest and importance when we have examined a considerable number of Europeans and people of other races by the same methods. This will necessarily take time, and all that can be done in this introduction is to give a general sketch of the methods and the conditions under which they were employed.

Murray Island had great advantages for our work. With so small a population we were able to become more or less acquainted with nearly all the inhabitants, certainly all the males, of the island, and were able to form a fairly accurate estimate as to how far the natives examined were representative of the whole community.

The people were sufficiently civilized to enable us to make all our observations, and yet they were sufficiently near their primitive condition to be thoroughly interesting. There is no doubt that thirty years[1] ago they were in a completely savage state,

[1] The first teachers landed in Erub (Darnley Island) in 1871, and a few months later Mataika, the Lifu teacher, went to Murray Island.

absolutely untouched by civilization. Owing to its inaccessibility, Murray Island has been much less affected by outside influences than the other islands of Torres Straits.

Our work was much assisted by the fact that all the younger men spoke "pidgin" or trade English, while there were few who did not know it to some extent. In beginning any investigation we were able to learn, from some of the younger men, any Murray Island words bearing on the subject in hand, and it was then often possible to work with the older natives who knew very little English. At least one instance[1] occurred in which the exclusive use of pidgin English might have led to serious error which was avoided by using the appropriate Murray Island terms.

We had little difficulty in getting the natives to make the observations we required. Owing to their previous acquaintance and friendship with Dr Haddon, we found ourselves on our arrival already on the most friendly terms, and were able to commence work at once. There was no evidence that the people were afraid that our instruments would do them any harm, a difficulty which has been encountered among other races in such matters as testing eyesight. We met with a certain amount of reluctance in many cases, and a few natives in Murray Island avoided us altogether, but we had good reason to know that this was due to other causes. The natives were told that some people had said that the black man could see and hear, etc., better than the white man, and that we had come to find out how clever they were, and that their performances would all be described in a big book so that everyone would read about them. This appealed to the vanity of the people and put them on their mettle, and in nearly all their observations there was no doubt that they were doing their best; in fact, I am doubtful whether, when collecting comparative data in some more or less primitive European community, it will be possible to excite the same amount of interest and to be certain that the observations are being made with zest and conscientiousness equal to that of the Torres Straits Islanders. Some of our investigations were distinctly laborious and made a considerable demand on the attention, and in some cases there is no doubt that the natives were careless and did not try to do their best, but in most cases they exhibited a degree of application which was surprising in face of the widespread belief in the difficulty of keeping the attention of the savage concentrated on any one thing for any length of time. The cases in which it was most difficult to keep the attention of the natives were those in which they were deficient in any respect, thus I met with much difficulty in testing cases of subnormal eyesight. So long as they were doing well they were thoroughly interested, but the interest began to fall off directly they found that they were not as good as their neighbours. In all cases the natives were closely watched for any falling off in interest or attention, and if this showed itself, the work was broken off and ten minutes or a quarter of an hour passed in smoking or looking over photographs or other recreation.

It was sometimes difficult to know what to do when a native was very reluctant to be examined in any given point. If he only consented unwillingly, there was the danger that he would not do his best, and that his observations would in consequence be unsatisfactory, but, on the other hand, it often happened that a native, who began

[1] See section on binocular vision.

his observations only after much persuasion, became interested as soon as he had begun and did as well as anyone else. The characteristic demonstrative nature of the Papuan was very useful here and always allowed one to see whether a native was trying to succeed or not.

The degree of trustworthiness of the observations was shown in several ways. In the first place, it was, as already mentioned, easy to tell from simple observation whether the native was giving his whole mind to the task in hand, or whether he was making his observations carelessly, and these facts of observation were noted at the time. In the second place, in the case of quantitative observations the mean variation (*i.e.* the mean of the deviations of the individual observations from the average of the whole number of observations) was a very useful index of the degree of concentration of attention. Those who had been noted as careless while making the observations were always found to have large mean variations, and I believe that the smallness of the mean variations in most of the quantitative investigations undertaken will convince those acquainted with the procedure of experimental psychology of the trustworthiness of the observations. Finally, I believe that when the account of our work is completed, the general consistency of the results will show that the observations must have been made with a due amount of care and attention on the part of the natives.

One of our chief difficulties was that of ensuring a regular attendance of natives to be examined. When we first started work a large proportion of the population used to arrive and we were surrounded by a noisy crowd which made serious work impossible. On other days owing to some counter-attraction we were deserted and had to go and search out natives to be tested. Unfortunately much time was wasted for these reasons till, with the aid of Mr Bruce, we were able to arrange with the two Mamuses (chiefs) that a limited number of men should come regularly every morning, Harry and Pasi, the two Mamuses, making themselves responsible for alternate weeks. After this we had much less difficulty, though even then our men would sometimes fail to come, or would come very late on some days, while on other days, owing either to rumours that we had some new attraction, or to lack of attractions elsewhere, we were invaded by a large number of natives. The people who came for medical or surgical treatment were also a valuable source of subjects for observation.

We found after a time that men from Las and other villages at the opposite end of the island were not coming to us and it turned out that this was due to the fact that an enthusiastic native, in insisting on the importance of truthfulness in their intercourse with us, had announced that if they told lies Queen Victoria would send a man-of-war to punish them, and this had so alarmed the people of Las that they thought it prudent to absent themselves altogether.

It appeared to be almost impossible to get the men to come to us in the afternoon and we therefore devoted this part of the day to work with the children, Mr Bruce kindly sending us from school any number that we wanted. The children regarded it as a great privilege to come to us and in consequence their observations were made with the greatest care and attention. In many cases their observations were distinctly different from those of the adults, a fact probably due to their school instruction, though some of the youths and younger men had also received instruction from Mr Bruce, and from Mr Hunt and other missionaries before Mr Bruce's arrival in the island.

Each man who came for a morning's work received a stick of tobacco at the end of the morning and the children received sweets. It is perhaps as well to mention that most of our observations on adults were made under the influence of tobacco.

I am not aware of any recorded investigation, even on civilized subjects, which resembles our work in Murray Island. Those who have employed the methods of experimental psychology in observations on numbers of individuals have usually obtained their information by a series of tests so devised that a more or less complete examination of an individual can be made on one occasion, usually within the limits of an hour. Thus in Galton's extensive observations, made at exhibitions and at the anthropometric laboratory at South Kensington, the time devoted to each individual was about half-an-hour.

Cattell[1] and Münsterberg[2] have published schemes for the examination of an individual which would take about one hour, and the former, in conjunction with Farrand[3], has published results in which the observations were made within this limit of time. Jastrow and Morehouse[4] have published the results of mental tests in which the time devoted to each individual was 50 minutes. In a discussion[5] on mental tests by a committee appointed by the American Psychological Association, it seems to have been understood that such tests should not occupy more than one hour.

Binet and Henri[6] have published a much more extensive scheme of observations in individual psychology, but up to now no systematic observations made on the lines of this scheme have been published.

In a recent investigation by Sharp[7] more extended observations have been made, but only on a few individuals, and the mental attributes tested were of a more complex nature than was possible in our work.

Our work in Murray Island differs from such investigations in that we examined most of the male members of a small community among whom we lived and with many of whom we became very intimate. We had, in consequence, many opportunities of general, as well as of experimental, observation. Secondly, our investigation was carried over several months, so that a certain number of individuals were examined many times and in different subjects of investigation on different days, so that the fatigue induced by one set of observations did not influence other measurements, as must be the case when a number of observations are taken rapidly one after the other. In any given subject of investigation as many observations were made as the power of attention of the individual allowed. The multiplication of observations in

[1] *Mind*, vol. XV. p. 373. 1891.

[2] *Centralbl. f. Nervenheilkde u. Psychiatrie*, S. 196. 1891.

[3] *Psychol. Review*, vol. III. p. 618. 1896.

[4] *Amer. Journ. of Psychology*, vol. IV. p. 420. 1892.

[5] *Psychol. Review*, vol. V. p. 172. 1898.

[6] *L'année psychologique*, II. p. 411. 1895.

[7] *Amer. Journ. of Psychology*, vol. X. p. 329. 1899.

any given measurement is not only important in giving a more satisfactory average, but it allows one to form some idea of the influence of such factors as constancy of attention, fatigue and practice, which are quite as interesting in many cases as the special measurement that is the immediate aim of the investigation.

In a few cases the investigation of a given subject in an individual extended over two or three days, and in one subject, viz. the influence of practice on mental work, observations were made at intervals of several weeks, but, as a general rule, a result was obtained in one sitting, although one often had, owing to the influence of fatigue, to be content with a rough and approximate determination of the measurements in question.

In the case of quantitative observations, the results will usually be expressed in the form of the average, while the accuracy and constancy of observation will be expressed by the mean variation, obtained by finding the arithmetical mean of the deviations of the individual observations from the average. In some cases in which sufficient observations were taken, the median value will also be given, viz. the value which stands exactly in the middle of all the figures obtained when these are arranged in order of magnitude.

In order to express the degree of variability of the individuals in any subject of investigation, the mean variation of the figures for the individual natives will be given, *i.e.* the arithmetical mean of the deviations of the results of different individuals from the average result. This will be recorded as M.V. in capital letters in order to distinguish it from the mean variation of an individual which will be recorded as m.v. in small letters.

M.V. will be an index of the degree of variability of the different natives in any measurement, while m.v. will be a guide to the accuracy and constancy of a given native in that measurement.

I am afraid that the introspective aspect of psychological experimentation was almost completely absent in our work. Occasionally a native would be able to give useful information as to what he had in his mind while he was making a measurement, but as a general rule, no information of this kind was obtainable. It was, of course, possible in some cases that when a native was asked to do one thing, he was in reality doing something different, but this danger was avoided as much as possible by making every method as simple as possible, while the general consistency of the results renders any such fallacy very improbable. In fact, I believe that the results are in some cases even more consistent than those made by civilized people, and especially by students of psychology. The latter, when asked to make a given measurement, are very apt to begin to speculate about what they are asked to do and allow their knowledge to influence their judgments. It is customary in experimental psychology to speak of differences of procedure according to the amount of knowledge of the experiment which the observer possesses. One speaks of the procedure as "with complete knowledge," "with partial knowledge," or "without knowledge" ("wissentlich," "halbwissentlich," or "unwissentlich"). It is almost impossible to have a completely "unwissentlich" procedure in a student of psychology, while probably in no investigations has the procedure ever been so completely "unwissentlich" as it was in our work in Torres Straits, and I cannot help thinking that this had something to do with the general consistency of the results.

In several investigations statistics will be given on the influence of age. The determination of the age of an individual was by no means an easy matter. The ideas of the natives themselves on the subject were of the vaguest description, and their statement as to age in years absolutely unreliable. They nearly always knew, however, which was the elder of any given two men, and one was often able in this way to arrange a group of men in order of age. There were further a certain number of men whose ages were known approximately in some way, and this enabled one to roughly arrange the whole series. The ages adopted are chiefly based on information given by Mr Bruce, who has been keeping for some years a very valuable register of births, marriages and deaths in the island. This often contained important evidence as to age, thus, one man had been entered as 21 in 1890, another as 23 in 1894. In the case of those under 20 or 21, Mr Bruce was able to be more definite, as he had known them all as children. In the case of some children, assistance was also given by the fact that they were represented in photographs taken at the time of Dr Haddon's previous visit.

In Mabuiag and Kiwai, the determination of the ages was still less definite, and the ages given are based mainly on the general appearance, assisted in Mabuiag by knowledge on the part of the natives of their relative ages.

I. VISION.

By W. H. R. RIVERS.

1. PHYSICAL CHARACTERS AND DISEASES OF THE EYES.

On examining the eyes in Mabuiag, I found a difficulty in getting an extensive view of the cornea and conjunctiva which I had not experienced in Murray Island, and it seemed to me that this was due to a greater narrowness of the palpebral fissure, but I have no direct measurements to show whether this was the case.

In nearly all cases the conjunctiva was pigmented. The pigmentation occurred in three chief forms. In many cases it was diffusely distributed over the conjunctiva, and, combined with considerable vascularity, gave the eye a yellowish appearance from a distance. In other cases, the pigment occurred in irregular patches. In some cases, these patches existed together with the diffuse pigmentation; in other cases, especially in younger men and children, the rest of the conjunctiva was white and clear. In many cases, the cornea was immediately surrounded by a definite ring of pigment, varying in breadth in different cases. A similar ring has been described by Pergens[1] as occurring in the Congolese, which appears, however, from his description to have been broader than among the Torres Straits Islanders. Kotelmann[2] has also described a circumcorneal ring in a Negro, and a similar ring may be seen in many animals. Pergens also observed patchy pigmentation among the Congolese, and the general appearance of the eyes of these people appears to have closely resembled that of the Torres Straits Islanders.

Pergens examined the eyes of a Negro who had died of tuberculosis and found that in the ring of pigmentation the superficial as well as the deep cells of the circumcorneal epithelium were loaded with pigment.

A definite arcus senilis was found in several of the older men. An indefinite haziness at the margin of the cornea, more superficial than true arcus, was very

[1] *Janus*, p. 459. 1898.

[2] *Berlin. klin. Wochensch.* S. 701. 1879.

common and was especially marked in the upper segment of the cornea, over which it often spread for some distance. This haziness gave the outer edge of the iris a bluish appearance from a distance. Abelsdorff[1] has noticed a similar appearance among Javanese and Negroes. In 1843, Furnari[2] noted arcus senilis as common among the Negroes and Arabs of Algeria, and this may have been of the same kind.

Opacities of the cornea were common and were often associated with scarring and distortion of the corneal margin. In some cases the opacities involved the centre of the cornea and were the cause of defective visual acuity. It is perhaps worth noticing that the most marked corneal changes were seen in natives living on the south-east side of Murray Island, *i.e.* the side exposed to the trade wind for about eight months of the year. This may simply have been due to greater exposure to dust, but there was also much reason to believe that this side of the island was less healthy in other ways.

A few cases of acute conjunctivitis were seen, both in Murray Island and Mabuiag, of the phlyctenular form, but the phlyctenules were larger than those commonly seen in Europe. There were two men on Murray Island, Gasu and Kapilag, who were almost blind owing to injury in early life. In both cases, the cornea and conjunctiva were almost completely covered by scar tissue.

Pterygium and pinguicula were very common. All stages of pterygium were noticed, from slight thickening and vascularity of the conjunctiva to a thick growth involving the cornea for several millimetres. The condition was in nearly all cases most marked on the inner side of the eyeball; in some of the slighter cases there was no marked difference between the two sides, while in one man on Murray Island, Billy Gasu, the pterygium in the left eye was distinctly more marked on the outer than on the inner side, involving the cornea for several millimetres. In no case had the pterygium spread so far over the cornea as to obscure the pupil in ordinary illumination. In some cases seen in Mabuiag, the corneal part of the pterygium was ulcerated.

In most of the slighter cases, the pterygial thickening of the conjunctiva led up to a pinguicula at the corneal margin. Pterygium and pinguicula are often described as separate conditions, but the cases in Torres Straits would certainly lead one to suppose that pinguicula forms one stage or part of one stage in the development of a pterygium. In some cases there was a well-marked pterygium on the inner side of each eye involving the cornea for some distance, while on the outer side of each eye there was thickening of the conjunctiva leading up to a pinguicula. Lopez[3], who finds pterygium extremely common in Cuba, has similarly noted the close relation between the two conditions and regards pinguicula as the first stage of pterygium.

The two men, Papi and Billy Gasu, in Murray Island in whom the condition was most marked were about 40 years of age, while in some of the oldest men it was very slight. The youngest individual in whom definite pterygial change occurred was Dick (son of Toik), aged 11, in whom there was marked swelling on the inner side of the conjunctiva extending to the margin of the cornea. Liu, aged 14, also

[1] *Klin. Monatsblätter f. Augenhlkde*, xxxvi. S. 330. 1898.

[2] *Ann. d'oculistique*, T. x. p. 145. 1843.

[3] *Arch. of Ophthalmology*, vol. xxvii. p. 279. 1898.

had a very distinct pinguicula and commencing pterygium. Webster Fox[1] noted the presence of pterygium in 65 of 250 American Indians examined by him, and as these were all under 23 years of age, it appears that both in Torres Straits and elsewhere pterygium may occur early in life. A large pterygium was noted in Bĭgĕd, wife of the Mamus of Murray Island, but I have not sufficient observations to say whether the condition was more or less common in women than in men. Lopez notes that in Cuba it is rare in women, and rarely found before the 20th year.

There was no marked difference in the frequency and severity of pterygium in Murray Island and Mabuiag, but it seemed to me to be less marked in Kiwai and also in the village of Old Mawatta on the mainland of New Guinea, where I looked at the eyes of many of the natives, although I was not in the village long enough to make any observations on visual acuity.

The chief cause of the prevalence of pterygium is probably irritation from dust and the smoke from the wood fires. In the wet season the people sit round the fires inside their houses, which have very scanty means of outlet. Pergens[2], who found pinguicula universal among the Congolese examined by him, states that this condition is attributed by the officials of the Congo to the influence of smoke within the huts but points out that this cannot be the only cause, for pinguicula is found in young natives brought up under the best hygienic conditions in Belgium.

It seemed in Murray Island as if the occurrence of pterygium had some connection with the general physique. Those in whom pterygium was well marked were as a rule less healthy in appearance than the average, while the disease was almost absent in some of the strongest and healthiest natives.

In no case had pterygium affected the visual acuity (see p. 39).

One man had a tumour within the orbit on the outer side of the right eye. His vision with that eye was very slightly affected, but the chief interest of his case lay in the fact that he was the only native in whom I failed to obtain evidence of binocular vision.

Two men in Murray Island had advanced cataract. Dauai, aged 50 to 55, had a mature cataract in the left eye with only perception of light. In the right eye there was slight opacity of the lens with vision of $\frac{5}{10}$. Jimmy Dei, aged 45 to 50, had distinct cataract in the right eye with vision of $\frac{2}{60}$, slighter change in the left eye with vision of $\frac{5}{15}$. Two other old men, the Mamus, aged over 60, and Lui, aged 55 to 60, with vision of $\frac{5}{10}$ and $\frac{5}{6}$ respectively, appeared to have slight change in the lens, but I was not able to make satisfactory examinations. I think it probable that the early falling off in visual acuity with advancing age (see p. 29) was probably in many cases due to slight changes in the lens which I was unable to detect. The opacity of the lens which appears to be more frequent than in Europe was probably due to the influence of tropical light. I am unacquainted with any other observations on the relative frequency of cataract in temperate and tropical climates. No case of cataract was seen in Mabuiag.

I did not notice any case of strabismus in Torres Straits. Guppy[3] notes that it

[1] *Philadelphia Med. Times*, vol. XII. p. 346. 1882. [2] *Janus*, p. 459. 1898.
[3] *The Solomon Islands and their Natives*, 1887, p. 177.

is not uncommon among the natives of the Solomon Islands. Pergens, on the other hand, observed no case among the Congolese, and states that medical officers on the Congo do not remember ever having seen a case.

Pupils.

I did not make any measurements of the size of the pupils, but they were in general small; often, in a good light, very small. They were circular and I did not notice any cases of irregularity. I have found few references to the size of the pupils in different races. Guppy[1] was inclined to regard those of the Solomon Islanders as larger than in Europeans and ascribes their power of seeing in low illumination to this cause (see p. 39). Furnari[2], on the other hand, noted that the pupils of Algerians are very small. Hyades and Deniker[3] give the diameter of the pupils in Fuegians as varying from 2 to 4 mm.

I examined a good many eyes for eccentricity of the pupils; many were median, some slightly nasal and a few decidedly on the nasal side, but not more so than is common among Europeans. I did not note any cases in which the pupils were temporally eccentric. Kotelmann[4] has described the pupils of three Patagonians examined by him in Berlin as situated on the upper and nasal side and in two cases to a marked degree. It is perhaps noteworthy in this connection that in such eccentricity as existed in Torres Straits, the displacement was also nasal.

The colour of the iris will be considered in the volume on physical anthropology.

[1] *loc. cit.*
[2] *loc. cit.*
[3] *Mission Scient. du Cap Horn*, T. VII. p. 196. 1891.
[4] *loc. cit.*

2. VISUAL ACUITY.

Those who have travelled or lived in uncivilized parts of the world are fairly unanimous in ascribing to savage and semi-civilized races a higher degree of acuteness of sense than is found among Europeans. It is said that savages can see objects and hear sounds which escape the most acute European.

Travellers have generally failed to distinguish between the two chief factors upon which the power of distinguishing objects by sight depends; one, visual acuity proper, depending on the resolving power of the eye as an optical and physiological mechanism; the other, which may be called power of observation, depending on the habit of attending to and discriminating any minute indications which are given by the organ of sense. Another fact which travellers have usually omitted to take into account is that the observations which have been held to show extraordinary sense acuity have been made in surroundings with which the savage is extremely familiar. A feat, which to the outsider may appear to depend on a marvellous degree of acuteness of vision, may depend merely on a correct inference founded on special knowledge.

Perhaps the most frequently quoted instance of extraordinary visual acuity in a non-civilized race is an observation made by Humboldt at Quito[1]. Some Indians saw the white cloak of Bonpland, Humboldt's companion, at a distance of about 85,000 Parisian feet, and Humboldt calculated that this implied the power of distinguishing an object at a visual angle of 7″ to 12″. Those who quote this instance do not, however, relate that both Humboldt and a Spaniard with him were able to distinguish the white object as soon as it was pointed out to them. The observation did not show any superiority of the Indian over the European in visual acuity, but only in his powers of observation.

Instances of acuteness of sight given by travellers could be multiplied indefinitely. I will content myself with giving two derived from Melanesian races allied to those on whom my observations were made. In 1865, Brenchley[2] noted that the men of

[1] *Kosmos*, 1850, Bd. III. p. 68.

[2] *Cruise of the Curaçoa*, London, 1873, p. 265.

San Christoval in the Solomon Islands had "eyes like lynxes, and could discover from a great distance, though the day was anything but clear, the pigeons which were in the trees hidden by the leaves." In 1885 Duffield[1] notes that the keenness of sight of the natives of New Ireland was remarkable. "They could discover land which we were unable to make out with good glasses, and they would find out small boats 6 or 7 miles off in bad weather which we were unable to do with binoculars or telescopes." Duffield states that the Indians of the South American desert do not surpass or equal the New Irelanders.

In 1885, a discussion on this subject was carried on for some time in the pages of *Nature*[2]. The chief antagonists were Lord Rayleigh and Mr Brudenell Carter. The former insisted that on theoretical grounds there were necessary limits to the resolving power of the eye, and believed that the highly developed visual powers of the savage depended on his attention and practice in the interpretation of minute indications. Mr Carter, on the other hand, was inclined to believe that the savage has much greater visual acuity than is possessed by the civilized man.

Since that time evidence has accumulated which enables one to speak more definitely than was formerly possible, and before considering the results obtained in Torres Straits and New Guinea a short account may be given of previous work and of the methods which have been used in ethnographical investigations of visual acuity.

Methods of testing visual acuity.

The accurate definition of visual acuity is, unfortunately, a point on which ophthalmologists have not yet agreed. The most general view is that visual acuity should be measured by the minimum visual angle, that is, the smallest angle at which two points can be distinguished as two. Snellen however has defined visual acuity by the minimum angle at which the eye can recognize the form of an object, while Guillery has proposed that the smallest angle which an object must subtend in order that it may be seen at all shall be taken as the measure of visual acuity.

In practice the method which is most widely used is that of Snellen. The degree of visual acuity is measured by the distance at which letters of a given size can be recognized. The smallest letters used for distant vision subtend an angle of 5 minutes at 5 metres, while each limb or component part of a letter subtends an angle of 1 minute, which has been found by experiment to correspond approximately with the minimum visual angle of normal European vision. In the accompanying letter, , each of the 25 squares into which the letter is divided subtends an angle of 1 minute at 5 metres.

The degree of visual acuity (V) is usually expressed by the formula $V = \frac{d}{D}$, where D is the distance at which a given type subtends an angle of 5 minutes, and d is

[1] *Journ. Anthropol. Inst.* vol. xv. p. 116. 1885.

[2] Vol. XXXI. pp. 340, 359, 386, 407, 433, 457, 503, 552.

the greatest distance at which this type can be recognized; thus $V = \frac{5}{5}$ or $= 1$ means that type subtending an angle of 5 minutes at 5 metres can be read at 5 metres; $V = \frac{10}{5}$ or $= 2$ means that type subtending an angle of 5 minutes at 5 metres can be read at 10 metres; and $V = \frac{5}{10}$ or $= \frac{1}{2}$ means that type subtending an angle of 5 minutes at 10 metres can only be recognized at 5 metres. When $V = \frac{5}{5}$ or 1, vision is usually spoken of as normal, but this does not mean that it represents the average vision of Europeans. This formula is especially used by clinicians who are chiefly interested in subnormal vision and especially in cases of abnormal refraction of the eye. Their object is to improve vision by glasses till $V = \frac{5}{5}$, which they regard as good enough vision for practical purposes, and the normal is an arbitrary one chiefly adopted for clinical purposes[1]. The true European normal, the average vision of Europeans with normal eyes, has not yet been satisfactorily determined, but, as we shall see, enough has been done to enable a rough comparison to be made between the visual acuity of Papuan and other primitive races and that of Europeans.

A distinction has been made by Cohn[2] between visual acuity (Sehschärfe) and visual efficiency (Sehleistung) which is of some importance for ethnographical purposes. By the former term is meant the acuteness of vision after any existing defect of refraction of the eye has been corrected by glasses, while by visual efficiency is meant the acuteness of vision without any artificial aid.

In most savage races in whom abnormalities of refraction are rare, there would be little difference between the average visual acuity and the average visual efficiency, while in civilized countries the difference might be considerable. The savage and the civilized man might differ very little in visual acuity in the strict sense while differing greatly in visual efficiency. In this work the term "visual acuity" will be used to cover both forms, but in special instances the distinction will be noted.

Although useful for practical purposes, the recognition of letters is unsatisfactory as an exact method of testing visual acuity. Some letters are recognized at much greater distances than others, and the degree of familiarity with letters is also of great influence, for anyone thoroughly familiar with the forms of different letters may often guess successfully when he sees the letters very indistinctly. For ethnographical purposes it is obvious that the method can be of little value.

For testing illiterates Snellen devised a test consisting of squares with one side open and on the same scale as the letters. These are often called Snellen's Haken. This test was found to give results which were not comparable with those obtained by the letter test, and Snellen further modified the test by using the letter E in different positions. The individual who is being tested may say which side of the ⊏ or E is open, or may place an E held in his hands in the same position as one pointed out to him. This method has been used in ethnological investigations, and is that which was found to give the most satisfactory results in Torres Straits.

Cohn has devised two modifications of the test, especially for ethnographical

[1] Snellen, who first adopted a letter subtending an angle of 5 minutes as the unit, acknowledged that this unit was arbitrary, but thought that it probably represented average visual acuity if the eyes of advanced age were included.

[2] *Deutsch. med. Wochensch.*, 1896, S. 698.

purposes. In one, 36 letters, all of the No. 6 size[1], are placed on one square card which can be hung up by each of its four sides, giving a very large variety of possible positions of the E, quite excluding the possibility of learning by heart. Cohn found the large number of letters on this card made it difficult in some cases to tell which E was being indicated, and he therefore devised another modification[2] in which a circular card is used on which eight letters are placed. The card can be turned round behind a cover in which there is a circular aperture through which one letter can be exposed at a time. This form of the test quite does away with the danger that the position of the letters may be learned by heart.

Steiger[3] has proposed a modification of the original form of Snellen's Haken (squares open on one side) in which smaller sizes are used so that all degrees of hyperacuity can be tested at a distance of 5 metres. These types can be used both for near and far vision.

Landolt[4] has recently proposed a modified test on the same principle as the E test, consisting of circles presenting at some point in their circumference a gap corresponding to an angle of one minute.

Before going out to Torres Straits it seemed possible that any tests involving the recognition of unfamiliar objects, such as letters, might turn out to be impracticable. Mr Marcus Gunn suggested to me that types representing the human hand with one or more fingers missing might prove more interesting to the natives than the ordinary tests and might give better results. I had such tests prepared, the fingers of the hand being on exactly the same scale as those of Snellen's letters. Owing to the fact that perfectly satisfactory results were obtained with the E test I did not find it necessary to use them.

Another kind of test which differs in principle and has been very largely employed in work on visual acuity, depends on the power of counting dots. One form of this test is employed in the British services, consisting of black dots $\frac{1}{6}$ in. square on a white ground. This test was used by the Anthropometrical Committee of the British Association in the investigation of visual acuity. The test was found to have the disadvantage that the distances between the different dots were unequal, and the distance at which they could be normally counted, viz. 57 feet, was so large as to make it difficult to find suitable open places for the process of testing.

Burchardt's international visual tests also depend on the principle of counting. They consist of round black dots on a white ground at distances apart equal to the diameter of the dots. They are arranged in groups of 4, 5, and 6.

Another test similar in principle is Snellen's test No. LIV. This consists of white dots each 5 mm. in diameter on a black ground[5]. Different groups of dots are exposed through an opening in a black screen. This method is perhaps the most satisfactory of those which depend on counting and I used it in Torres Straits. Any

[1] *i.e.* subtending an angle of 5 minutes at 6 metres.

[2] This may be obtained from Priebatsch's Buchhandlung, Breslau.

[3] *Einheitliche Sehproben zur Untersuchung d. Sehscharfe in d. Ferne u. in d. Nähe.* 1892.

[4] *Brit. Med. Journ.* Sept. 23rd, 1899.

[5] According to Burchardt white dots on a black ground give the same results as black dots of the same size on a white ground.

method, however, which involves counting is unsatisfactory for ethnographical purposes (see p. 33).

All the methods which have been described are not quite satisfactory from the purely physiological point of view; they all involve either counting or recognition of form, *i.e.* they involve psychological operations, often of some complexity, although these are very much reduced in importance in the E method.

For the purpose of testing the eye as a physiological mechanism the method proposed by Guillery[1] is perhaps more satisfactory. By this method visual acuity is measured by the distance at which a black dot on a white ground becomes invisible. It has been objected that this form of the test is greatly influenced by the illumination and that it is a test of the light sense rather than of visual acuity. We know, however, that the illumination is of considerable influence in all the methods of testing visual acuity and within the ranges of illumination which occur in practice, it is very doubtful whether Guillery's test is more influenced by differences of illumination than those in ordinary use.

In all methods of testing visual acuity, illumination is a matter of great importance. According to various investigators there is a progressive increase in visual acuity with increase of illumination up to a certain point beyond which further increase of illumination causes no increase in acuity, and may even lead to a decrease.

For ethnological purposes it will probably always be most convenient to test in the open air. Experiments by Seggel have shown that the distance at which letters and the E test-types are recognized is 2 to 3 metres greater in the open air than in a well-lighted room. The illumination of the open air varies of course very greatly, not only in different parts of the world, but on different days in any one country. I have reason to believe, however, that the difference in the illumination on a bright day in Europe and in the tropics is not sufficient to cause any distinct difference in the degree of visual acuity. When testing visual acuity in England to obtain results for comparison with those obtained in Torres Straits I at first chose very bright days (in August, 1899) but I soon found that some of these days were too bright to give satisfactory results with Europeans. The glare (even with the sun behind the individual under examination) was too great for distinct vision and much higher values for the visual acuity were obtained by moving into the shade.

Historical.

The first exact observations on visual acuity from the ethnographical stand-point were made in the American army in 1865[2]. The method used is not very fully described, but the white troops were examined with small pica type, while in the case of coloured troops an individual was passed when he satisfied the examiner that he could recognize the form of a letter. It was found that the white soldiers could

[1] *Arch. f. Augenhlkde*, Bd. XXIII. S. 323. 1891.

[2] See Gould, *Sanitary Memoirs of the War of the Rebellion*. Volume on investigations into the military and anthropological statistics of American soldiers. New York, 1869, p. 527.

read the type at 47·77 inches; full blacks at 45·33; mulattos at 47·23, and Indians (Iroquois) at 51·77 inches. The average Indian was slightly superior and the average Negro slightly inferior to the average white man but not in any marked degree.

In 1875 Callan[1] examined 456 Negro children in New York schools. He found that 94 per cent. had normal vision, 2·6 per cent. were myopic, and 3 per cent. were amblyopic from some cause. On testing those with normal vision with Snellen's letter test, 87·8 per cent. were found to have vision from $\frac{20}{20}$ to $\frac{29}{20}$[2], 10·7 per cent. from $\frac{30}{20}$ to $\frac{39}{20}$, 1·1 per cent. from $\frac{40}{20}$ to $\frac{49}{20}$, and 0·4 per cent. had vision of $\frac{50}{20}$.

In 1879 Cohn[3] examined 11 Nubians in a travelling caravan at Breslau. It was found that the natives could count up to 4, and Snellen's Tafel LIV. was therefore used on which the white dots should be counted at 16 to 17 metres. Seven of the Nubians counted correctly at 26 to 39 metres; while one probably of mixed Negro and Nubian blood was correct at 40 to 43 metres. One individual, the chief and priest, who could read Arabic, was myopic (− 1·5 D), but when his myopia was corrected, could count at 29 to 33 metres. Of two women of the party, one counted correctly at 17 to 22 metres, and the other at 27 to 31 metres. The latter was the daughter of the chief.

In the same year Reich[4] examined a company of 140 Georgians in the Russian army, using Snellen's test with Russian letters. He examined in the open air. He found normal vision in 16·4 per cent., $\frac{9}{6}$ in 47·8 per cent., $\frac{9}{5}$ in 32·1 per cent., and $\frac{9}{4}$ in 3·5 per cent.

In 1879 observations were also made in Berlin by Kotelmann[5] on 9 Lapps, 3 Patagonians, 13 Nubians, and 1 Negro. Snellen's Haken were used, probably of the E form. Seven of the Lapps who were old enough to be tested had an average acuity of $\frac{47}{20}$. The highest was $\frac{52}{20}$. The vision of the three Patagonians was $\frac{43}{20}$, $\frac{40}{20}$ and $\frac{40}{20}$ respectively. The 13 Nubians had an average acuity of $\frac{52}{20}$, the highest being $\frac{60}{20}$. The one Negro examined had vision of $\frac{50}{20}$.

In 1882 Webster Fox[6] examined 250 young American Indians, aged 8 to 22 years. Some had vision of $\frac{20}{15}$ with Snellen's letter types, but apparently he did not examine for higher degrees of visual acuity. In 1883 Seggel[7] records observations made by Schött on 6 Chippeway Indians; four had visual acuity of $\frac{3}{2}$ and the other two of $\frac{5}{4}$.

In 1884 Kotelmann[8] determined the visual acuity of 17 Kalmuks, 20 Sinhalese, and 3 Hindus. Snellen's Haken were used. The Kalmuks had an average acuity of 2·7, while one man read No. 6·5 correctly at 42 metres, *i.e.* visual acuity of 6·7 times the so-called normal, and one woman had visual acuity 5·4 times the normal. The average acuity of the Sinhalese and Hindus was less than that of the Kalmuks, viz. 2·1, and the highest value obtained was 3·1.

The observations on the Kalmuks are especially interesting from the fact that

[1] *Amer. Journ. Med. Sci.* Vol. LXIX. p. 331. 1875.

[2] *i.e.* read letters at 20 to 29 feet which subtended an angle of 5 minutes at 20 feet.

[3] *Centralbl. f. prakt. Augenhlkde.* III. S. 197. 1879.

[4] *Centralbl. f. prakt. Augenhlkde.* III. S. 301. 1879.

[5] *Berlin. klin. Wochenschft.* XVI. S. 701. 1879.

[6] *Philadelphia Med. Times*, vol. XII. p. 346. 1882.

[7] *Arch. f. Anthropol.* Bd. XIV. S. 349. 1883.

[8] *Zeitsch. f. Ethnol.* Bd. XVI. S. 77 and 164. 1884.

the visual powers of these people have been very highly extolled by travellers. As long ago as 1776 Pallas[1] recorded his astonishment at the way in which Kalmuks could distinguish distant objects on the steppes; on one occasion these people distinguished the dust of a herd of cattle at a distance of about 30 versts (20 miles), when the European commander of the party could see nothing with the aid of a telescope, and similar reports have been given by others who have visited these people.

In 1885 Guppy[2] recorded observations made on natives of the Solomon Islands by means of the square test dots used in the British army. Twenty-two young adults were tested, the average distance at which the dots could be counted being 57·5 feet and the maximum distance 70 feet. The average for English labourers examined by the same test by the Anthropometrical Committee of the British Association was 52·1 feet, the maximum, however, reaching 90 feet. Guppy's observations are also recorded in his book on *The Solomon Islands and their Natives*, 1887.

In 1885 König[3] examined 4 Zulus in Berlin, either with the E or the ⊏ type. Three had visual acuity 4 times the normal, and the fourth, a boy, only 1·5.

In 1889 Man[4] examined a party of young Nicobarese men with the army dot test and found that all could count correctly at 57 feet, and some at 66 feet. Only one native was superior to Man himself.

In 1891 Giltschenko[5] examined 142 Osset soldiers (method not stated), and found the average acuity 2·4, while that of other "Cossacks" was 2·65.

In 1892[6] Johnson in notes on a paper "*Bemerkungen über die Macula lutea*" mentions the cases of two boys from equatorial Africa with vision of $\frac{6}{1\cdot 5}$ and $\frac{6}{1\cdot 2}$ respectively. The method of testing is not mentioned.

In 1894 Seggel[7] examined 15 Lapps and 4 Hawaians in Germany by means of Burchardt's dot test. Of the Lapps 4 had subnormal vision, 3 normal, and 8 were above normal, 3 of these having more than double vision. Of the 4 Hawaians, three of whom were women, 2 had vision of $\frac{3}{2}$, one of 2 and the highest $\frac{12}{5}$.

In 1894 also Stephenson[8], in a paper on colour-blindness, mentions that visual power was normal in 191 Hawaians and 31 Aleuts and Aleutio-Russian creoles. He does not, however, give any details.

In 1897, K. E. Ranke[9] recorded observations made on inhabitants of Brazil, by means of squares with one side open. He was only able to examine 5 individuals, 3 of the Bakaïri and 2 of the Trumai tribe. The vision of the five is represented by the figures $\frac{12}{10}$, $\frac{14}{10}$, $\frac{15}{10}$, $\frac{18}{10}$ and $\frac{20}{10}$, while Ranke's own vision, after correction of his

[1] *Sammlung histor. Nachrichten*, Theil i. p. 100. Quoted by Lawrence, *Lectures on Physiology*, p. 467.

[2] *Nature*, Vol. XXXI. p. 503. 1885.

[3] *Verhandl. d. physikal. Gesellsch. in Berlin.* S. 15. 1885.

[4] *Journ. Anthrop. Inst.* vol. XVIII. p. 377. 1899.

[5] *Biolog. Centralbl.* Bd. XV. S. 304. 1891.

[6] *Arch. f. Augenhlkde.* Bd. XXV. S. 173. 1892.

[7] *Correspondenz-Blatt d. deutsch. Gesellsch. f. Anthrop.* etc. XXV. p. 51, 1894. Further details are cited by Cohn from a private communication.

[8] *Mittheil. d. deutsch. Gesellsch. f. Natur- und Völkerkunde in Tokio*, Bd. VI. S. 190. 1894.

[9] *Correspondenz-Blatt d. deutsch. Gesellsch. f. Anthrop.* etc. XXVIII. p. 113. 1897.

myopia, was $\frac{20}{10}$. Ranke had previously been very much astonished at the visual feats of the natives and was surprised to find their visual acuity so low. He records interesting observations showing upon what factors the visual feats depended (see p. 43).

In 1898 several sets of observations were recorded. Cohn[1] examined in Egypt 13 Arabs (7 Bedawin and 6 Bisharin); also 100 Egyptian soldiers (recruits) and 64 Egyptian children. Of the 13 Arabs one read No. 6 at 6 metres, four had visual acuity of 1·1 to 1·5, three of 1·6 to 2·0, four of 2·1 to 2·5, while one of the Bedawin read No. 6 at 36 metres, *i.e.* had a visual acuity 6 times the so-called normal; he was often right at 40 metres.

Of the 100 Egyptian recruits 75 per cent. had visual acuity from 1·1 to 2·0; one had a visual acuity of 4·5, and one of 5·0. An English officer examined at the same time read No. 6 at 22 metres, *i.e.* had acuity of 3·7 nearly, the same as the third best of the Egyptian soldiers. Seven per cent. had subnormal vision.

Of 42 Egyptian school-boys, of 15 to 20 years of age, no less than 29 per cent. had subnormal vision, while 54 per cent. had acuity of 1·1 to 2·0. One boy of 16 read No. 6 at 48 metres, *i.e.* had acuity eight times the normal.

Of 22 Egyptian girls, five had subnormal vision; twelve vision of 1·1 to 2·0. One had visual acuity of 6·3; this girl had an Egyptian father and a Circassian mother.

In the same paper Cohn records observations made in Breslau on 21 Kalmuks in 1897. Three had acuity of 1·1 to 1·5, six of 1·6 to 2·0, eight of 2·1 to 2·5, and three of 2·6 to 3·0. With the same illumination, several inhabitants of Breslau had acuity of 1·5 and that of one man was 2·2.

In 1898 Pergens[2] also published the results of the examination of 100 Congolese present at the Brussels Exhibition in 1897. He used Steiger's types, and found that most had visual acuity of two to three times, some four times and one five times the so-called normal.

Observations in Torres Straits and the Fly River.

Four methods were used in my work. The E method was found to be by far the most satisfactory. When I left England I was not aware of Cohn's modifications of this test and I used the ordinary type, known in this country as the test-type for illiterates. A certain number of observations were also made with the ordinary letter test-types of Snellen, chiefly on children. For observations on the method of testing by counting I used Snellen's test No. LIV. A few observations were also made with Guillery's test-types.

The observations by all the methods were made in the open air, either on a verandah in Murray Island and Kiwai, or completely in the open at Mabuiag. The verandah at Murray Island was entirely unshadowed on one side and can have differed very slightly in illumination from the open. Moreover, as the verandah was only

[1] *Berliner klin. Wochensch.* xxxv. S. 453, etc. 1898.

[2] *Janus*, p. 459. 1898.

15 metres long, cases in which the acuity was above $\frac{15}{5}$ had their examination completed outside. The verandah at Kiwai was more shaded and it is just possible that the lower illumination may have had some slight influence in producing the lower values for visual acuity in that island.

All the ordinary observations were made with both eyes; in some cases, especially those of subnormal vision, each eye was separately tested in addition. Most of those who have made observations on non-civilized races have adopted this method (Kotelmann being the chief exception), and for ethnological purposes I believe it is the most satisfactory. Many races are so shy of observations of this kind that the additional measure of covering one eye would probably in many cases make all the difference between success and failure. In Murray Island there were individuals who required much persuasion to have their sight tested and with them I have no doubt that covering one eye would have increased the difficulty. If in many races and individuals it is necessary to test both eyes simultaneously, it will be most satisfactory for comparative purposes to do so in all, and there is the further advantage that one is testing vision under the most natural conditions. The chief disadvantage is that one may overlook cases of unilateral defective vision, or even of unilateral blindness. An examination with both eyes simultaneously for comparative purposes, however, does not preclude an additional examination of each eye separately and in nearly all cases in Torres Straits, which presented any unusual features, this was done.

Of the four methods used in Torres Straits the E method gave the most satisfactory results. In most cases the method was understood readily; some men in Murray Island were very slow in learning what to do, and I also had a good deal of difficulty with the girls of that island, which at first led me to think that the girls must be much less intelligent than the boys. Further experience, however, left little doubt that the difficulty was due to shyness rather than stupidity. The natives of Kiwai were also slow in learning the method. The only case in which I failed altogether was that of a native of Kiwai, Emabogo, who seemed unable to understand the method even after he had seen others being tested. The same man, however, failed to understand the method of matching wools for testing colour-blindness. He had come from a neighbouring village for a short time only, and I was unable to repeat the observation as I should have done in Murray Island or Mabuiag. I also obtained very good results by this method with Australian natives and with young children.

Others who have used this method have also found that it was readily understood. The only exception which I have found recorded was in early observations by Cohn[1] on Nubians, some of whom had difficulty in distinguishing between right and left.

The main features of the method are shown in Fig. 1. The individual to be tested held in his hand a board on which was pasted a large E and when any letter was pointed out to him he simply had to put the E in his hand in the same position. On the back of the board was pasted a mark which indicated to me whether he had placed the E correctly or not.

Observations were always commenced at a distance of 15 metres from the type.

[1] *Centralb. f. prakt. Augenhlkde.* III. p. 197. 1879.

This distance had the advantage of being outside that at which most could read No. 5, and I was able at this distance to take them over the large letters of the first four rows till they became perfectly familiar with the method. In many cases the natives had first to be familiarised with the method at close quarters. When they had mastered the method, I took them down the board till they reached their limit at 15 metres. In some cases they could read to the bottom, and in those cases I had to increase their distance from the test-type. In most cases they failed at No. 15 or No. 10 or No. 6. I noted their degree of efficiency at 15 metres, and then brought them up to some nearer distance, till I found that at which No. 5 could be

Fig. 1.

read correctly nine times in ten; if twice wrong in ten, they were brought up a metre nearer. If right at this, they were again tried at the further distance. In judging when a given type can be seen, it is necessary to adopt a constant standard of correctness, in order to obtain data from different people and places which are, as far as possible, exactly comparable with one another. Most of those who have recorded observations of this kind do not appear to have adopted any fixed standard, or if so, have not recorded what it was. Cohn is an exception, and records that he passed four right answers[1]. If I had not adopted a fixed standard, but had gone by

[1] Where there are only 4 possible answers, as in the *E* test, this standard is probably too low.

general impression, I have no doubt that I should on the whole have obtained higher values than I did. In most cases, however, I found a very sharp dividing line. In many cases a native would at one distance be right every time without hesitation, while a metre farther away five or six mistakes in ten would be made, and this difference would show itself when the observations were repeated two or three times. I cannot speak positively on the question, but I have the impression that the sharpness of the dividing line was more marked than among Europeans.

The observations of two individuals in Murray Island may be given as samples.

Aki, *aet.* 20, at 15 metres was right with all lines down and including No. 6. Said he could not read No. 5. At 12 metres and at 13 metres read No. 5 easily. At 14 metres was nine times right and once wrong, but corrected the wrong answer when asked. At 15 metres was eight times right and twice wrong, but corrected both wrong answers. He could see only with difficulty and leant forward in order to see better and was obviously very near his limit which I put down as $\frac{15}{5}$.

Alo, *aet.* 50, at 15 metres was right with all lines down to and including No. 10. Several wrong answers with No. 6. At 12 metres still made mistakes in No. 6. At 10 metres was right every time with No. 6, but made several mistakes in No. 5. At 8 and 9 metres was right every time with No. 5. Tried again at 10 metres, was right five times and wrong twice, both wrong answers being in horizontal positions of the limbs of the E. At 11 metres he did No. 6 correctly but made several mistakes in No. 5. His limit was put down as $\frac{9}{5}$.

There are several possible sources of error. That of learning by heart has been already mentioned. Although always on the look out for this, I failed to detect one case in Murray Island. In Mabuiag, on the other hand, where the people have come much more into contact with civilization, and are, on the whole, more intelligent, I met with several cases, and sometimes the bottom line was already known when I began to test, having been learned while I was testing others. I was always able however to detect and overcome this difficulty. In the first place it was always No. 5 which was learned, and on going back to No. 6, mistakes would be made in this while No. 5 was done without error. In the second place, if the type were turned upside down, one obtained an entirely new set of letters, and no individual in whom I detected learning by heart was able to read No. 5 in its inverted position. One advantage of beginning well outside the probable limit of vision was to render the danger of learning by heart less frequent.

In other more civilized races, learning by heart would probably be much more common than in Torres Straits, and the modification used by Cohn should become the recognized ethnological method. It has the further advantage of compactness and portability.

While making these observations other natives were nearly always present; it was impossible to avoid this, and one obvious source of error was that a bystander might sometimes help a friend whose vision was less good than his own. Children were the worst offenders in this respect. This source of error is one which is readily avoided when one is alive to it. It was usually readily detected with the E method. One could often tell at once by the way in which the native turned round the board in his hands that he was doing it in response to a suggestion, and this was rendered more obvious in Murray Island by the fact that, so far as I could find, they had no very definite words to indicate the four positions of the E. In Mabuiag, on the other hand, they had definite words, thus ш was "kadakakīt"; m, "mōlukakit"; E and Ǝ were together "balkit," and were distinguished as "paipakit" (windward) when the open side of the E was towards the wind, and "pòpakit" (leeward) when away from the wind.

It is interesting that Cohn[1] found in Heligoland, where the natives, like those of Torres Straits, are all sailors, that instead of answering right or left for different positions of the E, they answered north or south, and Cohn found it difficult to get them out of this habit.

The reliability of the E method was shown very conclusively by the results of testing individuals on several occasions. In nearly all cases the results on the different days exactly agreed with one another. In only two cases, both boys, was there a difference of as much as two metres and in each of these cases the first observations had been noted as unsatisfactory. The close agreement of the observations on different occasions may also be regarded as evidence that such changes of the illumination as occur in that climate do not materially affect the visual acuity in the open air.

Results with the E method.

In Murray Island 115 individuals were tested. The average distance at which No. 5 could be correctly deciphered was 10·3 metres, the median[2] distance 11 metres, and the maximum 19 metres.

Of the 115 individuals 69 were men[3] whose average distance was 9·8 metres and median distance 10 metres. Eleven of these individuals, all old men, had distinctly subnormal vision (less than $\frac{5}{5}$) referable in nearly all cases to pathological causes. If these be excluded, the average acuity of the remaining 58 was $\frac{11 \cdot 1}{5}$, the median $\frac{11}{5}$, and the maximum $\frac{19}{5}$. Thirty-three boys were examined with an average of $\frac{11}{5}$, a, median of $\frac{12}{5}$, and a maximum of $\frac{18}{5}$. Thirteen girls had an average of $\frac{11 \cdot 4}{5}$, a median of $\frac{12}{5}$, and a maximum of $\frac{14}{5}$. The individuals tested were not completely representative of the whole male community owing to the fact that many of the younger men were away from the island pearl-diving and could not be tested. Nearly all the older men on the island were tested and their low figures reduce the average considerably, and if the whole male population could have been examined, there is little doubt that the average would have been higher.

In Mabuiag 35 individuals were tested with an average acuity of $\frac{11 \cdot 6}{5}$, and a median result of $\frac{12}{5}$. Of these 28 were men with an average of $\frac{11 \cdot 5}{5}$, and a maximum of $\frac{16}{5}$. All of these belonged to the islands of Mabuiag or Badu, with the exception

[1] *Deutsch. med. Wochensch.* xxii. S. 698. 1896.

[2] *i.e.* the distance at which No. 5 was recognized by the individual who was exactly in the middle of the whole series when the results were arranged in order of magnitude.

[3] *i.e.* including all males of and above the age of 17.

of one man from Moa, whose vision was $\frac{13}{5}$. One man, Bagari, had phlyctenular conjunctivitis at the time of examination. His vision was $\frac{12}{5}$, but would probably have been higher if he could have been tested again with his eye in its normal condition. Six boys gave an average of $\frac{11 \cdot 6}{5}$ with a maximum of $\frac{14}{5}$. The acuity of one woman tested was $\frac{12}{5}$.

The average acuity is slightly higher than in Murray Island. I believe that this is due mainly to the fact that the individuals tested were more nearly representative of the whole community.

Nineteen individuals were tested who belonged either to the island of Kiwai in the Fly River or to the Mawatta district of the mainland of New Guinea. These natives are closely allied to those of Torres Straits. The average distance at which they recognized No. 5 of the E test was 10·3 metres and the median distance 10 metres. Seventeen of the individuals tested were men with an average of $\frac{10}{5}$ and a maximum of $\frac{13}{5}$, while the figures for two boys, both from Mawatta, were $\frac{15}{5}$ and $\frac{12}{5}$.

The individuals tested were nearly all young men and though there were no cases of subnormal vision, the average was low compared with that of Mabuiag or of Murray Island (when subnormal cases are excluded). This may possibly have been due to the fact that the illumination in which they were examined was somewhat less bright than that of the other localities, but a far more probable explanation is that they were much less familiar with the "white man" than the other natives, understood what they were to do less readily, and took less interest in what they were doing. It was in Kiwai that I met with my only complete failure with the E method. I believe that with a longer stay among them, and with the same spirit of emulation which existed in Torres Straits, their results would have equalled those of Mabuiag.

Taking the ethnographical district of Torres Straits and the Fly River as a whole, 169 individuals were tested with an average visual acuity of $\frac{10 \cdot 6}{5}$, and a median acuity of $\frac{11}{5}$.

These results are set out in another way in Table I. for the purpose of comparison with results obtained elsewhere. All the observations comprised in this table were made by the E method in the open air, *i.e.* under conditions very closely resembling each other. The most important data for comparison are those collected by Cohn in Egypt and Heligoland. Cohn's Egyptian data are those which are most nearly comparable with mine in having been made by the same method and on a large number of natives in their own country, but they differ from mine in that they were not made on natives representative of a whole community, but only on school-children and young army recruits. The figures in the first column give the number of individuals examined in each group; those in the second column, the average acuity according to the formula $V = \frac{d}{D}$, some of the groups having been finally tested with No. 6 or No. 6·5 types instead of with No. 5 as in my own observations. The figures in the succeeding columns give the percentage number of individuals who recognized the types at different distances. The first column gives those who saw No. 5 at 5 metres or less, No. 6 at 6 metres or less, and No. 6·5 at 6·5 metres or less. The next column includes those who saw No. 5 at 6 to 10 metres, No. 6 at 7 to 12 metres, and No. 6·5 at 7 to 13 metres, and so on. The final column gives the percentages of those whose vision excelled what is often supposed to be the normal European standard.

The chief differences between the different Papuan groups have already been considered. The most striking difference shown by this table is in the column for subnormal vision, the large proportion in Murray Island being explained by the large number of old men tested on this island while the absence of subnormal cases in Kiwai may have been due to the fact that all those examined were young or middle-aged

TABLE I.

	No.	Average acuity	$V=1$ or <1	$V=1·1$ to 2	$V=2·1$ to 3	$V=3·1$ to 4	$V=4·1$ to 6	$V=6·1$ to 8	$V>1$
Murray Island	115	$\frac{10·3}{5}$	11·3	35·7	48·7	4·3	0	0	88·7
Mabuiag	36	$\frac{11·6}{5}$	5·6	22·2	69·4	2·8	0	0	94·4
Kiwai	19	$\frac{10·3}{5}$	0	63·2	36·8	0	0	0	100
Torres Straits and Fly River............	170	$\frac{10·6}{5}$	8·8	35·9	51·8	3·5	0	0	91·2
Kalmuks (Kotelmann and Cohn)...	38		2·6	34·2	55·3	0	5·3	2·6	97·4
Sinhalese and Hindus (Kotelmann)	23	$\frac{14}{6·5}$	0	30·4	65·2	4·4	0	0	100
Arabs (Cohn)	13	$\frac{13·6}{6}$	7·7	53·8	30·8	0	7·7	0	92·3
Egyptians (Cohn) ...	164		21·4	67·0	7·3	1·8	1·2	1·2	78·6
Heligoland men (Cohn)...............	100	$\frac{10·6}{6}$	14·0	56·0	30·0	0	0	0	86·0
German navy	100	$\frac{12·6}{6}$	11·0	46·0	42·0	1·0	0	0	89·0
German Artillery (Seitz and Seggel)	1398		5·3	57·0	30·9	6·5	·3	0	94·7

men. It is, however, quite possible that the pathological changes which so largely affected the vision of the old men in Murray Island would have been found to be present in Kiwai if more extended observations could have been made. It will be seen from the table that more than two-thirds of the Mabuiag Islanders had vision between 2 and 3 times what is commonly supposed to be normal European vision. The second part of the table shows observations made on non-European races. I have only included those which have been made by the same method as that employed in Torres Straits and on a sufficient number of individuals to give some idea of the average acuity. It will be seen that the figures for the Kalmuks and for the Sinhalese and Hindus show a fairly close agreement with those of Torres Straits, except that among the Kalmuks there were three cases of marked hyperacuity exceeding anything observed in Torres Straits. On the other hand, cases of subacute vision were almost absent, but this is readily explained by the fact that in both cases the observations were made on parties of natives brought to Europe for exhibition purposes. These natives were young and probably healthy, the eldest of the Kalmuks examined by Kotelmann being only 35, while the ages of the Sinhalese and Hindus ranged from 12 to 45. There is little doubt that these groups were not representative of their communities and probably gave higher average results on this account.

The few Arabs examined by Cohn gave an average agreeing almost exactly with that of Mabuiag. These observations, though few in number, are more satisfactory than the preceding in that they were men taken at random in their own country. They varied in age from 12 to 50, the only man of the latter age having vision $\frac{17}{6}$. The vision of one of the Bedawin was $\frac{36}{6}$, and this man was often right at 40 metres.

Cohn's Egyptian statistics are unsatisfactory for comparative purposes in that they are derived only from observations on children and on army recruits all under 25 years of age. In spite of this, they show distinctly lower average visual acuity and a higher proportion of cases of subnormal vision than the inhabitants of Torres Straits. The observations made on army recruits are open to the further objection that some cases of distinctly subnormal vision may have been excluded. On the other hand Cohn found a few cases of very hyperacute vision, including one boy with vision eight times the so-called normal.

The data for European vision made by the E method in the open air, comparable with those which have been considered, are not very abundant. The most satisfactory are those obtained by Cohn[1] from 100 inhabitants of the island of Heligoland. These were all adult males, varying in age from 20 to 84, so that they may be taken as representative of the whole community. The inhabitants of this isolated European island probably furnish a very satisfactory group for comparison with the natives of Murray Island. It will be seen that the general average acuity is distinctly less than that of Murray Island, though not so to any marked extent. On the other hand the general acuity of the Heligolanders is superior to that of the Egyptians examined by Cohn, though there were no cases of marked hyperacuity such as were found among the latter.

[1] *Deutsch. med. Wochenschft.* XXII. S. 698. 1896.

Cohn[1] also examined in 1871 and 1874 a number of the inhabitants of Schreiberhau, a village in the hills not far from Breslau. Unfortunately he limited his observations to children and to people of over 60 years of age, and consequently his figures are not representative of the whole community. The children, also, were examined with the ⊏ form of Snellen's Haken, which may be recognized at a greater distance than the E form. On these accounts I have not included these results in the comparative table. Of 100 old people, 12 had vision of $\frac{6}{6}$ or less, 87 had vision ranging from $\frac{7}{6}$ to $\frac{12}{6}$ while one had still higher visual acuity. Of 244 children's eyes (122 individuals) examined, only seven had vision of $\frac{6}{6}$ or less, 123 had vision ranging from $\frac{7}{6}$ to $\frac{12}{6}$ and 114 from $\frac{13}{6}$ to $\frac{15}{6}$. In Murray Island among 46 children, tested by a slightly more difficult method, there was no case of subnormal vision, 15 had vision ranging from $\frac{6}{5}$ to $\frac{10}{5}$, 30 from $\frac{11}{5}$ to $\frac{15}{5}$, and one had still more acute vision, so that the vision of the Schreiberhau children seems to have been distinctly inferior to that of the Papuans.

In 1883 Schadow[2] examined 146 children on the East Frisian island of Borkum. Unfortunately he carried out his investigations in a room and used the ⊏ type only for the younger children, and Snellen's letters for the older children. His results therefore are far from comparable with those already given. He found vision of $\frac{7}{5}$ in 91·8 per cent. but did not test for higher degrees of visual acuity.

Most extensive observations have been made with the E method in the open air in the German army and navy by Cohn[3], Seitz, and Seggel[4], which appear to be exactly comparable with those given in the table so far as method is concerned. From the ethnographical point of view, however, these observations are unsatisfactory in that they are made on selected members of the population. To show how far these figures must depart from a true representation of the whole community, I may mention that Seggel[5] found no less than 61·4 per cent. of volunteers and candidates for the German army had subnormal vision, while Seggel's figures given in the table show only 5·3 per cent. of cases of normal and subnormal vision. The results for the army are, however, very interesting in that they show the existence of considerable degrees of hyperacuity among Europeans and I have therefore included them in the table. It will be seen that the figures compare very favourably with those of Torres Straits and that cases of considerable hyperacuity are in a larger proportion. They show that if cases of subnormal vision are excluded there is no marked difference between the visual acuity of the average European and the Torres Straits Islander.

In the account of his observations in Egypt, Cohn[6] gives two tables comparing civilized with uncivilized vision (Naturvölker with Culturvölker), and has from these tables drawn the conclusion that there is no essential difference between the two groups.

[1] *Arch. f. Ophthal.* Bd. XVII. Abth. 2, S. 305. 1871. See also the paper on the observations in Egypt.

[2] *Klin. Monatsbl. f. Augenhlkde.* XXI. S. 150. 1883.

[3] *Deutsch. med. Wochenschft.* XXII. S. 698. 1896.

[4] *Münchn. med. Wochenschft.* XLIV. S. 1011. 1897.

[5] *Arch. f. Anthropol.* Bd. XIV. S. 319. 1883.

[6] *Berliner klin. Wochenschft.* S. 501. 1898. Also *Ztschft. f. Ethnol.* Bd. XXX. S. 263. 1898.

These tables are, however, open to very serious objections. Among the "Naturvölker," comprising only 238 individuals, Cohn has included the 100 Heligolanders, while the remaining 138 are made up of a number of small groups, the largest comprising 21 individuals, and some of these groups were examined by different methods.

The table of civilized people which Cohn gives for comparison contains the results for 2620 individuals, nearly all examined by the E method. Among these, however, Cohn includes his 164 Egyptians and also 140 Georgians, of whom Reich distinctly states in his paper that they were essentially "Naturleute." Further the 2620 individuals include no less than 2212 men either in the army or navy of Germany, and therefore a selected group from which cases of subnormal vision would have been excluded.

So far as present investigations have gone, the only results for European populations which are at all strictly comparable with my results are those obtained by Cohn in Heligoland. If the figures for the two groups are compared, it will be seen that the Heligolanders are distinctly inferior to the Papuans, the averages being as 1·77 : 2·12 and more than half the former have vision less than twice the so-called European normal, while more than half the latter have vision between two and three times the same standard. The difference, however, is not great and seems to show that European islanders living an outdoor, seafaring life do not differ very greatly in visual acuity from Papuan islanders whose life is also largely spent upon the sea.

Influence of sex.

It would be very interesting to know whether there is any marked difference between the sexes in a savage community in respect of visual acuity, but unfortunately I can contribute little to this problem as very few women were tested in Torres Straits. In Murray Island 13 girls, ranging from 10 to 17 years of age, were tested, their average visual acuity being $\frac{11\cdot4}{5}$. This is slightly above the average for 33 boys of Murray Island, viz. $\frac{11}{5}$. No case of subnormal vision was found and the maximum was $\frac{14}{5}$. There was certainly less variation than among the boys, but the numbers were not sufficient to allow one to speak very definitely on this point. The only woman tested in Mabuiag had acuity of $\frac{12}{5}$. The scanty data, so far as they go, tend to show that there was no marked difference between the sexes in Torres Straits.

Kotelmann's observations point in the same direction. Among the Sinhalese and Hindus tested by him 15 were male and 5 female. The average acuity of the former was $\frac{14}{6\cdot5}$, of the latter, $\frac{13\cdot9}{6\cdot5}$. Of the Kalmuks tested by Kotelmann 9 were male and 8 female. The average acuity of the former was $\frac{19\cdot9}{6\cdot5}$, of the latter, $\frac{16\cdot4}{6\cdot5}$, and one woman had visual acuity of $\frac{35}{6\cdot5}$ or more than five times the so-called normal.

Among the Egyptians examined by Cohn 22 were girls. Cohn does not give the individual observations or the average, but 12 out of the 22 had vision between 1·1 and 2·0. Three were between 2·1 and 2·5, while two others had vision of $\frac{20}{6}$ and $\frac{38}{6}$ respectively.

Among the Congolese examined by Pergens, on the other hand, the men were distinctly superior; 40 men had an average acuity of 2·62, while the average for 10 women was 2·0.

Further observations on this question are needed. The facts, so far as they go at present, seem to show that in a state of nature there is no marked sexual difference in visual acuity.

Influence of Age.

The relation between visual acuity and age is shown in Table II.

The numbers given in column *A* give the number of individuals of each age examined. Those in column *B* give the average number of metres at which No. 5 was recognized. In Murray Island, column *C* represents the results when any defect of refraction had been corrected (Cohn's *Sehschärfe* in the strict sense). Owing to

Table II.

Age	Murray Island				Mabuiag	
	A	*B*	*C*	*D*	*A*	*B*
above 55	5	4·6	4·6	0	2	7·5
50—55	6	8·1	8·6	2	2	10·5
45—50	7	7·3	7·9	3	3	8·6
40—45	8	7·7	8·1	5	4	10·2
35—40	13	9·9	10·3	4	4	11·5
30—35	9	13·6	13·6	6	4	14·0
25—30	8	11·0	11·0	8	4	13·5
20—25	5	12·0	12·0	12	2	14·0
15—20	7	12·1	12·6	9	4	12·8
boys under 15	33	11·0		4?	6	11·3
girls	13	11·4				

the rarity of errors of refraction, it will be noted that there is very little difference between the figures in the columns *B* and *C*.

Column *D* gives approximately the number of individuals of each age whom I failed to examine in Murray Island. The figures in this column show very clearly that the younger men were less fully represented than their elders (owing to their being away pearl diving), and, as already mentioned, the figures for visual acuity for this island are certainly lower than they would have been if the whole community had been examined.

The figures for both Murray Island and Mabuiag show a very distinct and progressive decrease of visual acuity from the age of 35 onwards. The agreement between the results for the two islands compensates in some measure for the small number of individuals of each age examined.

Among Europeans the decline in visual acuity is said to begin about the age of 50. The fact that it begins at an earlier age in Torres Straits is probably due to definite pathological changes, especially in the lens and cornea (see p. 10).

Fatigue and Practice.

In testing Europeans, especially in a bright light, it sometimes happens when near the limit of vision that the first three or four letters are recognized correctly, and then mistakes are made and the person tested may say that he is unable to see the letters any longer. This may only be due to glare in a bright light but in some cases it has seemed as if the mistakes were caused by some alteration of accommodation. This rapid change occurred very rarely in Torres Straits. When testing some Australian natives in Mabuiag, it seemed more marked, but I was unable to make up my mind whether it was not due merely to rapid falling off in interest.

The influence of practice is of more importance. We have at present no data to enable us to say whether the power of recognizing letters or the position of an E is influenced by long-continued practice. Very little experience with the E method is however sufficient to show that there may be a rapid improvement by practice. It has occurred to me over and over again that an individual has been unable to recognize the position of the E, say at 10 metres, but after trying at a nearer distance and then returning to 10 metres he has been right every time and may even have been able to give correct answers at 11 or 12 metres. This rapid improvement by practice is more common among Europeans than I found it to be in Torres Straits. From the results of my own experience when being tested by the method, and this has been confirmed by others, I believe the explanation to be that one can recognize the position of the E when it is merely a blurred spot if one notices that one side is slightly less definite than the others. I had previously met with cases in which individuals were right every time although they said that their answers were pure guesses. There can be little doubt that their correct guesses were due to the sensory indication afforded by the smaller degree of definition of the open side of the E, although they were not clearly conscious of the indication.

The fact that the position of the letter can be recognized correctly when it is merely a blurred spot has important bearings on the value of the method. In the first place, it shows that one must be very careful in drawing conclusions from this method as to the minimum visual angle. Cohn has stated that the Egyptian boy, whose visual acuity was $\frac{48}{6}$, distinguished at a visual angle of 7·5″, but since his success almost certainly depended on recognition of the kind described above, and since the whole letter subtended an angle of 5′, one cannot say that his visual angle was smaller than 37·5″. Conclusions as to the minimum visual angle from any of the customary methods of testing visual acuity can in any case only be rough approximations owing to the psychological factors involved in these methods.

In the second place, an element of uncertainty is introduced into the comparison of the results of different individuals and races. Two individuals with the same visual acuity may give different results with the E method owing to the fact that one may only recognize the positions of the letters when he sees them distinctly, while another may make use of the indication above-mentioned. I have already said that the natives of Torres Straits did not show the rapid improvement while being tested as commonly as do Europeans. This may mean that they failed to make use of this indication and only recognized the position of the E when they saw it distinctly or they may, with their quick observation, have noticed the difference in the blurred E at once. Unfortunately in the case of such people, one is unable to discover upon what sensory basis their answers depend. If the former supposition is correct, the method, as a means of testing visual acuity in the strict sense, would give too low values for such people, as compared with Europeans.

The fact that the position of a letter can be recognized when only a blurred spot is a distinct disadvantage of the E method, but this disadvantage may be very much lessened by using an E in which the middle limb has been prolonged so that it is of the same length as the upper and lower limbs, and I am now making observations to compare the results with the two forms of the letter.

Other methods of testing visual acuity.

In addition to the E method, three others were tried on beginning work in Murray Island. The great advantage of the E method soon became so obvious that the other methods were discontinued. These methods, however, brought out some points of interest which may be briefly considered.

Twenty-two natives of Murray Island (chiefly children) were examined with the ordinary letter test-types of Snellen. The general method was exactly the same as with the E method, observations being commenced at 15 metres, and then at nearer distances till No. 5 could be read correctly.

The method is unsatisfactory for two reasons; in the first place, mistakes were obviously made owing to unfamiliarity with the letters. Some children made occasional mistakes in some letters even when quite close to them, and this lack of familiarity is sufficient to prevent any satisfactory comparison of their results with those of the average European child. In the second place, the method is radically defective as a scientific method of testing visual acuity (however useful it may be as a practical clinical method) in that different letters differ greatly in the ease with which they can be recognized. It is consequently impossible to adopt any definite standard. Thus to give one instance, a fairly intelligent boy in Murray Island made four mistakes in No. 5 at 15 metres, three mistakes at both 14 and 13 metres; only one mistake at 12 metres but was unable to correct this mistake till 8 metres from the type. A more intelligent boy at 10 metres and at 9 metres made four mistakes; at 8 metres two mistakes and at 7 metres all were right. If one required every letter to be recognized, the

TABLE III.

Name	Age	E	Letters			Name	Age	E	Letters		
			3—4 mis-takes	1—2 mis-takes	All right				3—4 mis-takes	1—2 mis-takes	All right
Pasi	42	12		5		William (Tat)...	$11\frac{1}{2}$	15	10	3	
Charlie (Pasi)	17	8	betw	een $\frac{9}{9}$	and $\frac{9}{6}$	Abau	11	9			7
Sailor	$11\frac{1}{2}$	11		10	9	James	13	13	11	9	8
Captain	$11\frac{1}{2}$	14		11		Poi (Pasi)	13	12	12	9	8
Sam............	13	13		11	10	Depoma	10	11		8	7
Apori	14	9	7	6		Loko	9	8	7	6	4
Jimmy Rice	$12\frac{1}{2}$	18	14	12	8	Harry	$10\frac{1}{2}$	14	10		8
George (Pasi)	11	6			4	Nanai	10	12	10	8	7
Jacob (Gabi)	13	12	10	8	7	Aki	$10\frac{1}{2}$	7	6		3
Manowar......	11	11	9		8	Godaia............	13	14	11	10	
Tom (Tamu)	$11\frac{1}{2}$	10		9	7	Maletta (Joani)	$13\frac{1}{2}$	11		9	

acuity of these boys would have been put down as $\frac{8}{5}$ and $\frac{7}{5}$ respectively, although by the E method it was $\frac{18}{5}$ and $\frac{12}{5}$. The letter test would have wholly failed to show the great difference between them. In Table III. are given the results for the letter as compared with the E method. The figures given in the first of the three columns for the letter method show the distances in metres at which three or four mistakes were made, the second column those at which one or two mistakes were made, and the third column the distances at which all were read correctly. The unsatisfactory nature of the method will be at once apparent.

One fact which comes out very clearly, however, is that the distance at which letters could be read, even with a liberal allowance of mistakes, is much less than that at which the position of an E could be recognized.

The counting method.

Another method which I tried in Murray Island was Snellen's Table LIV., which seemed to me the most satisfactory of the methods which depend on counting. I used it under exactly the same conditions as the other tests, beginning observations at a distance of 15 metres. In this test the white dots may be exposed through a hole in a screen in numbers varying from 2 to 7. One fact soon became obvious, viz. the results for visual acuity if tested with groups of 2, 3 and 4 dots would give very different values to those with groups of 5, 6 and 7 dots, the difference in distance for the two sets of numbers being in some cases as much as 5 or 6 metres: thus Ulai, tested on two occasions, counted the groups of 2, 3 and 4 dots at 13 metres, while he was only doubtfully correct with the large groups at 8 metres. The same difference was present in the case of the boys, although they were taught arithmetic; thus Captain, aged 12, counted 2, 3 and 4 at 14 metres, and 5, 6 and 7 only at 8 metres. I only examined 10 individuals as the method seemed to me entirely worthless for the people in question. In Murray Island the power of counting is very poorly developed; in their own language they have individual words only for 1 (netat) and 2 (neis). By compounding these (neis-netat, neis-neis, neis-neis-netat, and neis-neis-neis) they obtained numerals up to 6, and beyond this they resorted to special methods of counting by the fingers and joints. At the present time they chiefly use English numerals. For such people, it is not surprising that a method of testing visual acuity which involves counting should prove to be unsatisfactory; but there are many other races in whom the power of counting is also very little developed, and in devising methods for ethnological purposes, it is of supreme importance that they should be capable of universal application.

A method in which the numbers to be counted should be limited to one and two was suggested by Mr Galton in a discussion at the Anthropological Institute in 1885, but this would involve a serious difficulty. Two dots close to one another would be seen at a certain distance as one linear object and only as two dots at a greater distance, and the results might be misleading. One individual would only say he saw two points when he distinctly discriminated the points, while another sharper individual might answer two as soon as he saw a linear instead of a punctiform object. I have tried this form of the test myself, and found that I could give correct answers for one and two dots (using Snellen's test-type) at a distance at which I was wholly unable to distinguish the two dots. The same difficulty is met with in observations on the discrimination of two points touching the skin: many individuals notice after a little practice that two points below the threshold often produce the same sensation as a linear or oval object, and they distinguish one from two points by this means although they do not distinctly experience two separate sensations. Among savage and half-civilized peoples it is impossible to discover upon what sensory basis a judgment depends and any opening for equivocal results of the kind should be avoided. As we have already seen, even the simple E method used in Torres Straits is not wholly free from this objection.

Guillery's method.

From the physiological point of view the most satisfactory method of testing visual acuity is that proposed by Guillery[1]. In it psychological factors are reduced to a minimum and any opening for the kind of equivocal result just considered is entirely done away with. This method depends on the visibility of a black dot on a white ground; the distance is found at which a black dot of a certain size situated in a square space is no longer distinguished from the ground. There are two theoretical objections to it; one is that if visual acuity is defined by the angle at which two points can be distinguished, this method does not measure visual acuity in the strict sense. The other objection is that the power of distinguishing one object depends so greatly on its luminosity. We see a star although the visual angle which it subtends must be infinitely small. This objection is, however, of more theoretical than practical importance. Under all ordinary circumstances the visibility of a black dot on a white ground is not more affected by illumination than is that of other objects used for testing visual acuity.

I had a set of Guillery's test-types with me and used them in a few cases with satisfactory results, but was unable to use them in any large number of cases owing to two disadvantages in the present form of the types. In the first place the two rows of No. 5 were so close to one another that there was occasionally doubt as to the square which was being indicated. In the second place the dots are placed either in the middle or in one corner of each square, and the individual under examination is required to give the position of the dot. There was only one blank square in each row. It is obvious that this method would lead to difficulties in respect of language and the only method which I found practicable was to give the native an empty square in which he had to mark a dot in the same situation as occupied by that in the square to which I was pointing. This method was necessarily laborious and I only made sufficient observations to satisfy myself that the method would be satisfactory if modified for ethnological purposes. This might be done on the same lines as those on which Cohn has modified the E test, either by having a large number of squares at some distance from one another with a large proportion of blank squares interspersed among the others, or by exposing squares with and without dots through an aperture.

The power of distinguishing stars might be a useful test of visual acuity in the absence of other objective tests. Extraordinary instances of powers of discrimina-

[1] *Arch. f. Augenhlkde*, Bd. XXIII. S. 323. 1891.

tion have been recorded in Europeans; thus Humboldt[1] records the case of a man who could see with the naked eye the satellites of Jupiter, and other similar cases are said to have occurred. There was no doubt that the natives of Torres Straits could distinguish stars of low magnitude well. Several men made for me drawings of constellations (*i.e.* their own constellations), but these were obviously to a great extent conventional and could not be regarded as evidence of what they really saw. Two men who made drawings of the Pleiades agreed in giving eleven stars grouped in very much the same way, but their drawings were almost certainly conventional. The subject is worthy of further investigation, and drawings of various constellations made by members of different races might illustrate their powers of vision, although the differences of distinctness owing to atmospheric conditions would prevent any exact comparison. The Pleiades are especially useful in this respect owing to the interest which this group excites among so many savage races. The star "Alcor" in the tail of the Great Bear (of the 5th magnitude but obscured by its close proximity to Mizar) is said by Humboldt[2] to have been used by Arab and Persian astronomers as a test of visual discrimination.

Abnormal refraction of the eye.

Most of the natives who were found to have low visual acuity were tested for errors of refraction. In testing with glasses each eye was examined separately, but otherwise the conditions were the same as in the ordinary determination of visual acuity. The process was in most cases very tedious, and usually more than one day was necessary. The natives did not like being tested. They were always interested in anything in which they excelled, but disliked having their inferiority in any respect shown, and consequently I had more difficulty with this than with any other of my observations. Unfortunately it was not possible to determine the refraction by means of the ophthalmoscope or by retinoscopy.

Hypermetropia.

Slight degrees of hypermetropia have been described as the normal condition of the child and of the savage. Cohn[3] found that 77 per cent. of the 240 children of the village of Schreiberhau showed manifest or facultative hypermetropia, while after the instillation of atropin, every child was found to be hypermetropic.

Similarly Callan[4] found 67 per cent. of the Negro children examined by him to have facultative hypermetropia. Nearly all the Lapps, Patagonians, Nubians and Kalmuks tested by Kotelmann[5], were hypermetropic in one or both eyes, to amounts varying from ·25 to 2·0 D.; of the 23 Sinhalese and Hindus, 13 were hypermetropic, the amount varying from ·25 to ·75 D.

Schött[6] found six Chippeway Indians to have slight hypermetropia.

[1] *Kosmos*, 1850, vol. III. S. 112. [2] *Ibid.* S. 65.
[3] *Arch. f. Ophthal.* Bd. XVII. Abth. II. S. 305. 1871. [4] *loc. cit.* [5] *loc. cit.* [6] *loc. cit.*

Abelsdorff[1] found that some Kirghises and Togo Negroes examined by him had slight hypermetropia.

Pergens[2] notes that two of his Congolese had at least one diopter of hypermetropia.

High degrees of hypermetropia, on the other hand, have not been recorded except in one Lapp woman examined by Seggel.

Of the cases of subnormal vision examined by me in Murray Island none were hypermetropic; all had distinctly worse vision with convex glasses.

I tested several of those who had the most acute vision without any decided result. When placed at their limit of vision some saw distinctly worse with a + 1 D. lens, while to several + 1 D. made no appreciable difference, and when the natives were placed slightly outside their limit there was no obvious difference in the number of letters recognized correctly with and without a convex glass. Unfortunately I had not with me a convex glass of less than one diopter, and the fact that the vision of some was certainly not diminished, renders it probable that slight degrees of hypermetropia existed in Murray Island.

Myopia.

Myopia appears to be very rare among savage peoples. As long ago as 1843, Furnari[3] noted that it was almost unknown among the Kabyles and other races of Algeria. Cohn[4] found that of the 17 Nubians examined by him in 1879 one was myopic—being the only member of the party who could read Arabic. Kotelmann, Seggel and Pergens[5] found no case among the Kalmuks, Sinhalese, Hindus, Lapps and Congolese examined by them. Abelsdorff[6] found one Javanese myopic to the extent of one diopter. Guppy[7] found that one of his Solomon Islanders was probably myopic.

In school children belonging to various races, myopia appears to be more frequent. Callan[8] found myopia in 2·6 per cent. of the Negro school children he tested. Webster Fox found it in 2·4 per cent. of his American Indian children. Roberts[9] examined 6163 school children in Buenos Aires and found 4·2 per cent. myopic.

In Mexico Ramos[10] found that of the children attending the superior schools who were mostly of European parentage 19 per cent. were myopic, while only 4·4 per cent. of the half-castes and ·3 per cent. of the children of the indigenous inhabitants had this defect.

Among the Japanese, myopia appears to be very common. Stephenson[11] quotes results obtained by Berry by examining 1410 men of Kioto of whom 33·2 per cent. were myopic. Stephenson also gives reports from the public school reports of Yokohama,

[1] *Klin. Monatsbl. f. Augenhlkde*, XXXVI. S. 330. 1898. [2] *loc. cit.*

[3] *Annales d'oculistique*, T. X. p. 145. 1843. [4] *loc. cit.*

[5] *loc. cit.* Seggel also examined 8 Fuegians with the ophthalmoscope; all had normal refraction, but one had an atrophic crescent which is usually associated with myopia. He also records that Schött found the same condition in one of his Chippeway Indians, who was also emmetropic.

[6] *loc. cit.* [7] *loc. cit.* [8] *loc. cit.* [9] Quoted by Cohn.

[10] *Verhandl. d. X. internat. med. Congress Berlin*, Bd. IV. Abtd. X. S. 79. 1890.

[11] *Mittheil. d. deutsch. Gesellsch. f. Natur- und Völkerkunde Ostasiens in Tokio*, Bd. VI. S. 190. 1894.

showing 5·4 per cent. of myopia. Reich[1] found that myopia was as common among Armenian and Georgian children as among Russians.

Several men and boys in Murray Island were improved by concave glasses.

Groggy, *aet.* 35—40,

R. eye $V = \frac{5}{20}$. With -3 D, $V = \frac{5}{6}$.
L. eye $V = \frac{5}{10}$. With -2 D, $V = \frac{5}{5}$.

Komaberi, *aet.* 50—55,

R. eye $V = \frac{7}{5}$. With -1 D, $V = \frac{11}{5}$ nearly.
L. eye $V = \frac{7}{5}$. With -1 D, $V = \frac{10}{5}$ nearly.

Canoe, *aet.* 45—50,

R. eye $V = \frac{6}{5}$. With -2 D, $V = \frac{8}{5}$.

Sisa (Caesar?), *aet.* 45—50,

L. eye $V = \frac{5}{10}$. With -1 D, $V = \frac{5}{5}$.
For right eye, see p. 39.

George (Pasi), *aet.* 11,

R. eye $V = \frac{5}{5}$. With -1 D, $V = \frac{9}{5}$ nearly.
L. eye $V = \frac{6}{5}$ nearly. With -1 D, $V = \frac{10}{5}$.

Charlie (Ako), *aet.* 11,

R. eye $V = \frac{6}{5}$. With -1 D $= \frac{10}{5}$.
L. eye $V = \frac{6}{5}$.. With -1 D $= \frac{10}{5}$.

This boy had a distinctly myopic appearance and had been especially noticed by Mr Bruce, as having defective eyesight.

Aki, *aet.* 10,

$V = \frac{7}{5}$, improved slightly by -1 D.

Two young men, Meiti and Loko, had vision with the E test which must be regarded as subnormal, viz. $\frac{7}{5}$ and $\frac{6}{5}$, but unfortunately I was not able to test them with glasses. I have little doubt that they were myopic or astigmatic. One boy, German, a younger brother of Meiti, has vision of $\frac{8}{5}$, but I was also unable to test him with glasses.

In some of the above cases the improvement by a concave glass was very slight, but in each case there was no doubt that they read better with than without the glass. There were other men whom I tested with glasses without bringing about any improvement, but the observations were difficult and often unsatisfactory, and I therefore refrain from giving the percentage of myopia in Murray Island. The condition certainly existed, but only in slight degrees and in a few individuals.

[1] *Arch. f. Ophthalm.* Bd. xxiv. Abth. iii. S. 231. 1878.

Astigmatism.

Very few cases of astigmatism have been recorded: Callan[1] found 5 cases in 456 children. Ramos[2] found 3·2 per cent. among the children attending the superior schools in Mexico, ·5 per cent. among half-caste children, and no case among 300 indigenous children. Seggel[3] found hypermetropic astigmatism in one Lapp girl.

Oliver[4] states "astigmatism of no mean degree" has been found among Amerinds (American Indians), but unfortunately he gives no reference and I have been unable to find upon what evidence his statement depends. Of 250 Indian children examined by Webster Fox[5] only 3 were astigmatic.

Abelsdorff[6] examined 35 Kirghises and 10 Negroes from Togoland with the ophthalmometer and found twenty of the former and three of the latter free from corneal astigmatism. In the astigmatic cases, the vertical meridian was the more convex, as is most frequently the case among Europeans.

Several cases of astigmatism were discovered in Murray Island. One of the many advantages of the E method is that it often enables one to detect the presence of astigmatism. In many cases I found that ш or m were recognized at a greater distance than E and Ǝ, and *vice versâ*, and some of these on examination with glasses were found to have measurable astigmatism. In other cases the differences in the correctness for the two directions were slight, and I think it probable that in these the answers indicated a slight degree of astigmatism which I could not improve by means of glasses.

One point of interest is that a measurable amount of astigmatism may exist with power of vision above the normal; thus, Charlie Pasi, aet. 17, read no. 5 E at 8 metres, while at 9 metres he gave wrong answers in the vertical positions only. I tried him with glasses, and with − 1 D. cyl. ax. vert., he was right every time at 11 metres. The only other simple case was one of myopic astigmatism, viz., our servant Debe Wali, aet. 35—40, whom I tested on various occasions, when he varied between $\frac{6}{5}$ and $\frac{7}{5}$; with − 2 D. cyl. ax. vert., his vision was $\frac{9}{5}$ and very nearly $\frac{10}{5}$.

Three men were improved by combining spherical and cylindrical glasses.

Barsa, a good observer, aet. 35—40, could only read no. 5 E at 4 metres; with the left eye alone he made mistakes at this distance. With − 2 D. sph. he recognized ш and m at 7 metres, but made mistakes in the horizontal positions; with − 2 D. sph. c̄ − 1 D. cyl. ax. vert. his vision became almost $\frac{8}{5}$ with each eye. On testing again without glasses he could not recognize no. 5 correctly at 4 metres.

Another man who probably had compound myopic astigmatism was Magi, aet. 40—45. His unaided vision with each eye was only $\frac{5}{10}$. With − 2 D. sph. he could read E and Ǝ of no. 5 correctly, but not ш and m. With − 2 D. sph. c̄ − 1 D. cyl. ax. vert., his vision was $\frac{6}{5}$ with the right eye, and almost $\frac{7}{5}$ with the left eye.

Sisa, aet. 45—50, was more doubtful. His left eye was probably myopic and

[1] *loc. cit.* [2] *loc. cit.* [3] *loc. cit.*

[4] Norris and Oliver's *System of Diseases of the Eye*, vol. IV. p. 410. 1900.

[5] *Philadelphia Med. Times*, vol. XII. p. 346. 1882.

[6] *Klin. Monatsbl. f. Augenhlkde*, XXXVI. S. 330. 1898.

has already been mentioned. With his right eye his vision was $\frac{5}{10}$, mistakes being made chiefly in the verticals. With -2 D. sph. $V = \frac{5}{5}$ nearly, the verticals being again mostly wrong. With -1 D. sph. $\bar{c}$ -1 D. cyl. ax. vert. $V = \frac{6}{5}$. On his left cornea there was a distinct nebula, partly obscuring the pupil and there was probably slight change of the same kind on his right cornea. The improvement by glasses was less definite than in most other cases, and taking into account his corneal condition, one is hardly justified in saying positively that his refraction was abnormal.

It is known that pterygium sometimes affects visual acuity by distorting the cornea, but this did not appear to have happened in any case in Torres Straits. The four men in whom the condition was most marked, viz. Papi and Billy Gasu of Murray Island, and Gizu and Wame of Mabuiag, had visual acuity of $\frac{9}{5}$, $\frac{12}{5}$, $\frac{10}{5}$ and $\frac{12}{5}$ respectively.

Visual acuity in feeble illumination.

In his book on the Solomon Islands Guppy notes that the natives of those islands did not appear to experience the temporary derangement of vision on passing into their dark houses which occurs with Europeans. In other words he believed that their eyes became adapted to darkness more rapidly than that of the European.

It is obvious that observations of this kind may be misleading. The familiarity of the natives with the contents of their houses would enable them to move about and find objects with a freedom which might suggest a greater power of vision than they actually possessed. I endeavoured to investigate this question experimentally but, owing to the unsuitability of improvised apparatus, without any definite result.

It is a familiar fact that the sensitiveness of the eye to light increases greatly on staying in the dark or in low illumination for some time, and the nature and amount of this increase has been carefully studied in the European eye. The condition of increased sensitiveness is known as dark-adaptation. One has to distinguish between several problems: (i) the determination of the threshold for light, *i.e.* the smallest amount of light which can be seen at all; (ii) the determination of the threshold for form, *i.e.* the smallest amount of illumination which enables the form of an object, such as a letter, to be recognized; (iii) the determination of the rapidity with which the dark-adaptation takes place which enables one to see light or form in a given feeble illumination. It has been stated that some races see better in the dark than Europeans, *i.e.* their thresholds for light or form are lower. It was, however, with the third of the above problems that Guppy's observations were concerned and it was this problem that I endeavoured to investigate. I endeavoured to determine the time which elapsed from the time the head was put into a dark chamber to the time when a letter or group of letters within the chamber were recognized. The letters used were cut out of No. 5 Snellen's test-types and pasted on a small square of white paper. I used a portable dark chamber which we had with us for photographic purposes and I placed the letters on the floor of this. The chamber was not sufficiently dark and I had therefore to cover part of it with a blanket. The chief factor which prevented the observations from being satisfactory was change in the external illumination (daylight). The observations were made on three boys, Apori, James, and Sagigi, while for comparison, observations were made by Dr Haddon and myself. It certainly seemed as if the boys were able to recognize the letters decidedly more rapidly than either Dr Haddon or myself, but I should not like to lay any great stress on the results owing to the imperfections of the method. One set of observations may, however, be given as an example.

Aug. 9th, afternoon. Dr Haddon, the letter *Z*.

After 2 min.	45 secs.,		saw a glimmer on the floor of the chamber.
" 4 "	0 "		saw sharp line, edge of white patch.
" 6 "	0 "		saw black blur in the middle of the white patch.
" 8 "	15 "		letter *G*.
" 9 "	30 "		white patch more distinct, can see that it is oblong.
" 10 "	30 "		letter *Z* seen, but not certain about it.
" 13 "	0 "		still not quite certain about letter.

Apori, letter *E*, external illumination rather duller than for Dr Haddon.

Seen correctly in 6 min. 40 sec.

Sagigi, letter *T* illumination rather brighter than for Apori, but about the same as for Dr Haddon.

Seen correctly in 2 min. 30 secs.

W. H. R. R., letter *R*.

7 min. first saw oblong white patch.
11 min. black blur in middle.
15 min. patch quite definite, can see that the letter is more or less square, probably either *Z*, *E*, *R* or *K*, but could not say which.

These observations were made on a dull day and were more satisfactory than those on bright days, as it was more easy to graduate the illumination of the dark chamber.

Although the method was not good enough to allow any definite conclusions to be drawn, the observations so far as they go support Guppy's belief that the eye of the Melanesian adjusts itself to the dark more quickly than that of the European[1]. Guppy believed that this was due to the larger size of the pupil in dark races but another explanation is much more likely. We have now reason to believe[2] that the increased sensitiveness of the dark-adapted eye depends on accumulation of visual purple in the rods of the retina. We know also that the formation of visual purple is closely connected with the pigment epithelium. In dark races there is reason to believe that the eye shares in the greater abundance of pigment, and it is quite possible that in deeply pigmented races visual purple may be formed more readily and more rapidly than in white races, and it is therefore quite conceivable that dark-adaptation should take place more rapidly. I regret very much that I cannot contribute more positively to the problem, but hope that its investigation may be undertaken again at some future time with more suitable apparatus than was at my disposal.

[1] In a recent paper (*Les Missions Catholiques*, 1898, p. 176) Guis states that the natives of New Guinea (Yule Island) can see nearly as well by night as by day.

[2] Schäfer's *Textbook of Physiology*, vol. II. p. 1101.

The visual acuity of Australians.

Observations were made in Mabuiag on the visual acuity of six Australian natives from the district of Seven Rivers on the East coast of the Gulf of Carpentaria. Four of these learned the method without any trouble, the other two were slower but still better than several men both at Saguane and Murray Island. The only other point which seems worthy of notice is that they seemed to fatigue more quickly than the natives of Torres Straits. The results from the six natives were $\frac{15}{5}$, $\frac{11}{5}$, $\frac{11}{5}$, $\frac{12}{5}$, $\frac{12}{5}$ and $\frac{14}{5}$, giving an average of $\frac{12 \cdot 5}{5}$. This average is higher than that obtained in Mabuiag, but this is probably due to the fact that all those tested were young, healthy men.

In all there was marked general pigmentation of the conjunctiva and one had a marked circumcorneal ring. There were slight conjunctival changes, but no case of definite pterygium. The palpebral fissure was narrow and not obviously different from that of the Mabuiag people.

The observations were made under exactly the same conditions as those under which the Mabuiag people were tested and, so far as any conclusion is justified from the few cases, one may say that there was no obvious difference between the two races. The ease with which most of them acquired the method and their general behaviour in connection with the testing gave me the impression that they differed little in intelligence from the average Torres Straits Islander and that they are far from being so low in the scale of intelligence as has been sometimes supposed.

Numerous writers have called attention to the sharpness of vision of the Australian aborigines, thus Lumholtz states that, though his own vision was twice as keen as that of the normal eye, it was usually impossible for him to discover bees even after the natives had indicated where they were. The bees were very small and yet the natives would see them flying to their nests in the trees as much as 30 feet above the ground. The powers of Australian natives as trackers are well known.

The only reference to previous exact observations on the vision of Australians which I have found is in a note on p. 24 of Spencer and Gillen's *Native Tribes of Central Australia*, in which it is stated that Dr E. Eylmann found the vision of the natives was not on an average better developed than in Europeans.

Visual acuity of Polynesians and Melanesians.

Six Polynesians were examined, five Samoans and one man from Niue or Savage Island. One Samoan boy was only examined with Snellen's letters and had vision of $\frac{7}{5}$. The five examined with the E test gave an average of $\frac{9 \cdot 8}{5}$ with a maximum of $\frac{12}{5}$. One boy in whom $V = \frac{6}{5}$ was almost certainly myopic, but was not tested with glasses. There were very slight conjunctival changes and little or no pigmentation, except in one Samoan who had in the left eye a large vessel running up to the cornea from below surrounded by pigment.

Two men, half Samoan and half English, were examined who had vision of $\frac{4}{5}$ and $\frac{10}{5}$

respectively. The latter had a very marked pterygium in one eye. One boy, half Samoan and half Mabuiag, had vision of $\frac{9}{5}$.

Only three Melanesians were examined. Two of these belonged to the island of Tanna, one had vision of $\frac{8}{5}$ and the other only $\frac{2}{15}$, owing to corneal opacities. The third came from the Lakon district of the island of Santa Maria in the Banks Group. His acuity was only $\frac{5}{20}$, and in the right eye he had an extremely well-developed pterygium, forming a large raised swelling, spreading down over the cornea to the bottom, where there was a good deal of ulceration. The pupil however was not obscured.

Nine half-castes were examined whose mothers belonged to the western tribe of Torres Straits, while the fathers were Melanesian, of these six were from Tanna, two from Uea in the Loyalty Group, and one from Sandwich Island in the New Hebrides. The average for the nine was $\frac{11 \cdot 2}{5}$. In two, $V = \frac{16}{5}$, and two were almost certainly myopic, one having vision of only $\frac{5}{10}$. All were between the ages of 12 and 25. The conjunctival changes were slight in all, but several had marked pigmentation, with a well-developed circumcorneal ring in two cases. It was among the boys in this group that I met most frequently with cases of learning the test by heart.

Conclusions.

The general conclusion which may be drawn from the preceding account is that the visual acuity of savage and half-civilized people, though superior to that of the normal European, is not so in any marked degree. There is no doubt that errors of refraction producing defect of vision, and especially myopia, are much more common among civilized people, but when this source of difference is excluded, the races which have so far been examined do not exhibit that degree of superiority over the European in visual acuity proper which the accounts of travellers might have led one to expect. It is true that exceptional individuals have been met with by Kotelmann and Cohn whose acuity distinctly exceeds anything that has ever been recorded among Europeans, but the general average has not shown the same superiority, and this is especially well marked in the observations made in Torres Straits where the results obtained are representative of complete communities.

Although the visual acuity (in the strict sense) of the Torres Straits Islanders was not found to be in any way extraordinary, their visual powers were, I think, equal to any of those which have excited the admiration and wonder of travellers elsewhere.

Travellers have repeatedly called attention to the way in which savages are able to distinguish birds among the thick foliage of trees, and the quickness of the natives of Torres Straits in this respect was very striking. The power of distinguishing boats at a distance was also remarkable. We usually found, however, that as soon as a native had seen a boat and pointed out its position to us we were able to see it, but while we could perhaps barely see the boat, the natives would describe its rig and in some cases knew what boat it was. Their visual accomplishments in this respect were obviously of a kind in which special knowledge would be of enormous importance.

The most striking visual feat which came under my notice occurred when I was sailing from Mabuiag into Thursday Island with three natives. Two or three weeks before, a new Government steamer had arrived in the Straits, which the natives could only have seen on one occasion. On turning a point of land at some distance from Thursday Island all three natives simultaneously shouted out and then told me that the steamer was in the harbour. At that time I could see nothing of the steamer, but when much nearer, found that there was a steamer on the far side of Thursday Island. The low-lying end of the island was between us and the steamer so that it was impossible that the natives could have seen more than the tops of the masts. The visual acuity of the best of these three men was $\frac{15}{5}$. We had been discussing the whereabouts of the steamer on our way and it is possible that the men only made a lucky guess, but from the unanimity with which they called out I have little doubt that they really recognized the presence of the vessel by seeing the tops of its masts from a great distance.

Ranke[1], who lived for some time among the Bakaïri of South America, has given a very interesting account of his experiences. On first going among the natives he regarded their visual powers as something wonderful, but after living among them for some time he says that the vision of the Indians lost its wonderfulness. He found that it depended very much on the knack of noting certain details and that, although myopic, he was able with practice to see and distinguish objects almost as well as the natives. Ranke is of opinion that the superiority of the savage is greatly due to practice in the adjustment of accommodation for distant objects, and believes from his own experience that with practice one can adjust accommodation for very much greater distances than is commonly supposed. The power of seeing birds in trees depends, according to him, in great measure on adjustment of accommodation. He also gives one instance which shows very well the great importance of special knowledge. He was at first astonished at the way the Indians could tell the sex of a deer at a distance which would have implied vision at an extremely small angle if the distinction had depended on seeing the antlers. After a time, however, he noticed the peculiar gait of one deer and this led to the discovery that the Indians distinguished the sex by a peculiarity of the gait of the male. Having once noticed this peculiarity he found that he was able to recognize the sex of a deer at as great a distance as could a native.

The instances which have been given will suffice to illustrate the special nature of the visual powers of those who live in a state of nature. We have at present very insufficient knowledge of the degree of visual acuity in Europeans with normal refraction, but so far as our data go it seems that the savage starts with visual acuity which is but slightly superior to that of the average normal-sighted European. By long-continued practice, however, in attending to minute details in surroundings with which he becomes extremely familiar, the savage is able to see and recognize distant objects in a way that appears almost miraculous, but it is doubtful whether his visual powers excel those of the European who has trained his vision to any special

[1] *Correspondenz-blatt. d. deutsch. Gesellsch. f. Anthrop.* S. 113. 1897.

end[1]. There is little doubt that the most acute sighted savage transferred to a Scotch moor would, in the unfamiliar surroundings, be a very poor match for the gillie, and, in fact, it has been found that the Australian tracker is of little or no use out of his own country[2].

The possible influence of accommodation which has been suggested by Ranke is a matter about which it is difficult to express any definite opinion. It is generally assumed by ophthalmologists that the amount of accommodation which takes place for distances greater than about 6 metres is negligeable. It is however possible that delicate gradations of accommodation may take place which adjust the eye to much greater distances than this, and there are a few facts which tell in favour of this view. There seems to be a certain amount of correlation between acuteness of vision and the development of accommodation. The visual acuity of some birds, as the hawks, etc., appears to be greater than that of the most acute sighted mammal, and in the hawks the alteration in the curvature of the lens, common to birds and mammals, is supplemented by a change in the curvature of the cornea. The range of accommodation, again, is greater in birds than in man[3].

The frequency of hypermetropia in savage races may also have some importance in this connection. It is one of the consequences of hypermetropia that accommodation becomes necessary even for the most distant vision. In the hypermetrope the mechanism of accommodation is always more or less in action, and it seems quite possible that with the more extensive use of accommodation, there may be associated a higher degree of delicacy of adjustment than exists in the emmetropic eye, and that by practice this may become in the case of the savage one of the causes of his superiority over the European.

There is no doubt that the savage is an extremely close observer of nature. In Torres Straits we were continually meeting with instances which illustrated the powers of the natives in this respect. Nearly every detail of landscape and seascape had its special name and nearly every species which the zoologist or botanist would recognize as distinct was also differentiated by the native and had its distinctive name. In the case of familiar plants, such as the yam or banana, there were many named varieties[4]. The same characteristic has been found to hold good for many other parts of the world.

Minute distinctions of this sort are only possible if the attention is predominantly devoted to objects of sense, and I think there can be little doubt that such exclusive attention is a distinct hindrance to higher mental development. We know that the growth of intellect depends on material which is furnished by the senses, and it therefore at first sight may appear strange that elaboration of the sensory side of mental life should be a hindrance to intellectual development. But on further consideration I think there is nothing unnatural in such a fact. If too much energy is expended

[1] The whole subject is illustrated in a very instructive manner in Baden-Powell's "Aids to Scouting." Those who wish to understand the visual powers of the savage cannot do better than read pp. 30 to 41 and pp. 51 to 77 of this book.

[2] See Oldfield, *Trans. Ethnol. Soc.* vol. III. p. 254. 1865.

[3] Pflüger's *Archiv f. Physiol.* Bd. LIII. S. 175. 1893.

[4] Sir William Macgregor states that the natives of Kiwai have 36 named varieties of banana, 20 of yams, and 10 of sweet potatoes, etc. *Ann. Rep. Brit. New Guinea C. A.*, 105, 1890, p. 40.

on the sensory foundations, it is natural that the intellectual superstructure should suffer. It seems possible also that the over-development of the sensory side of mental life may help to account for another characteristic of the savage mind. There is, I think, little doubt that the uncivilized man does not take the same æsthetic interest in nature which is found among civilized peoples. Ranke has made some interesting observations which help to explain this fact. Naturally a great lover of scenery, Ranke found after living in South America, learning to see things as the natives saw them, that he had lost his capacity for the æsthetic enjoyment of scenery; he found that individual objects forced themselves upon his attention and prevented his enjoyment of the scenery as a whole. He also found that, owing to the fact that he was continually attending to details, any one of which might be important, he was unable to devote attention to the more serious problems of life. Ranke's experience is strongly in favour of the view that the predominant attention of the savage to concrete things around him may act as an obstacle to higher mental development.

Observations with Masson's disc.

The sensibility to differences of brightness was tested by means of Masson's discs rotated on a colour wheel. In the ordinary form of these discs black patches of equal size are placed in a radial line on a white disc. When the disc is rotated, the disc shows a series of grey rings gradually diminishing in darkness from centre to periphery of the disc, and shading off till they become invisible. The just perceptible difference is determined by finding the faintest ring which can be seen.

The only account of previous ethnographical work on this subject which I have been able to find is that given by Schöler[1] of observations made on some Nubians in an exhibition in Germany. He found that some of these Nubians were able to distinguish fainter rings than Schöler himself in spite of the long practice of the latter in this kind of observation. One man could distinguish a ring which differed from the background by only $\frac{1}{291}$st, while the highest degree shown by Schöler himself was represented by $\frac{1}{235}$th.

In my observations, I used discs on each of which there was only one patch in a position which was unknown to the observer. For this purpose two parallel radial slits were made in each disc at a distance of from one to two millimetres from one another. A strip of black paper was then passed transversely through these slits so that on the front of the disc a narrow black patch was seen which could be placed at any distance from the centre. A series of six discs were used with the black patch at different distances from the centre. Unfortunately one of these was destroyed before I had determined the exact distance of the ring from the centre. The results with another disc were found to be unsatisfactory because the ring was too close to the periphery of the disc. On rotating a simple white disc and examining it carefully, as would be done in looking for a ring, the outer edge may often appear whiter than the rest (owing to contrast against the darker background), while inside this may be

[1] *Zeitsch. f. Ethnol.*, Bd. xii. S. 67. 1880.

seen a darker ring. If the objective ring is too near the periphery, these contrast effects may increase its darkness and deceptive results may be obtained. As a matter of fact, I have found that a ring may be recognized near the periphery which differs less in intensity from the background than one situated farther from the periphery of the disc.

The results given were obtained by means of 4 discs with rings differing in brightness from the background by the following fractions:—

No. 1 $\frac{1}{99}$. No. 2 $\frac{1}{166}$. No. 3 $\frac{1}{248}$. No. 4 $\frac{1}{334}$.

The method employed was to put No. 1 on the wheel, cover it in front and set the wheel in rotation. The native was then called up, the wheel uncovered and he was asked whether he could see a ring (gogob); if he said he could see one, he was given a piece of grass and asked to point out the position of the ring. He then went away out of sight and the operation was repeated with the same or another disc. Owing to the fact that the colour wheel was lost till near the end of our stay in Murray Island, I was unable to make as many observations as I should otherwise have done, but I was able to examine 24 individuals in Murray Island and Mabuiag, viz. 12 men, 11 boys and 1 girl.

No. 1 was seen by nearly all; the only failures were in the cases of the Mamus of Murray Island, whose sight was very defective; Smoke, who was always a careless observer, and two boys, who were also careless.

No. 2 was seen by five adults and four children.

No. 3 was seen by the same five adults and by two of the children.

No. 4 was seen quite definitely and on every occasion by only one man, Mabo. Another man, Jimmy Rice, located the ring correctly twice and failed in three other trials. He had seen No. 2 and 3 easily. Waria of Mabuiag only located the ring correctly on the first trial after searching the disc for a long time; in later trials he was twice right and twice wrong. Only one boy (Jimmy Rice, jun.) was right with this disc and that only on one occasion. He had seen No. 3, but not readily.

These results seemed to show that some of the natives had a much higher degree of sensibility than had been previously recorded for European vision. So far as I know no observations by this method have been made on a large scale on Europeans but the highest degree of sensibility which I have found recorded by those who have used this method for researches on Weber's law is represented by $\frac{1}{240}$th (Ole Bull[1]). In Torres Straits five adults and two children recognized a ring of about the same intensity as this, viz. $\frac{1}{248}$, and one Murray Island native could distinguish with ease a ring which only differed from the background by $\frac{1}{334}$th, while two other natives recognized the position of this ring two and three times in five. This degree of sensibility seemed to be so greatly in excess of what has been recorded among Europeans that I was inclined to be incredulous. On repeating exactly the same procedure since returning to England, I found that some individuals gave as good results as were obtained by Mabo of Murray Island. Of 23 individuals examined all could see No. 1, nine could

[1] *Arch. f. Ophthal.* Bd. xxvii. Abth. i. S. 67. 1881.

distinguish No. 2, eight distinguished No. 3 correctly, while no less than five could see No. 4. The 23 individuals examined had had no previous practice.

The discrepancy between these results and those of earlier observers may have been due to some feature of my method or it may have been that previous observations have been made on laboratory workers whose visual powers are below the average, or at any rate below that of many individuals.

One feature of my method was that the observer was allowed to come as close to the disc as he liked and to look in any direction he liked. This was done in order that the natives should be as free from constraint as possible and it was also necessary that they should be near the disc in order to be able to point out accurately the position of the ring. Other workers have seated their observers at a given distance from the ring. It is possible that this difference in procedure may have something to do with the smaller difference threshold which I have found.

It is more probable that there was some defect of the No. 4 disc which made the grey ring darker than it should have been, but I have not been able to satisfy myself as to the nature of this defect. For the present purpose it is sufficient that the Papuans tested have not shown any superiority over Europeans tested by exactly the same method and with the same discs, and I do not wish to lay stress on the absolute threshold.

The observations in Torres Straits brought out one further suggestive point. Mabo, who had the highest degree of sensibility among the men tested on Murray Island, was the native who had the highest visual acuity, viz. $\frac{19}{5}$. Jimmy Rice, who came next in order of sensibility, was also second to Mabo in visual acuity, viz. $\frac{17}{5}$. Of the boys Jimmy Rice, jun., who gave the best results with Masson's discs, had also the highest visual acuity, viz. $\frac{18}{5}$. These results suggest that there may be a close relation between visual acuity and the power of distinguishing differences of brightness as tested by means of Masson's discs, and I am making further observations with the aim of finding if the two conditions are correlated.

3. COLOUR VISION.

The colour vision of primitive races has excited interest mainly in its philological aspect and has been considered especially in relation to the hypothesis that there has been considerable modification of the colour sense of man within historical times. This question was first raised by Gladstone[1], who from a close study of the epithets for colour used by Homer came to the conclusion that the people of that age could have distinguished little more than differences of brightness and darkness. Geiger[2] later advanced the view that there had been a definite evolution of the colour sense in man; that at one period of his existence he had distinguished nothing more than differences of brightness; that red had been the colour first distinguished and that the discrimination of other colours had developed in the same order as that of the arrangement of the colours in the spectrum, the power of seeing blue and violet having been the latest to develop. These views of Geiger were based entirely on philological evidence derived from a wide study of ancient literature. He was supported by Magnus[3], also on philological grounds, but it was generally held that these writers were not justified in their conclusions and that the close relation between language and sense which these authors supposed to exist was far from being a fact. It was also found by Virchow[4] and others that savages might have exactly the same peculiarities of colour nomenclature which are found in ancient literature and might yet have a well-developed colour sense, while various theoretical objections to the views of Gladstone and Geiger were raised.

The controversy gave rise to an extensive literature[5] which it would take too long to consider here. It must suffice to say that Magnus[6] collected a large amount

[1] *Studies on Homer and the Homeric Age*, 1858, vol. III. p. 457.

[2] *Contributions to the History of the Development of the Human Race*, p. 48.

[3] *Die geschichtliche Entwickelung des Farbensinnes*, Leipzig, 1877.

[4] *Zeitsch. f. Ethnol.* Bd. x. 1878; Bd. xi. 1879.

[5] So far as I know, Bastian (*Zeitsch. f. Ethnol.* Bd. I. S. 89, 1869) was the first to call attention to the colour language of savage or barbarous races in its bearing on the controversy; while in addition to the papers of Magnus an important contribution was made by Andree (*Zeitsch. f. Ethnol.* Bd. x. p. 323, 1878).

[6] *Untersuch. ü. d. Farbensinn. d. Naturvölker*, Jena 1880, and *Ueber ethnologische Untersuch. d. Farbensinnes*, Berlin, 1883.

of evidence from existing races of mankind showing the same kinds of defect of colour language which are found in ancient literature and argued that these defects must have some definite basis, probably of a physiological nature. In general, however, the views of Gladstone and Geiger have been wholly rejected and it has been supposed that there is no necessary connection between colour language and colour sense.

One of the chief interests of the work described in this report is that it shows that defect in nomenclature for a colour may be associated with defective sensibility for that colour and so far lends some support to the views of Gladstone and Geiger.

Observations with Holmgren's wools.

I began the investigation of colour vision in Torres Straits with Holmgren's wools. The three test-wools used by Holmgren for the diagnosis of red-green blindness were supplemented by four others:—a bright green of about the same degree of saturation as Holmgren's red, a yellow, a blue, and a violet. The three latter wools were of medium saturation, the violet being rather less saturated than the others. Holmgren's wools are very deficient in yellow examples and in any set used for ethnographical purposes this defect should be remedied.

The seven test-wools were used in the following order:—red, green, pink, Holmgren's green, yellow, blue, violet. Red was selected to begin with owing to the familiarity of the natives with this colour and the consequent ease with which they were made to understand the process of matching. Whenever the matches with any wool were in any way abnormal the wool was repeated at the end of the series.

The natives understood what they were required to do very readily in most cases, and among over 200 individuals examined I only met with one man, a native of Kiwai[1], with whom there was any doubt as to whether he understood the process of matching. In some cases the natives would select a number of wools, and spontaneously arrange them in order of similarity to the test. When a number of wools were chosen which included one or more bad matches, the wools were laid out in a row, and the native was told that one wool was "no good," and was asked to pick out that wool. In other cases, the native was asked to pick out from those selected the wool most like the test, and then the next and so on, when in nearly all cases the faulty wool would be left till last; the latter procedure is more satisfactory, as one need not suggest that any of the matches are bad.

Care was taken to avoid the names of the colours as much as possible till after the matching was completed. There was a natural tendency to put together all the wools to which the same name was given, thus in Murray Island, Holmgren's green wool was often called kakekakek (white) or pipi (grey), and there was a tendency to place with it other unsaturated wools of any colour to which the same name would be applied. One could often hear a native saying "kakekakek" to himself as he picked up a colourless wool to place with the green, and there is no doubt that

[1] See p. 52.

this was a source of fallacy especially with the pale green and the violet tests. Every care was taken not to accentuate this tendency by mentioning the names of the colours, but there is no doubt that the difficulty must always exist in ethnographical investigations when colour nomenclature may be on a very different level to that of civilized races[1].

Another source of fallacy may be noted. The wools were often taken up into the hand as they were chosen, and in such a case the native was liable to match, not with the test, but with the last wool taken into the hand. Consequently after each wool had been chosen it was placed on one side.

In testing for colour-blindness, it is always important to record not only the actual matches made, but also any wools compared with the test, and I noted every wool which was even transiently compared with the test-wool. If this feature had been neglected, even the few cases which excited suspicion of colour-blindness would have been passed as absolutely normal.

In Murray Island 107 individuals were tested; 56 men, 7 women, 31 boys, and 13 girls.

The red wool was matched readily by all. As it was the first wool used, mistakes were made by several owing to misunderstanding, but in all these cases this wool was repeated at the end of the series. A considerable proportion matched it with saturated pink as well as with red wools. The bright green wool was matched readily; often blue-greens were matched with it, and in a few cases almost pure blue wools. The pink wool (Holmgren's test) was matched very readily by all, though the majority refused to take pink wools if much less saturated. Two young boys picked up and compared a green wool, but I was quite satisfied that this was only due to carelessness. The pale green wool (Holmgren's test) was matched correctly by the majority, but in a large number of cases it was matched with a number of bluish or violet wools of about the same saturation, while seven individuals matched it with neutral wools with a faint pinkish tinge. The yellow wool was matched correctly by nearly all. Two men and five children matched it with reddish wools. One man and three boys compared this wool with blue wools. One boy was one of those who compared pink and green and both his comparison and that of the other boys I believe to have been due to carelessness, but the man (Mapoali) did the wools otherwise so well that this abnormality appeared very strange.

The blue test-wool was matched by 27 individuals with violet as well as with blue or bluish green wools. One man matched it with an almost colourless wool and another with a brown wool. This man (Ekede) also compared the blue with a yellow wool. The violet wool was matched or compared by 12 with neutral wools and by 14 with distinctly reddish or pinkish wools. One boy (Depoma) matched it with a brown wool, and the Mamus matched it with a blue and a green wool of about the same saturation, calling all "kakekakek."

[1] In some more recent work in Egypt, I have found that this tendency to match wools to which the same name is applied may, in some cases, lead to results which make it impossible to decide whether an individual is colour-blind or not by means of Holmgren's wools alone.

The most definite result of these observations was that there was no red-green blindness. The matches made with the pale green wool might be regarded as evidence of this defect, but I have no doubt that the matches with neutral or even faintly pinkish wools were due to the influence of language to which I have already referred. No single individual matched, or even transiently compared Holmgren's pink wool with blue or violet, the most frequent confusions which occur in red-green blindness.

The fact that the violet test-wool was matched by no less than 14 with pinkish wools might also be regarded as suspicious, but I have little doubt that it was not due to any weakness for red. Confusion between pink and violet may be due to insensitiveness to red, but it may also be due to insensitiveness to blue, and in the case of these people the latter was the probable cause[1].

Confusion between green and blue was very common and also between blue and violet, and there was obviously much more imperfect discrimination with these colours than in the case of red.

There was more reason to suspect the existence of yellow-blue blindness, rare as that condition is among Europeans. Two men compared yellow and blue wools though they did not actually match them, and several children made similar errors. One man matched blue with a brown wool. The other tests of these individuals were not, however, of the kind that would be made by cases of yellow-blue blindness, and I believe the explanation, so far as the confusion was not due to carelessness, to be that the yellow test-wool used by me was a dull yellow while blue was also regarded by them as a dull colour (see p. 55). The men who made the comparison of yellow and blue were not people with whom I had much to do, and I had considerable difficulty in getting one of them to understand the E method when testing visual acuity.

These observations become of importance in connection with the fact that Schöler[2] described a Nubian examined by him in Berlin as probably yellow-blue blind. This man confused red and orange with purple; blue with yellow and grey, and yellow with blue and grey. The mistakes made by this man were much more faulty than anything that was done by any Torres Straits natives, but it is noteworthy that the suspicious cases met with in Murray Island made mistakes in the same direction as Schöler's Nubian. The subject is one of great importance, for it would be very remarkable if yellow-blue blindness, so rare among Europeans, should be present in other races. I may mention here that I later met with cases of red-green blindness among natives of Lifu and the condition was so marked in them that there could not be the slightest room for doubt, while the suspicion of yellow-blue blindness in Murray Island was only based on transient comparison of unlike wools. I believe that the tendency to confuse blue and yellow was due to the cause I have already mentioned, but I do not feel the same confidence in denying the existence of some defect as regards these colours which I feel in the case of the common form of colour-blindness.

Twenty-eight individuals belonging to the western tribe of Torres Straits were

[1] The wool was unsaturated and the faulty comparisons or matches were probably also in part due to the influence of language. When asked the name of the violet test-wool, it was usually called kakekakek (white), and occasionally kebe mamamamam (little red).

[2] *Zeitsch. f. Ethnol.* Bd. XII. S. 59. 1880.

examined. Of these 22 belonged to the island of Mabuiag or Badu, four to Muralug, one to Moa, and one woman to Saibai. Of the 22 individuals from Mabuiag and Badu, 15 were men, six boys, and one a girl.

The general results closely resembled those of Murray Island. The matches with the red wool were normal except that eight matched with pink as well as red. The pale green wool gave, as in Murray Island, doubtful results; eight individuals matched it with bluish wools, four with violet wools, and four with very faint pink wools, but in all cases the wools chosen were very pale, and I believe that the matches were influenced by nomenclature; thus Mengoi, who matched this wool with neutral, yellow, violet and pinkish wools called all miakalunga (white). Violet was matched by nine with colourless or almost colourless wools, and by three with pinkish wools. Blue and violet were also confused.

There was no single case of suspicious matching or comparison of the pink test with blue or violet, while the behaviour in matching with blue and violet was consistent with some degree of insensitiveness to these colours.

Seventeen individuals, all males, were examined belonging to the Fly River district of New Guinea. Thirteen of these belonged to the island of Kiwai (Ipisia eight, Saguane one, Mabudame three, Sumai one), two came from Mawatta on the mainland of New Guinea, one from the island of Parama and the locality of the remaining man was doubtful.

Red was matched with pink by eleven men. The matches with the pale green wool resembled those in Murray Island and Mabuiag. Yellow was matched by one with a greenish-blue, blue was confused with violet by nine, while violet was matched by three with blue, by two with greenish wools, by four with neutral wools, and by two with pinkish wools. The most noteworthy feature was the large proportion who confused red with pink, while confusion of green, blue and violet was more common than elsewhere. It will be noted that one man confused yellow and blue-green wools. When, however, this man was told that one of his wools was bad, he at once picked out the blue-green wool from the rest and rejected it.

It was in Kiwai that I met with the only individual, a man named Emabogo, who failed to understand the method of matching although he had seen others doing it correctly. Many of the wools he picked up were consistent with his being red-green blind, but from his behaviour I came to the conclusion that he failed to understand the method. I also failed to render the method of testing visual acuity intelligible to him (again the only case of failure). It is, however, just possible that he was colour-blind, and it was very unfortunate that, owing to the shortness of our stay in Kiwai, I was unable to examine him again. I may mention that he gave the names of colours fairly correctly except that he first called blue dogòdogò (red) before calling it wibu-wibuna (the customary name).

Altogether, in Torres Straits and the Fly River district of New Guinea, 152 individuals were tested of whom 130 were males. With the just possible exception of Emabogo, there was not a single case of red-green blindness, although this condition exists in about 4 per cent. of the male European population. This can hardly be due to chance, and I think the number examined is sufficiently large to justify one in saying that this form of colour-blindness is either absent[1] in this race, or much rarer than among European populations.

Colour nomenclature.

The names used for colours were next investigated. I first obtained the names of a set of papers sold by Rothe, of Leipzig, which are now so largely used by workers on colour vision that they may be regarded as standard colours. The set includes the following:—red, orange, yellow, yellow-green, green, blue-green, blue, indigo, violet, purple, white, and two blacks. I also used some grey papers sold by Rothe, and I obtained the names of the test-wools and of various brown wools, and often asked the names of the colours of various objects. A few colour names were only obtained when working with the tintometer or when showing contrast colours[2]. It is important in collecting colour vocabularies to use more than one method. It is very dangerous to trust to the names of the colours of natural objects, as it sometimes happens that the colour of a given object may have a special name which is not applied to that colour apart from the object. I obtained the names for colours from a large number of individuals independently of one another, and then compared the different lists and questioned some of the older natives when discrepancies were found[3]. Often lively discussions were started among the natives as to the correct name of a colour, and I always endeavoured to profit by these. It was found that the names of the colours could only be satisfactorily obtained from the older men. The children hardly knew the names at all, and the young men were little better, while even middle-aged men would sometimes say that they did not know the names properly and wished to consult older men. Even in so simple a matter as colour nomenclature native knowledge is rapidly being lost.

The women did not appear to know the names of colours as well as the men and they were also less critical about shades when being tested with Holmgren's wools. One somewhat ludicrous incident occurred in getting colour names from one elderly woman in Murray Island. She gave me names which I had received from no other native. On going through the papers a second time her names were fairly consistent with those first given, and she thought seriously about each colour and was evidently not giving names at random. I discovered that she had given me her own name for the first colour shown her, and for the other colours had given the names of her friends. The names she gave were almost certainly dependent on associations of some kind, probably connected with dress.

In Murray Island red was called mamamamam by all. Purple and pink were called

[1] Additional evidence against its presence will be given in the account of observations with Lovibond's tintometer.

[2] The three green papers of Rothe were so much alike that I had intended to use only one of them, but I soon found that they were readily distinguished and were given different names by many.

[3] I also asked some of the men to pick out all the wools and show me objects to which they would apply a given colour name.

kĕbĕ mamamamam (little red) by many, in which cases the red paper was often called au mamamamam (big red). One man, however, reversed these names. Another name often used for pink and purple was kiamikiam, and these colours were also called ĕrŏko-mamamam, and sŏmer-mamamam.

Orange was called bambam by nearly all, but it was called mamamamam or kebe mamamamam by a few. It was also occasionally called mòsiu. One called it mairmair.

Yellow was called bambam by most; siusiu by a good number, more rarely giazgiaz or zomkolberkolber and sunursunur by one.

Yellow-green was called soskĕpusoskĕp by the majority; also giazgiaz, gausgaus, and lulam gimgam. A few called it suserisuseri. One man called it bambam golegole (yellow-black), and one young man called it karem gausgaus (seagreen), pointing at the same time to the position of a large reef over which the shallow water had very much the same colour as that of the paper.

Green was called soskepusoskep by most; also gausgaus, lulam gimgam, suserisuseri, giazgiaz, and kebe siusiu (little yellow).

Blue-green was called by the same names, suserisuseri being rather more common. It was also called ogog siusiu (dirty yellow).

Blue was called bŭlu-bŭlu, golegole, suserisuseri, gausgaus, giazgiaz, lulam gimgam, akòsakòs, and soskepusoskep.

Indigo was called either bulubulu or golegole with much more unanimity; by a few it was called suserisuseri and by two or three individuals karem golegole (sea-black).

Violet was called golegole or bulubulu golegole; also akòsakòs, kupekupe (dark), kiamikiam, suserisuseri, golegole suserisuseri, kebe mamamamam (little red) and mamamkakekakek (red-white).

White was called kakekakek by the great majority; also zazerzazer, and giaudgiaud.

Deep black was called golegole or au golegole; one man called it kukikuki.

Dull black was called golegole or kebe golegole; also, pipi, pipi golegole, kobegud, budbud and ogog.

One grey (162° W + 198° Bk)[1] was called kakekakek, kebe kakekakek, pipi kakekakek, or pipi zazerzazer.

A darker grey (49° W + 311° Bk) was called pipi, kobegud or golegole. The name applied to a given grey depended a good deal on the paper which had been previously shown. If the previous one had been white or a light grey, a dark grey might be called golegole, while if shown after black the same grey would be called pipi. Holmgren's pale green test-wool was called kakekakek, pipi, kebe bambam, zazerzazer and zomkolberkolber. The violet test-wool was called pipi, kakekakek, zazerzazer, kebe mamamamam, and occasionally golegole.

Brown wools were called kebe mamamamam, kebe bambam, pipi, golegole, akòsakòs, according to their prevailing tone and shade.

It will be seen that there was great definiteness and unanimity in the nomencla-

[1] i.e. a grey matched by mixing 162 parts of white and 198 parts of black on the colour wheel.

ture for red, rather less so for orange and yellow, less so for green, and very great indefiniteness for blue and violet. Soskepusoskep was evidently the most definite word for green, while the word used most frequently for blue and indigo was bŭlubŭlu, which was the English word reduplicated and with the contiguous consonants separated. The old men agreed that their own proper word for blue was golegole (black), and they regarded it as quite natural to apply this name to the brilliant blue of the sky and sea.

Differences of brightness and saturation were chiefly named by means of the words au (big) and kebe (little): debe (good) and wit (bad) were occasionally used in the same sense. Ogog (dirty) was also used sometimes for less saturated colours. Dudu was also occasionally used for slightly saturated colours and for dull black, but I do not know the usual meaning of this word.

The word which gave me most difficulty was akòsakòs. I first met with it as a name for blue: later as a word for brown, and I was at one time inclined to think that it might be a word for the latter colour, but it was certainly used also for blue and violet and I believe that its correct translation would be "dull," as opposed to brilliant or bright. In the observations made with the tintometer akòsakòs was occasionally used as a word as qualifying other colours, thus a faint yellow glass was called akòsakòs bambam.

It is possible that this word may furnish a clue to the tendency to compare blue with brown or dull yellow (see p. 51); it is possible that the natives who confused these colours may have thought of them both as akòsakòs.

The word "sunursunur" evidently meant "bright." It was used occasionally for bright colours such as yellow. They apply this word to the colour of the skin of the white man as opposed to that of their own (golegole), and they also use it for those natives who are lighter in colour than the rest, for cases of partial albinism and for half-castes. It was never used spontaneously for white, but they would agree that white and other bright objects were all sunursunur[1]. Another word, zoromzorom, apparently meant bright or glittering.

The word "kupekupe" probably means "dark," but it is now used by the missionaries as a word for dark in the sense of wicked, and was only used as a name for a dark colour by one or two women.

Particoloured objects were called "warowar": the word was applied to marks or patterns of any kind. Writing, for instance, was called warowar.

I had much trouble in endeavouring to ascertain if there was an abstract term for "colour." In Haddon and Ray's Murray Island vocabulary "warowar" is given as a word for colour, but there is no doubt that this means particoloured. The nearest approach I could find to a generic name was "gimgam." Green was often called lulam gimgam (lulam = leaf) and occasionally other colour names had the same suffix as "bulubulu gimgam," "kiamikiam gimgam." It was used for colours of wools and of the tintometer and could not therefore have been used for paper (a fact which I

[1] It is possible also that giazgiaz (used mainly for green, yellow-green, and once or twice for yellow) may also have signified "bright" or "light" as opposed to dark.

at one time suspected). It is perhaps in favour of this term that a similar word "gamul" was probably the nearest approach to an abstract word for colour in the Western tribe of Torres Straits.

Another word which was occasionally used as if it might be an abstract word for colour was mairmair. Mair was red ochre and mairmair was apparently an old word for red, although very rarely used now. It was used by only one or two individuals in the same way as gimgam, and a very intelligent young man, Jimmy Wailu, who knew English well, told me that "mair" meant colour. It would be interesting if a word for red should become an abstract term for colour.

Colour adjectives in Murray Island are formed by reduplication from the names of various natural objects. In the following table is given a complete colour vocabulary of this island with the derivations, the chief names being printed in capital letters.

Murray Island Colour Vocabulary with derivations.

MAMAMAMAM	Red	Mam, blood.
Kiamikiam	Pink, purple	Kiam, purple secretion of "Eroko."
Eroko-mamamam	Pink, purple	Erŏko, Dolabella scapula, Martyns.
Somer-mamamam	Purple	Fruit of Sŏmer, Ochrosia sp.
Mairmair	Red	Mair, red ochre.
BAMBAM	Orange, yellow	Bam, turmeric.
SIUSIU	Yellow	Siu, yellow ochre.
Mòsiu	Orange	Probably a variety of yellow ochre.
Zomkolberkolber	Yellow	Flower of Zŏm, Thespesia populnea, Corr.
SOSKEPUSOSKEP	Green	Sŏskĕp, bile, gallbladder.
Lulam gimgam	Green	Lulam, leaf.
Gausgaus	Green	Gaus, pus.
Giazgiaz	Green (light?)	Giaz, new-born child.
Suserisuseri	Green and blue	Susĕri, rainbow.
BULUBULU	Blue	English word 'blue.'
KAKEKAKEK	White	Not known.
Zazerzazer	White	"
Zoromzorom	Bright, glittering	"
Giaudgiaud	White	Giaud, lime.
GOLEGOLE	Black and blue	Gole, cuttle-fish.
Budbud	Black	Bud, earth from New Guinea.
PIPI	Grey	Pi, ashes.
Kobegudkobegud	Grey	Kobĕgud, a grey clay.

It is interesting here that of the words in common use I only failed to obtain the derivations of the words for "white" and of sunursunur and akòsakòs, meaning respectively "bright" and dark or dull. I also failed to find the derivation of three words which were rarely used in the sense of dark, viz. kupekupe, kukikuki, and kakerikakeri. All the other names used for colours were found to be derived from natural objects which could be identified. Some of the objects from which colour names were derived were brought to me by the natives and are now in the Museum at Cambridge, viz. bam, eroko, zom, and kobegud. I recorded the colours of somer and zom with Lovibond's tintometer. The colour of each was more saturated than the necessary combination of glasses and had to be diminished by the addition of neutral glasses to make a match. The matches were

$$\text{Pulp of Somer} + 2{\cdot}0 \text{ neutral} = 20{\cdot}0\ R + 2{\cdot}6\ Y.$$
$$\text{Petals of Zom} + 2{\cdot}0 \text{ neutral} = 11{\cdot}5\ Y + 3{\cdot}2\ R.$$

Other points of interest will be considered in connection with the Mabuiag vocabulary.

The Western Tribe of Torres Straits.

The following names were given to the papers and wools by natives of Mabuiag and Badu.

Red was called kulkadgamulnga by nearly all; paramadgamulnga by a few. Purple and pink were called kulkadgamulnga or tata kulkadgamulnga by most; several called these colours irukadgamulnga, and they were also called boaboadgamulnga and bēūladgamulnga by individuals. One man, Kanai, Mamus of Badu, called both the red and pink wools miakalunga (white or bright).

Orange was called murdegamulnga or tata murdegamulnga by the majority; other names used were paramadgamulnga, daumadgamulnga, wudgamulnga and arakulkadgamulnga.

Yellow was called murdegamulnga by nearly all; also daumadgamulnga, bamegadgamulnga, and paramadgamulnga.

Yellow-green was called ildegamulnga or maludgamulnga, the latter often qualified by "tata" or "amadan."

Green, maludgamulnga or ildegamulnga.

Blue-green was called maludgamulnga most frequently; also ildegamulnga, giadgamulnga, nisadgamulnga, idiiridgamulnga, buiadgamulnga, wibadgamulnga and piawat.

Blue was called maludgamulnga by most; also ildegamulnga, nisadgamulnga, deabudgamulnga, murugamulnga, muradgamulnga and kubikubinga.

Indigo was called maludgamulnga by nearly all; also ildegamulnga, bulugamulnga, and kubibudadgamulnga.

Violet was called maludgamulnga by several, sometimes qualified by "tata"; it was often called kubikubinga or kubibudadgamulnga; also ildegamulnga, irukadgamulnga, idiiridgamulnga and duduam.

White was called miakalunga by most; also merkalunga, karbaidgamulnga, daiadgamulnga, etc.

Black was called kubikubinga by nearly all; also muradgamulnga and kubibudadgamulnga.

Greys were called kubikubinga, kubibudadgamulnga, budadgamulnga, seradgamulnga or miakalunga according to shade.

The pale green test-wool was most commonly called miakalunga or seradgamulnga, and the same names were applied by many to the violet test-wool.

No definite word was obtained for brown. Dark browns were called kubikubinga or budadgamulnga; lighter browns were called murdegamulnga, often qualified by "amadan" or "tata," while nurumurdgamulnga, wudgamulnga, etc., were also employed.

The chief features of the colour vocabulary resemble those of Murray Island. There was a very definite term for red, and also a perfectly definite term for yellow, which was also used for orange. Maludgamulnga was used for both green and blue, while ildegamulnga was also used for both these colours, though it may be regarded as more properly a term for green. These four colour terms were used by the large majority of individuals, but in addition many other terms were used for special tints and shades. Some individuals contented themselves by using these four terms, perhaps with qualifying adverbs for some colours, but most gave special terms for many other colours. Some individuals gave a very large number of such names, many of which were almost certainly devised on the spur of the moment by adding -degamulnga to the name of some natural object which the coloured paper or wool most nearly resembled. One old man, Gizu, was especially apt in this direction and gave me over 30 names for different colours, and could probably have given many more. These names cannot, however, be regarded as colour names in the strict sense and were certainly not in general use. Other instances have been given of savage languages with a very large colour vocabulary; thus Kirchhoff[1] states that some natives of Queensland examined by him in Germany had 70 colour names, but there is little doubt that these were of the same nature as those given to me in Mabuiag. The tendency to devise special names may be a source of fallacy when colour vocabularies are collected from only a few individuals; thus I was given names for several special browns, but I was able to satisfy myself completely that none of these were generic words for brown, and that there was no word in the language which could be used for all those colours which we recognize as brown.

Among these people there was a native word for blue which was also used for green, but other names, which were occasionally used for blue, such as inuradgamulnga, kubikubinga and idiiridgamulnga were also used for dark colours or for black. The confusion between the terms for blue and black was present, though in a less degree than in Murray Island.

Differences of brightness and saturation were denominated by using "tata" little, and "amadan" nearly ('close up' in pidgin English). Möge (big) was used once or twice. Tutai (dirty) was used less commonly than the corresponding word 'ogog' in Murray Island.

I could not be sure that any term was used for "bright," equivalent to sunursunur in Murray Island. "Miakalunga" was used for the colour of the skin of the white man, and also for those natives whose skins were lighter than usual, but this was also the common term for white. I have mentioned that one man, Kanai, called red and pink wools miakalunga, and I think he was probably using this term in the sense of "bright. Another term which was used rather widely was seradgamulnga;

[1] *Das Ausland*, 1883, S. 546.

it was used for grey and for both the pale green and the violet test-wools, and may possibly be translated "dull."

Minar was used for marked or variegated surfaces, whether coloured or in black and white. It was apparently exactly equivalent to the "warowar" of Murray Island. Patterns were called "minar," and this term was also used for scarification marks.

As in Murray Island, I had a good deal of difficulty in determining the existence of a word for colour. In Haddon and Ray's Vocabulary "minar" is given this meaning, but this is certainly not correct. Probably "gamul" is the nearest approach to such a word.

The names given by natives of Muralug did not differ in any important respect; purple and pink were called grusadinga, and a few other terms were used which were probably of the same special nature as many of those obtained in Mabuiag. They differed however in grammatical form.

The names given by Gida (Tarbucket), Mamus of Muralug, were very erratic and may be mentioned, as they show how easily one might go wrong by trusting to the names given by one individual. Black was called lagimaiginga, which was freely translated by another native, Wallaby, as meaning "No, can't see him," and white was called "lagimari" also freely translated as "You and me see him." After having been shown yellow-green which was called maludunga, green was called "maluwarungadali—waragube," meaning "like another kind of sea—another wind," while blue-green was given another name which Wallaby translated freely as "sea with another kind of wind, plenty blow." These instances illustrate very well the liking of these people for similes.

The colour names obtained from natives of Saibai did not differ from those of Mabuiag, and the same was the case with those obtained from a native of Yam Island by Mr Seligmann.

Derivation of colour names.

Nearly all the colour names were formed by adding the suffix -dgamulnga or -degamulnga to the name of a natural object. In a few cases in Mabuiag this termination had become simplified as in miakalunga (white) and kubikubinga; rarely in these cases was the full form of the latter given as kubikubigamulnga[1]. Occasionally this shortened form was given for other colours, as in maludunga, wudinga.

As already mentioned, names for unfamiliar colours were apparently invented for the occasion by adding the usual suffix to the name of some natural object, and once or twice a native omitted the termination and simply gave the name of the object.

The words given by natives of Saibai and Yam did not differ from those of Mabuiag, but the Muralug natives gave the shortened form, as in kulkadunga, maludunga, kubibudunga. Names were only obtained from four individuals, but they

[1] This word is also the only instance of reduplication in Mabuiag.

all agreed in this respect. They also, however, used the termination gamulei, as in kulkadgamulei, which was never met with in Mabuiag. White was called miakalei and miakaginga.

Only one Moa man was examined, but as he made use of such terms as blugamulnga, yēladgamulnga and waitadgamulnga for blue, yellow and white, little importance can be attached to his evidence.

The following vocabulary is divided into three parts. The first giving the names in general use. The second gives the names which were used by several individuals and were probably colour names more or less in general use. The third gives the names that were only used by single individuals and were probably made for the occasion.

Colour Vocabulary.

Names in general use.

Name of colour.	*English equivalent.*	*Derivation.*
Kulkadgamulnga	Red and purple	Kulka, blood.
Murdgamulnga	Yellow and orange	Mur, yellow ochre.
Ildegamulnga	Green and blue	Il, gall-bladder and bile.
Maludgamulnga	Blue and green	Malu, sea.
Miakalunga or Merkalunga	White	? Merkai, spirit.
Kubikubinga	Black	Kubi, charcoal, and also night, darkness.

Names less commonly employed.

Paramadgamulnga	Red and purple	Parama, red ochre.
Irukadgamulnga	Purple	Iruk, a mollusc, probably the same as the "Erŏko" (Dolabella scapula) of Murray Island.
Daumadgamulnga	Orange and yellow	Damna, ? yellow ochre.
Wudgamulnga	Orange and yellow	Wu, a yellow, sere leaf.
Nīsadgamulnga	Green	Nīs, leaf.
Karbaidgamulnga	White	Karbai, reef heron (Demiegretta sacra, Gm.)
Seradgamulnga	White and grey	Sĕra, a tern (Sterna bergii).
Budadgamulnga	Grey	Bud, pigment obtained by crushing coral.
Kubibudadgamulnga	Black and blue	Kubi and bud.
Inuradgamulnga	Black and blue	Inur, extreme darkness ("dark altogether, no see nothing").
Idiiridgamulnga	Blue and dark brown	Idiiri, water in which "biiu" (mangrove shoots) had been washed.
Duduamgamulnga	Blue and violet	Duduam, a fresh-water plant, the under side of the leaf of which is "duduamgamulnga."
Sainguiadgamulnga	Used for dark brown	Saingui, ink of cuttle-fish.
Nurugamulnga	Used for blue and violet	Nuru, unripe.

Names only used by one or two individuals.

Name of colour	*English equivalent.*	*Derivation.*
Deabudgamulnga	Yellow-green	Deabu, a wild yam, which, when cooked, is yellow inside.
Guamakiamadgamulnga	Green	Guamakiam, a kind of taro.
Wibadgamulnga	Blue-green	Wiba, another kind of taro obtained from New Guinea.
Kubikimadgamulnga	Violet	Kubikim, a large kind of taro.
Gīītadgamulnga	Red	Gīīt, tree, used in sorcery.
Kurubudgamulnga	Green	Kurubu, a tree with yellow pungent fruit.
Isadgamulnga	Used for pale green wool	Is, wax?
Kerikeradgamulnga	Yellow	Keriker, ginger?
Kiauradgamulnga	Violet	Kiaur, a cloud which is black on one side and "kiaur" on the other.
Tutaigamulnga	Brown	Tutai, dirty.
Wamauwibadgamulnga	Light brown	Wamauwiba, a kind of honeycomb.
Gabuikuradgamulnga	Brown	Gabuikur, part of an edible plant.
Wabadgamulnga	Brown	Wab, a tree from New Guinea, probably Dracæna.
Damabadgamulnga	Drab colour	Damab, part of a New Guinea tree, aerial roots?
Guabaguabadgamulnga	Dark grey	Guabaguaba, stone of which the head of a club is made.
Kunaradgamulnga	Light grey	Kunara, lime.
Maidgamulnga	White	Mai, pearl shell.
Daiadgamulnga	White	Dai, a white powder obtained by rubbing a shell on a stone.
Bamegadgamulnga	Yellow	Bameg, a tree.
Boaboadgamulnga	Purple	Boa, fire? also a wild yam.
Dibidibidgamulnga	White	Dibi-dibi, shell ornament.
Bēūladgamulnga	Pink	Bēūl, "sea grass eaten by turtle."
Gainadgamulnga	Used for pale violet	Gainau, Carpophaga luctuosa, a white pigeon.
Bagewadgamulnga	Dull yellow	Bagewad, dead leaves in North-West monsoon.
Bidaidgamulnga	Brown	Bidai, a porpoise.
Gòdadgamulnga	Light grey	Gòd, some kind of earth.
Sikadgamulnga	Pale violet	Sik, foam.
Arakulkadgamulnga	Orange	Ara, sunrise.
Iwiridgamulnga	Reddish brown	Iwiri, wood which, if chewed, gives the saliva this colour.

Other names were also given to individual wools or papers of which I could not find the derivation; such are baradaradgamulnga, pale green; puipuidgamulnga, brown; giadgamulnga, blue-green; bòladgamulnga, white; karadgamulnga, yellow; buiadgamulnga blue-green; iadgamulnga, brown; used for pale green and violet wools; pagoradgamulnga and damadgamulnga, brown.

One man, Paipi, used several names without the usual suffix; he called blue-green "piawat," meaning fresh water when nearly dried up; white was called "meitaian," a name for clouds close together; and a grey was called "brŏdar" as it resembled the colour of the earth when digging out a waterhole.

Blue and brown were also called tatagamulnga and kuzigamulnga, tata being the qualifying word for pale colours so that tatagamulnga may be translated "slightly coloured." Kuzigamulnga appears to be a similar word.

A Saibai man examined by me and two examined by Mr Seligmann used gabauadgamulnga for purple and violet, gabau being a yam with purple flesh when cooked.

The word "grusadinga" which was used by Muralug men for purple instead of irukadgamulnga, is derived from grus, which, so far as I could tell from a description and a drawing made for me by "king Tarbucket," is identical with the "iruk" of Mabuiag and the "erŏko" of Murray Island. The Muralug men also used the word "urunga" for orange and yellow, "uru" being the mangrove shoots when ready for making "biiu." Other words which were used by Muralug men of which I could not find the derivation were buradunga, used for pale green and violet, said to mean "close up white," inguidunga for blue, pagadunga for orange and brown, bagamulei for pale green, and kaietgamulei used for brown.

Of the four well-established and definite colour names of the Western Tribe it will be seen that three have the same derivation as in Murray Island. In both tribes the common name for red is derived from blood, and the most usual name for green from bile, while names for yellow are derived from ochre, though in Murray Island the word with this derivation was much less common than that derived from turmeric. We saw that in Murray Island there was a tendency to name blues and greens after the sea (karemgausgaus, sea-green, and karemgolegole, sea-black), and in the Western Tribe a definite name for these colours derived from the word for "sea" has become established. It is noteworthy that the sea, rather than the sky, should have been the source of the word for blue.

The derivation of the word for red from blood is very common and is found among other instances in several Melanesian languages (Duke of York Island[1], Solomon Islands[2], etc.). The derivation of the word for yellow from turmeric is also met with in Melanesia[3].

The usual words for green both in Murray Island and in Mabuiag were derived from the names for bile and the gall-bladder, and they referred especially in this connection to the gall-bladder of the turtle. This organ has a very brilliant deep-green colour which might well have excited the interest of the natives for its intrinsic qualities, but this organ was interesting in a more practical way. In the Western Tribe, if the gall-bladder of the shell turtle were injured during the operation of cutting up, so that bile ran out, the whole animal had to be thrown away, while in the case of the green turtle all those parts touched by the bile had to be rejected[4].

[1] Codrington's *Melanesian Languages*, p. 87.

[2] Woodford's *Naturalist among the Headhunters*, 1890, and Guppy's *The Solomon Isles and their Natives*, 1887, p. 123.

[3] Cf. Codrington.

[4] I do not know whether any similar custom existed in Murray Island.

It was probably on account of its practical rather than its æsthetic interest that bile became the source of the name for green.

It is an interesting fact that bile is the source of colour names in other parts of the world. Our own words for "gall" and "yellow" are closely connected, and the same is the case in other languages. Almquist[1] found that the Chukchis used a word for yellow and green (also for blue) "dlilil," which meant bile. Kirchhoff[2] states that the word used by the Samoyeds for green and blue, viz. "padiraha" is derived from padea, bile; and he quotes Budenz that the Voguls call green and yellow "vosrem ospe," vosrem being the word for bile. It would be interesting if among these closely related Asiatic peoples, who derive their words for green in the same way, there should be found to be any customs relating to this substance similar to those existing in Torres Straits. A word used by some of the Eskimo for yellow has also the same derivation[3].

In both tribes of Torres Straits the words for purple and pink were derived from one of the Aplysiidæ. In Murray Island we obtained a specimen of "eroko," and though we were unable to obtain specimens in the Western Tribe there was little doubt that the "iruk" of Mabuiag, and the "grus" of Muralug were of the same or closely allied species, viz., Dolabella scapula, Martyns (D. Rhumphii, Cuv.), which is common all round N.E. Australia. It is interesting that the name for purple should be derived from the secretion of a mollusc, as was that of the Phœnicians, although murex and eroko belong to widely separated divisions of the group[4].

One of the most interesting features of the Mabuiag vocabulary is the existence of a large number of special names together with a few well-established names for the chief colours. Though it seemed to me that many of these special names were devised on the spur of the moment, the fact that this was done so readily and by several individuals independently of one another, may be taken as evidence that it was a recognized usage of the language. The words in question were formed in exactly the same way as those in common use, and they seem to illustrate very well the method of growth of a colour vocabulary.

The use of words like orange and violet in our own language shows that as we separate and discriminate variations of colour which have previously been merged in some larger class, we most naturally choose the names of natural objects.

There is, however, one striking difference between the English language and those of Torres Straits. On going through the list of objects from which colour names are derived in Murray Island and Mabuiag one finds that nearly all come into the lives of the people in some practical way, either as food, medicine, or as objects used in sorcery. Objects which might have attracted attention on account of their beauty seldom seem to form the basis of colour names. In Murray Island only one of the names used, zomkolberkolber, was derived from the name of a flower; while of the large number given to me in Mabuiag not one was derived from the name of a flower. This

[1] *Die wissenschaft. Ergebnisse d. Vega-expedition.* 1883. Bd. I. S. 42.

[2] *Das Ausland,* 1883, S. 546.

[3] *Proc. Camb. Phil. Soc.* vol. XI. p. 148. 1901.

[4] According to Whitmee the Samoans use a word for purple derived from the name of a mollusc.

contrasts very strongly with our use of violet, pink, mauve, heliotrope, rose, etc., all derived from the names of flowers. In discussing the derivation of the words for green, I have mentioned that the gall-bladder probably attracted attention, not on account of the brilliance of its colour, but because of its practical importance. I believe that the nature of the colour nomenclature is but one indication of a characteristic feature of the savage mind, viz. a complete lack of any æsthetic interest in nature.

It is a fact, however, that flowers were largely used by the people of Torres Straits for personal adornment. The scarlet hibiscus flower was especially popular, but it was not used as the basis of a colour name.

I have earlier suggested (p. 45) that this lack of æsthetic interest may be directly due to over-development of the sensory aspect of mental life. The Mabuiag colour vocabulary illustrates very well the extensive knowledge which the savage possesses of the concrete things around him and the powers of observation which are associated with this knowledge. Some of the men in Mabuiag seemed to have some natural object in mind to compare with every shade of colour shown to them, and in the discussions which often ensued it was obvious that most of the natives were intimately acquainted with the objects in question. This intimate acquaintance is also shown by the existence of a definite name for nearly every species of animal and plant, and for the individual parts of many animals and plants, for every condition of earth and water, for every feature of the landscape, and for every reef and sandbank of the sea.

I have met with a few references to other examples of extensive colour nomenclature resembling that of Mabuiag. I have already mentioned Kirchhoff's observations on natives of Queensland. Gatschet[1] states that American Indian tribes have many colour names owing to the tendency to specialization, and Schellong[2] was inclined to suspect that in German New Guinea there were no generic colour names in the strict sense, but that colours were named by comparison with natural objects.

It is probable that when primitive man began to use names for colours, he used the names of natural objects either simply or modified in some way, and that definite generic terms for colours have evolved out of these. The Mabuiag vocabulary is a good example of the coexistence of a large number of special names with a few which have become definitely abstract terms for colour.

The Fly River District.

Our stay in the Fly River district was so short that the colour language could not be investigated with the thoroughness which was possible in Murray Island and Mabuiag. Colour names were, however, obtained by me from fifteen individuals, while names from several others were obtained by Mr Ray. One man from the island of Parama and two who came from Mawatta differed slightly from the natives of the island of Kiwai, chiefly in having a different name for red.

[1] *Zeitsch. f. Ethnol.* Bd. XI. S. 293. 1879.
[2] *Ibid.* Bd. XXIII. S. 156. 1891.

Red was called dŏgòdŏgò by the majority, oroare by three, and arimaarima by one man. The Mawatta men and the man from Parama called this colour kopona. Purple was called dogòdogò, and also oroare, arimaarima and ididi. The Parama man and one Mawatta man called this colour kopona, and the other Mawatta man, driadriana.

Orange was called ogòogòogòogò by the majority; by others, oroare, dogòdogò, sisia and gazerogazero. One Mawatta man called the colour by a name somewhat like agòagò, which I wrote garhogarhona; another Mawatta man called it weriweri (weri = sandy beach), and the Parama man called it hoahoa.

Yellow was called ogòogòogòogò by nearly all; also gazerogazero, ĕmăsòro and sisia.

Yellow-green was called pŏropŏrona, ogòogòogòogò, emasòro, gazerogazero, ididi and tĭgīro.

Green was called poroporo, ogòogò, tigiro, emasòro, ididi, while three called it wībuwībuna (black).

Blue-green was usually called tigiro; also poroporo, ididi, ĭpua and wibuwibu.

Blue, wibuwibu by several; also poroporo and ididi, and by one emasòro.

Indigo was called wibuwibu by most; also poroporo, ididi, ipua, tigiro, and by one man questioned by Mr Ray, bulubulu.

Violet was called wibuwibu, ididi, ipua, tigiro and poroporo, and by one man tematema.

White was called kēakēa or kēakēĕna by nearly all; two called it sisiasisia and one emasòro.

Black was called wibuwibu or wibuwibuna by nearly all; also tigiro, wibu-tigiro and ipua or ipuaipua.

The Mawatta and Parama natives agreed in calling all green and blue papers poroporona, and indigo and violet wibuwibuna.

The wools brought out few different names; the pale green wool was called by two men ŭgŭtser, and the pale violet was called keena by nearly all.

Browns were called different names according to their prevailing colour-tone and shade, including dogòdogò, arimaarima, ogòogòogòogò, ididi, ipua, sisia, emasòro, gazerogazero and wibuwibu. Sisai of Parama called a number of browns pănapăna, while Broga of Mawatta used a similar word pănina for a faint red seen in the tintometer.

In each of the dialects of Kiwai and Mawatta there was a very definite name for red, and both dialects had similar names for yellow, while there were other terms occasionally used for red and orange, viz. arimaarima and oroare. The most definite word for green was poroporona. Blue was most commonly called by the same name as green or black. There were definite names for white and black.

There were other terms to which it is difficult to assign a definite meaning. Sisiasisia was used for white and for bright colours such as yellow, while pink was called sisia by one man. It seems to have been a term used in the sense of "bright."

Tĭgīro was applied to black, violet, blue, and green, and almost certainly means "dark."

Emasòro was used for white, yellow, green, and light blue, and probably may be translated "bright" or "light."

Ipuaipua meant "dirty," and was used for black, violet, indigo, and blue.

Ididi was used very widely for purple, blue, violet, green, and brown. It may possibly be a similar word to akòsakòs of Murray Island and may be translated "dull."

Another term used less frequently was gazerogazero, for yellow and yellow-green; while the following were only used once or twice, tematema, violet; ugutser, pale green and violet; barumabaruma, blue-green; giotare, violet; tsoroobar, used for orange and yellow-green; borogoborogo, yellow-green; otorootoro, indigo.

Some of these may not have been colour terms at all, especially those which were not reduplicated.

In addition to kopona, red, the following terms were only used by Mawatta or Parama natives; hoahoa, orange, weriweri, orange, driadriana, purple, panapana, brown, and aiiaii, red.

The colour names in Kiwai were, as in Murray Island, formed by reduplication, and in one instance ogòogòogòogò, probably by quadruplication as in the case of mamamamam in Murray Island. In addition 'na' or 'una' was added as an adjectival suffix, but this was often omitted, especially by the Kiwai people, and occasionally the reduplication was also omitted.

I was unable to discover the derivation of the names in most common use, viz. dogòdogò, kopona, ogòogòogòogò, wibuwibuna or keakea. Oroare used for red and orange meant "flame." (Note the word arakulkadgamulnga once used for red in Mabuiag.)

Arimaarima was derived from arima, blood. Poroporo was derived from poro, which probably meant beeswax. Sisiasisia may have been derived from the name of a parrot. Tigiro and emasòro were said to be names either of special kinds or special parts of the coconut palm.

I was unable to ascertain the existence of an abstract term for colour. One man used the word merereia after each paper in the same way that gimgam was used in Murray Island, and one man questioned by Mr Ray used 'mabu' in much the same way.

The chief features of the colour nomenclature.

On comparing the three colour vocabularies of Torres Straits and the Fly River district, it will be seen that they resemble each other closely in that in each the words for red and yellow are far more definite and well established than those for other colours. In each there is also a word which is especially used for green, poroporo in Kiwai, soskepusoskep in Murray Island, and ildegamulnga in Mabuiag, but these words are not used with the unanimity which is present in the nomenclature for red and yellow. As regards blue, the three languages may be taken as representatives of three stages in the evolution of a nomenclature for this colour. In Kiwai there is no word for blue; many blues are called names which mean black, dark, dull or dirty, while other blues are called by the same word which is used for green. In Murray Island there is no proper native term used for blue. Some of the natives, especially the older men, use golegole, which means black, but the great majority use a term borrowed from English and modified so as to resemble the other members of their colour vocabulary. Another word, suserisuseri, is used occasionally for blue and also for green, and in the absence of the borrowed word this might have been used more often.

The language of the Western Tribe of Torres Straits presents a more developed stage in the existence of a word, maludgamulnga, which is used definitely for blue, but is also used for green. In this language, however, traces of the tendency to confuse blue and black still persist in the use of such words as i nuradgamulnga and kubibudadgamulnga to denote blue.

In dealing with Australian languages later, we shall meet with instances of a degree of development of colour nomenclature still less developed than that of Kiwai in which only red, black and white seem to have definite, established names.

There are many other languages in stages of development comparable with those of Kiwai, Murray Island and Mabuiag. The confusion of blue and black is very common. It has been noted in Melanesian language by Strauch[1] (New Hanover and New Britain) and by Schellong[2] (Malayta in the Solomon Islands), and I have found a distinct tendency to confuse black and blue in nomenclature among natives of Tanna and Lifu (see p. 85). According to Magnus[3], the same confusion is found among the Bushman and Ovaherero of South Africa, the Hovas of Madagascar, the tribes of the Nilgiri Hills in India and the natives of Borneo. Andree[4] quotes the same confusion as occurring among the Mpongwe of the Gaboon and the Caribs of South America. Keller[5] found that 90 per cent of the Nubians of the hills called both blue and black "hadel," while those of Suakin gave each a different name. The Nubians examined in Germany by Virchow and others also called both blue and black "hadel." Almquist[6] found that the Chukchis gave the same name to dark blue as to black, and Gibbs[7] gives the same peculiarity in the Chinook language, light blue having a different name. The modern Egyptian peasant also uses the same words for black and dark blue.

There are other races who resemble the inhabitants of Murray Island in having borrowed a word for blue from another language. The English word has been borrowed by many African races, often taking the form of "bru." The Maoris[8] use the English word changed into "puru." The Battas of Sumatra use the word "balau," borrowed in a slightly modified form from the Dutch. They are also said to have borrowed the word "biru" from the Malays, but this is probably a modification of the English word. Some races in Borneo are said to use a word "hidjan" borrowed from the Malay, and the Berbers are said to use a word "samawi" (sky colour) borrowed from Arabic[9]. The Hindustani word "nil" is used for green and blue by several Asiatic peoples including the Tamils and Siamese[10].

[1] *Zeitsch. f. Ethnol.* Bd. VIII. S. 405. 1876.
[2] *Ibid.* Bd. XXIII. S. 156. 1891.
[3] *Untersuch. über den Farbensinn d. Naturvölker.* Jena, 1880.
[4] *Zeitsch. f. Ethnol.* Bd. X. S. 323. 1878.
[5] *Mittheil. d. k. u. k. geograph. Gesellsch. Wien*, Bd. XXV. S. 382. 1882.
[6] *Die wissenschaft. Ergebnisse d. Vega-expedition*, Bd. I. S. 42. 1883.
[7] *Alphabetical vocabulary of the Chinook Language.* New York, 1863.
[8] See W. Williams, *Dictionary of the New Zealand Language.* 1892.
[9] For this and preceding instances, see Magnus, *Untersuch. ü. d. Farbensinn d. Naturvölker.*
[10] *Zeitsch. f. Ethnol.* Bd. I. S. 89. 1869.

The Samoyeds sometimes use the Russian word "sjinioi" for blue[1]. In the Philippine Islands, the words used for green and blue by several tribes, such as the Ilocos, Tagals, and Bisayos, have been borrowed from the Spanish[2], and one of the Araucans of South America examined by Kirchhoff also called blue "azul[3]."

The use of the same word for green and blue is very common. Many instances are given by Andree and Magnus in the papers already cited, and many other instances could be added. It will perhaps be sufficient to mention that one instance occurs so near home as in the Welsh language, in which there is only one word "glas" for both green and blue.

In some languages one finds a word used for both green and blue, and in addition, other words by which these colours may be distinguished. In Mabuiag the case was somewhat different. In this island there were two words, each used for both green and blue, but it seemed as if these words were in process of becoming terms by means of which the two colours could be distinguished.

Another feature which was common to the three languages of Torres Straits and the Fly River was the absence of a word for brown. Brown papers and wools were called red, yellow, grey or black, according to their colour-tone and shade. In Mabuiag names were given to special browns, but it was quite certain that these were not generic terms for brown in the sense in which we use the word. When a number of wools were put together which the European would call brown, the natives would not acknowledge that any one term would apply to all or even to any considerable group of them.

The absence of a word for brown appears to be characteristic of very many languages, probably of the great majority of the languages of the world. Among those which I have had an opportunity of investigating, I have found no word for brown in several Australian, Melanesian and Polynesian languages, in Tamil, Eskimo[4], Welsh and the Arabic of the Egyptian peasant. The absence of a word for brown has been noted in many other races. Bastian[5] notes that the Siamese call brown "dam-deng," meaning "black-red." Kotelmann[6] found that the Lapps called brown "tscharpis roksad," again meaning "black-red." The Ainus[7] call brown "furiambe," red being fure. Pergens[8] found that of the 57 Congolese examined by him, only two could give a word for brown: one called it moïndo, which was also used for black, and the other "ossingaiumbayéta," m'bayéta being used for pink. Gatschet[9] records that a word for brown is absent from several American Indian (Amerind) languages, while in others there may be several terms for this colour. It is possible that, in the latter case, the words used were names for special browns, as in Mabuiag, and were not true generic terms for brown. This may also be the case in other languages, such as Patagonian[10], Tongan[11] and Araucan[12], in which names for brown have been recorded.

[1] *Das Ausland*, S. 546. 1883.
[2] *Zeitsch. f. Ethnol.* Bd. I. S. 89. 1869.
[3] *Das Ausland*, S. 256. 1884.
[4] *Proc. Camb. Phil. Soc.* vol. XI. p. 143. 1901.
[5] *Zeitsch. f. Ethnol.* Bd. I. S. 89. 1869.
[6] *Berlin. klin. Wochensch.* S. 701. 1879.
[7] *Das Ausland*, S. 546. 1883.
[8] *Janus*, p. 459. 1898.
[9] *Zeitsch. f. Ethnol.* Bd. XI. S. 293. 1879.
[10] Musters, *At Home with the Patagonians*, p. 339, 1873, and Kotelmann, *Berlin. klin. Wochensch.* S. 701. 1879.
[11] Mariner's *Tonga*.
[12] *Das Ausland*, S. 256. 1884.

The records given of the colour names of several parties of Nubians travelling in Germany show how easily mistakes may be made in such a matter. Kirchhoff[1] concluded that "hamasch" was a definite word for brown, while the same and other Nubians examined by Nachtigal[2] and Cohn[3] gave hamisch or hamasch as a word for grey and for dark and impure colours generally, while it was also used for violet.

Schellong[4] gives "mela" as a word for brown in two Melanesian languages. This is probably the same word as mera, which is a common Melanesian term for "red."

The confusion of brown and violet is common. It will be remembered that both occasionally received the same names in Murray Island and in Mabuiag. Gatschet[5] notes that the Kalapuya Indians of north-west Oregon call violet "tútĕlu," and brown "púdschnank tútĕlu," meaning "not quite violet." The Creeks use oktsadi both for violet and dark brown. Kirchhoff[6] notes that the same confusion is still common in German villages, and that when Halle students wearing violet caps are seen, the villagers say "Here come the browns." Kirchhoff also notes that the middle High German "brûn" was used for violet.

There appears to have been no word in Homeric Greek which one can regard as equivalent to brown, and I am indebted to a note from the Rev. H. T. F. Duckworth that the same is true of the Greek spoken by the majority of the inhabitants of Cyprus at the present day. They call dark brown objects *μαῦρος*, which is the word in common use for black, while other brown objects are called *κόκκινος*, which is also applied to brilliant scarlet.

Colours of the rainbow.

In the discussions on the colour vision of the ancients, the descriptions of the rainbow have played an important part[7].

I was unable in Torres Straits to ask the names of the colours while a rainbow was visible, but a number of natives gave me an account of the colours in the rainbow from memory. They first enumerated the colours they saw and picked them out from the series of coloured papers and then gave them in order on a rough drawing. The accounts given by the younger men were of very little value; some did not think there was any red in the rainbow, and Tapau, an intelligent young man, gave the four colours of the rainbow in order from without inwards as blue-green, yellow-green, yellow, orange. The answers of the elder men were more interesting. Ulai saw mamamamam outside, kakekakek in the middle, and golegole inside; Papi put mamamamam outside, bambam in the middle, and golegole inside. Jimmy Dei put mamamamam outside, then bambam, then suserisuseri (indigo paper), and golegole (black) inside. Barsa put mamamamam outside, then pipi golegole (violet paper), giazgiaz (yellow-green paper),

[1] *Zeitsch. f. Ethnol.* Bd. xi. S. 397. 1879.
[2] *Ibid. Verhandl. d. anthrop. Gesellsch.* S. 452.
[3] *Centralbl. f. prakt. Augenhlkde*, S. 197. 1879.
[4] *Zeitsch. f. Ethnol.* Bd. xxiii. S. 156. 1891.
[5] *Ibid.* Bd. xi. S. 293. 1879.
[6] *Das Ausland*, S. 546. 1883.
[7] An account of the various colours ascribed to the rainbow in ancient writings is given by Magnus in *Die Entwickelung des Farbensinnes.* Jena, 1877.

and golegole (indigo paper) inside. Billy Gasu said he saw five colours; three chief colours, red, indigo, yellow from without inwards, with a very narrow strip of orange outside the red, and a narrow strip of purple inside the yellow. Pasi, on the other hand, only remembered two colours, red outside and blue inside. Kudub gave three colours, red, green and blue, but gave red inside and blue outside. The observations are interesting in one way as showing the degree of accuracy with which the natives can give a description from memory of a natural phenomenon. The failure of the young men is only one among many instances of the loss of the powers of observation of nature which has accompanied contact with civilization. It will be noted that all the men put red in its correct place, except Kudub, who had reversed the natural order. Ulai's answer was very interesting. This old man had a good colour sense and was a good observer, and yet the only colour he described in the rainbow was red, and he called the rest of the bow white and black. The fact that only one colour is mentioned in a description of the rainbow, as in that given by Homer, is far from showing that only the power of perceiving that colour has been developed.

Several natives in Mabuiag made coloured representations of the rainbow for me. Very nearly all drew two rainbows, a big and a small; and on the occasions when I saw a rainbow in Torres Straits, the secondary rainbow was well marked. In no representation, however, were the colours of the small rainbow given as reversed. Gizu called the outer part of the rainbow "zuru" glittering; then paramadgamulnga, red, kubikubinga, black, and murdgamulnga, yellow. Waria called the outermost part daiadgamulnga (an unusual word for white), then murdgamulnga (yellow), paramadgamulnga (red) and maludgamulnga (blue). The descriptions of the others were still more faulty.

I am sorry that I did not examine a larger number of men, and especially of old men, on this subject, as it is an interesting test of the powers of visual observation and memory in addition to its interest in relation to colour vision.

Quantitative observations.

The observations so far described show that, in spite of the absence or indefiniteness of terms for blue, this colour can be recognized by the Torres Straits islander, while different shades or tints of blue can be distinguished from one another, and the same is true of other races in whom the same defect of colour nomenclature exists. It is, nevertheless, possible that there may be some degree of insensitiveness to this colour, which makes a given blue a darker and a duller colour than it is to European vision, and may help to account for the confusion of the colour with black.

In order to study this question, it seemed desirable to make quantitative observations on the relative degree of sensitiveness to different colours. For this purpose I made use of Lovibond's Tintometer which had been generously lent to the expedition by Mr Lovibond, and I take this opportunity of expressing my thanks to him for his valuable loan. The essential part of this apparatus consists of three series of coloured glasses, red, yellow and blue, very delicately graded so that each forms a series by means of which one passes from a colour so faint as to be indistinguishable from colourless glass up to a glass of a high degree of saturation. The instrument itself is a tube at the end of which are two square apertures. On looking into the tube one sees two square patches of light, either of which can be given any degree of coloration by placing before one of the apertures a glass from one of the three series. With this instrument I was able to determine the threshold for each of the three colours, measured by the faintest glass of which the colour could be recognized. The top of the instrument was covered with a cardboard screen so that the glasses which were being placed in the instrument should not be seen. The native had not only to say what colour he saw, but also to say which of the two apertures was coloured. I usually began[1] by placing on one side a faint glass, ·10 or ·20, and gradually increased the intensity till the colour was recognized and then diminished again till the threshold was found. The three colours were given in irregular order. The threshold was determined by finding the glass which could be correctly named four times in five observations, though often more observations were made with a given glass.

The red glasses were always called mamamamam as soon as their colour was recognized. The yellow glasses were sometimes called "soskepusoskep" or "gausgaus" as well as "bambam," but as they have a distinctly greenish tinge, I passed these answers as correct. European observers often call these glasses green with low strengths. Owing to the fact that bulubulu had become the general term for blue, there was no indefiniteness in the naming of this colour; when it was not recognized, the natives either said that they saw "kakekakek" (white) or that the two sides were "okakis" (equal) or "mokŏkalam" (the same).

The threshold was determined at one sitting. Owing to the influence of fatigue and practice, this was often difficult. For comparative purposes it is, however, important that all observations should be made under conditions as similar as possible, and it seemed better to be content with a rough determination[2] of the threshold at one sitting than to compare the results of one individual in one sitting with those of another individual in two or more sittings. There was the further difficulty that one could never be sure that a native would make observations on a second occasion. I looked out carefully for signs of fatigue and inattention, and rests of ten or fifteen minutes were taken when necessary. In the table which follows, the thresholds are given in Lovibond's units (omitting the decimal points), the fainter glasses having the lower numbers. On the left-hand side are given the results for 18 Murray Island men and boys, and on the right-hand side those for 18 English men and boys.

The two parts of the table show a striking difference between the results for

[1] In more recent observations, I have found it better to begin with a glass distinctly above the threshold (say 1·0), so as to give a clear idea of the three colours at the beginning and then progressively diminish. This procedure saves time and consequently diminishes the influence of fatigue.

[2] One example may be given in detail to show the kind of result with which one was satisfied. Wasalgi first recognized red at ·50, yellow at ·40 and blue at 1·00. On going down the series red was recognized 5 times in 6 at ·30, 6 times in 7 at ·20; yellow was recognized 4 times in 5 at ·30, only twice in 5 times at ·20; blue was recognized every time at ·60, 3 times in 5 at ·40, only twice in 5 at ·30. Blue ·50 was not tried, but if it had been would almost certainly have been recognized at least 4 times in 5, and Wasalgi's thresholds were therefore put down at red ·20, yellow ·30, blue ·50.

TABLE IV.

MURRAY ISLAND					ENGLISH			
NAME	AGE	R.	Y.	B.	NAME	R.	Y.	B.
Ulai	55—60	10	35	55	E. H.	80	60	30
Wasalgi	45—50	20	30	50	W. M. M.	20	10	25
Pasi	40—45	10	15	40	G. M.	15	10	15
Kaige	35—40	40	30	60	E. C.	40	20	80
Debe Wali	35—40	25	40	90	C. R. M.	10	20	30
Jimmy Wailu	25—30	20	40	40	H. B.	10	4	26
Loko	25—30	25	30	45	C. A. N.	20	20	60
Meiti	25—30	10	15	40	S. C.	26	30	45
Tapau	20—25	10	25	40	G. K.	10	10	60
Madsa	18	5	15	30	H. H. D.	15	15	20
Berò	17	10	10	75	A. L.	50	20	50
Charlie Pasi	17	15	20	65	J. B.	15	15	20
Jimmy Rice	12	30	15	90	S. W. C.	20	20	20
Biskak	11	15	20	80	W. F.	20	15	30
Depoma	10	10	40	60	A. E. T.	120	40	30
Nanai	10	25	30	100	P. V. B.	15	25	35
Jimmy Dauar	10	20	10	60	F. R.	70	15	60
Sailor	11	100	100	150	W. M.	15	20	20
Average		22·2	33·6	65·0	Average	31·7	20·5	36·4
Average, omitting Sailor		17·6	26·5	60·0				
Maximum		40	50	100	Maximum	120	60	80
Minimum		5	10	30	Minimum	10	4	15
M.V.		7·66	9·71	16·5	M.V.	22·5	8·11	15·13
$\frac{M.V.}{A.}$		·435	·366	·275	$\frac{M.V.}{A.}$	·710	·395	·415

the Papuan and English observers. (In taking the Murray average it is more satisfactory to exclude Sailor's observations. Though an intelligent boy, he was only able to recognize the colours when much stronger than the other natives. I have had exactly similar results in testing Europeans in too strong a light, and I think it probable that his defective observations were due to a slight degree of photophobia.) The Murray Islander recognizes red most easily, then yellow, while blue is only recognized when of considerably greater strength. The English observer, on the contrary, recognizes yellow most readily, while the figures for red and blue do not differ greatly from one another. The results tend to show that the Murray Islander is relatively rather more sensitive to red than the Englishman, and distinctly less sensitive to blue. Another striking difference between the two sets of results is that the Murray individuals conform more nearly to one type and vary less from one another than do English observers. In only two cases, Kaige and Jimmy Dauar, was yellow recognized at a lower unit than red, and in no single case was blue recognized at a lower unit than red or yellow, while in nearly all cases the threshold for blue was much higher than that for the other colours.

The figures for the English observers show more variation The majority resemble the average results in showing comparatively small differences for the three colours. A few observers had a high threshold for blue comparable with that of the Papuan, while others gave figures which are wholly unrepresented in the Murray Island table, red having a much higher threshold than the other colours.

The extent to which the different individuals of the two groups deviated from the average is shown by the mean variation, M.V., given in the last line but one of Table IV. It will be seen that there is a rough correspondence between the amount of the variation and the degree of sensitiveness which is especially close in the case of the Murray Island figures.

In order to compare the degree of variability in the two sets of observers, it is perhaps most satisfactory to take the mean variation in its relation to the average. I have therefore given in the bottom line of Table IV. the figures expressing this relation. the M.V. for red in Murray Island being 43·5 per cent. of the average and so on. If the figures be taken as the measure of the variability of the two groups, it will be seen that there is less variation among the Murray Islanders for all colours than among the English observers, the difference being very great in the case of red.

This large variation for red in the English observers is due to the presence of a few individuals exceptionally insensitive to this colour. Two of these (F. R. and A. L.) were also insensitive to blue, but the other two individuals (E. H. and A. E. T.) had probably some degree of weakness of the red-green sense, though not sufficiently pronounced to prevent them from passing the ordinary tests for this condition. The fact that such individuals were not found among the Murray Island natives may be taken as additional evidence that red-green blindness was absent or extremely rare among these people. In addition to the individuals given in Table IV. I tested others in whose behaviour with Holmgren's wools there was anything suspicious and was able to satisfy myself that they could distinguish red at low values, even when for any reason I was unable to make the complete examination which would have allowed me to include them in Table IV. I may mention here that the behaviour of a definitely red-green blind individual with Lovibond's tintometer is quite characteristic; the red and blue glasses are confused with one another[1], even when of considerable strength, and the determination of the thresholds for red and blue is quite impossible. Individuals with weakness of the red-green sense distinguish strongly-coloured glasses but confuse red and blue as soon as they are shown faintly-coloured glasses.

I also attempted to compare the relative sensibility of the natives to the three colours of the tintometer by determining the just perceptible difference for each. A glass was placed in one aperture and a slightly stronger or slightly weaker glass of the same colour in the other aperture with the object of finding the smallest difference of colour that could be recognized. Observations were made on a few individuals but were discontinued owing to the difficulty of ascertaining whether the natives distinguished the difference of colour or merely the difference in brightness. It is quite possible that an individual who was insensitive to blue might yet successfully distinguish two blue glasses by the difference in the darkening of the two apertures. It seemed that any results obtained would be inconclusive. The observations were, however, interesting in showing that, under favourable circumstances, the psychophysical method of "just perceptible difference" is one which could perfectly well be used in investigations on these natives.

Another method with which I tried to compare the relative sensibility to red and blue and other colours was that of determining the distance at which a small patch of colour could be seen and its colour recognized. I used patches of Rothe's papers two mm. square on a white ground. The observations were made in the same place and under the same conditions as those employed in testing visual acuity. It was found that red was perceived at a much greater distance than other colours, while a blue was not distinguished from a black patch till quite close to the observer. Other colours occupied an intermediate position. The same result is, however, obtained with Europeans, especially when the blue patch is placed on a white ground, the blue then being very much darkened by contrast, and using the same test on Europeans I have found almost as great a difference between the distances at which red and blue are recognized.

Most of the Murray Islanders could recognize red at 15 metres, and one man, Mabo (visual acuity $\frac{19}{5}$ by the E method), was right every time at 18 metres, and at 22 metres recognized red seven times in ten. The same man at first confused blue and black at two metres, but after having distinguished them at this distance was able to distinguish them at five metres, possibly, however, owing to their difference in brightness. Others were able to distinguish blue and black and blue and green only at distances of two or three or four metres.

Owing to the influence of contrast and the difference of brightness of different colours, the test, as I employed it, was very unsatisfactory and I do not attach much

[1] The confusion of the red and blue glasses is due to the fact that the red glasses in Lovibond's tintometer are distinctly bluish, and the red-green blind individual probably sees both sets of glasses blue.

importance to these results. They agree, however, with the tintometer test in showing a high degree of sensitiveness to red.

So far as I have been able to find, this test is the only one which has been previously used for quantitative observations on non-European races. In 1879, Cohn[1] made observations on four Nubians in Breslau, and found very slight differences in the distances at which small patches of red, yellow, green and blue paper could be recognized. His observations differed from mine in that the coloured patches were placed on a black ground. The nature of the background is always a great difficulty in observations of this kind, for one may name a colour correctly, not because one sees the colour, but because one recognizes how far it differs from the background in brightness. A suitable form of the test for ethnographical purposes has yet to be devised.

Webster Fox[2] has also made some observations on American Indians (Amerinds). He found that they recognized patches of coloured paper 1 mm. square at one-third greater distances than white men, but he does not mention whether there was any difference in the results for different colours.

Ranke[3] also tested the natives of the Bakaïri and Trumai tribes in Brazil with Wolffberg's colour-points and found that one could distinguish the colours at 27 metres, Ranke's own distance being 20 metres, but nothing is said of any difference in the distances for different colours.

The methods which I employed to make quantitative observations were the best that I could devise with the means at my disposal. The unsatisfactory feature of the test with the tintometer is the impurity of the glasses. It is possible that with pure spectral colours, the deficiency for blue would have been even more marked than I found it. When I found that the colour vision of the natives in Murray Island presented so many features of interest, I wrote to Queensland for some kind of spectral apparatus, but, owing to the slowness of communication in that part of the world, I was unable to get anything in time. It would, however, be far from easy to devise a practical test with spectral colours which could be employed so as to obtain a definite result in a short time, as can be done with Lovibond's tintometer.

Colour vision of the peripheral retina.

I did not take a perimeter to Torres Straits, and for work on indirect vision, I was obliged to be content with comparatively rough observations by means of patches of colour upon black cards. I used the four cards supplied for the purpose in the Milton-Bradley set of pseudoptics, supplemented by two others with orange and purple patches of the same size. I sat directly in front of the native with my face towards the best illumination, so that the cards should be well and regularly illuminated. The native closed one eye and with the other fixed the root of my nose, so that I was

[1] *Allgem. medicin. Central-Zeitung*, Jg. XLVIII. S. 899. 1879.
[2] *Philadelphia Med. Times*, vol. XII. p. 346. 1882.
[3] *Correspondenz-blatt d. deutsch. Gesellsch. f. Anthropol.* etc. XXVIII. S. 113. 1897.

easily able to detect any departure from accurate fixation. I then gradually brought the discs at arm's length from outside the native's field of vision, up to the point of fixation, noting the point at which the colour was first named, and in those cases in which it was first named incorrectly, the point at which the colour was correctly recognized. When most colours are passed from periphery to centre of the retina, they may be observed to undergo apparent changes of colour tone, all colours containing yellow or blue components being seen as yellow or blue in the periphery, while the true colours are only recognized when approaching the centre of the field. I was able to determine roughly the points at which the four colours, red, yellow, green and blue, were first recognized, while the natives also in many cases observed changes of colour tone which agreed with those observed by Europeans.

In the absence of a perimeter, I did not attempt to make any quantitative observations, but the rough method brought out several interesting features. The observations are given below in a tabular form; I have only said that the field for one colour was larger than another when the difference was obvious; if accurate measurements had been made, there is no doubt that there would have been minor differences in the limits. Each colour was tried five times *R*, *Y*, *G* and *B* are used for fields for red, yellow, green and blue respectively. In most cases fixation was good, and was well kept up throughout.

As regards the limits for the different colours, the most obvious result is that there was comparatively little difference in the sizes of the fields for red, yellow and blue, but blue tended to be the largest of the three, and in some cases blue was recognized very distinctly outside the limit for red, while in no single case was red seen outside blue. The field for green was, however, in nearly all cases obviously smaller than those for the other colours. The difference was so striking as to leave no doubt whatever; in many cases the other colours would be recognized at 50 to 60 degrees from the centre, while green was not named correctly till within a few degrees of the point of fixation. The absolute size of the fields depends so much on illumination and other factors that little importance can be attached to any observations on this head.

In a few individuals, especially Jimmy Rice, the fields for blue were very large, as large as in Europeans, but the general impression left on my mind was that the colour fields were distinctly smaller than in Europeans, especially considering the fact that the illumination was very good. It must be remembered, however, that the observations were probably not easy for the natives, and that the attention devoted to keeping up accurate fixation may have interfered with their powers of observation. It may be noted that in those in whom I was unable to detect any difference in the sizes of the colour fields, the fields were all very small. The large size of the field for red is not in agreement with what is found among Europeans. In the latter it is found that there is a close agreement in the size of the fields for red and green, both being smaller than those for blue and yellow. This agreement has been found to be exact when the colours are of equal intensity and saturation. It is known, however, that the limit at which a colour is recognized depends on its brightness, and that, if sufficiently bright, all colours are recognized to the extreme limits of the fields of vision. We have seen that there is reason to believe that red is to these people a relatively

TABLE V. COLOUR FIELDS IN INDIRECT VISION.

Name	Age	Fixation	Right eye	Left eye	Changes in colour tone
Wanu	50—55	Not good	R and B about the same size. G very small		
Tibi	45—50	Very good	B largest. No marked difference between R, Y and G	B very large, distinctly larger than R. Y and R about the same size. G smaller	G called 'bambam' nearly every time. Purple called 'bulubulu' nine times in ten
Sisa	45—50	Good	R, Y and B same size. G smaller	No appreciable difference. Once blue distinctly outside red	
Pasi	40—45	Good	R, Y, B about the same size. G much smaller	R, Y, B same size, possibly B largest. G much smaller	G twice called bambam in periphery before its correct colour was seen
Oroto........	35—40	Very good	No marked difference; possibly G and Y smaller than R and B	No appreciable difference	B once called kiamikiam in periphery
Bemop	35—40	Fair	Little difference	R, B, Y equal. G smaller	Twice called G 'bambam' in periphery
Mabo........	30—35	Good	No obvious difference; perhaps B largest and G smallest	do.	R once called 'bambam' in periphery and B once called kiamikiam
Dick Tui ...	30—35	Good	No difference. Fields very small	do.	
Giaz	25—30	Fair	No difference R, Y, B. G smaller	do.	G twice called 'bambam' and purple twice called bulubulu in periphery
Tapau	20—25	Good	No appreciable difference	R and B same; Y slightly smaller; G smallest	Called purple and Y 'bulubulu' and G 'kiamikiam'
Tepem	18	Good	No difference. Fields very small	do.	
Madsa	18	Good	Little difference; possibly B largest and G smallest	B distinctly larger than R	Twice called purple 'bulubulu' for a considerable distance before recognizing it as 'kiamikiam'
Berò	17	Good	B and Y very large; R slightly smaller; G much smaller	No appreciable difference R, Y and B. G smaller	Purple called 'bulubulu' in periphery before recognizing it as 'mamanamam'
Charlie ...... (Pasi)	17	Fair	No marked difference. Perhaps B largest and G smallest	Y and B distinctly larger than R and G	G three times called 'bambam' before being seen as 'soskepusoskep.' After this called Y 'soskepusoskep'
Jimmy Rice	12	Good	Little difference, but B largest and G smallest	do.	G and R each called once 'bambam' in periphery
Tom (Tanu)	11	Good	B and Y much larger than R and G	B slightly larger than R	Purple once called 'pipi' (grey) in periphery
Sailor	11	Good	B largest. R and G distinctly smaller. Y very small		Yellow called 'pipi'
Jimmy ...... Dauar	10	Bad	R, Y, B equal. G smaller	do.	

brighter colour than it is to the European eye[1], and it is possible that the relatively large fields may be referred to this cause. The greater definiteness and certainty in naming red may also have contributed to increase the apparent size of its field.

The other most noteworthy result of these observations was the large size of the blue field, notwithstanding the apparent insensitiveness to this colour as shown by other tests. This point will be more fully considered presently. The approximate agreement of the fields for yellow and blue is in accordance with European vision.

A certain number of natives observed distinct changes in colour as the patches were passed from periphery to centre of their fields of vision. The green used had a distinct yellow tinge, and six natives called it "bambam" (yellow) in the periphery, most more than once recognizing it as green only when much nearer the fixation point. The red was called yellow twice (by Mabo and Jimmy Rice, both good and intelligent observers). The purple test was called blue in the periphery by five natives, who only recognized it as mamamamam or kiamikiam when nearer the centre.

The orange test was of little use, since both orange and yellow (the colour in which orange should appear in the periphery) have the same Murray Island equivalent, viz. bambam. It is, however, important that orange was never once called mamamamam in the periphery.

The changes of colour observed agree in general with the normal behaviour of European eyes, and they afford important evidence that in Murray Island, as in Europe, the fields for green and red were smaller than those for yellow and blue. On the other hand, two good observers, Mabo and Oroto, called blue "kiamikiam" (pink) in the periphery; this only happened, however, once in each case. Several natives tended to answer wildly after they had found that they had been wrong once or twice, and I have often noticed the same behaviour in Europeans; after having named several colours wrongly people lose confidence in their powers of observation and name the colours almost at random; thus Charlie Pasi, after having twice called green "bambam," called yellow "soskepusoskep," green. Tapau's answers were especially wild, but his knowledge of native nomenclature was very defective and he made mistakes in naming, both with coloured papers and with the tintometer: in fact his mistakes were so marked that I took especial pains to examine him several times to assure myself that he was not colour-blind. Tibi's observations were especially interesting in regard to change of colour tone. He was an elderly man, who kept up extremely accurate fixation; I was unable at any time to detect the slightest wandering of his eyes. In order not to confuse him, I only moved the purple disc towards the centre till he recognized it as blue, and only after he had five times called purple "bulubulu" did I move it on nearer to the centre, when he called it "kiamikiam"; on repeating with the left eye, he again called this colour "bulubulu" four times out of five.

It is known that all colours are seen (at ordinary illumination) as grey in the extreme periphery of the retina. Only two natives, both boys, called any colour grey; one called purple and the other yellow "pipi" or grey in the periphery. The fact that this did not happen more often was possibly due to the fact that the natives

[1] In my experience in using the same or similar tests on Europeans, red is seen outside green very commonly if the red one uses is at all bright and saturated.

were only on the look out for colour (in the narrow sense) and did not give an opinion till some definite colour appeared. One of the two boys, Sailor, who called yellow "pipi" did so till it was quite close to the fixation point. This boy had a very high threshold with the tintometer, and when tested the first time with Holmgren's wools, he matched the yellow test with almost colourless wools, but when examined on a second occasion there was no definite evidence that his colour-sense was defective. If there was any defect in his colour-sense, it was, however, certainly not of the common type in which red and green are confused, but rather of the type, so rare among Europeans, in which there is confusion between yellow and blue (see p. 51).

Observations on the peripheral colour vision of Nubians travelling in Germany were made by Schöler[1], using Förster's perimeter. His results agree closely with those gained by my less exact method. He found the field for green smallest, then red and blue in order, that for white being the largest. The different individuals varied from one another, but on the whole the fields were as large or larger than in a European, especially in the temporal direction. Schöler also examined an Indian and a Negro, who gave similar results. He notes the excellent attention and fixation of the Negro as compared with the Nubians, whose power of attention is described as very weak.

Lombroso and Carrara[2] examined the visual fields of some individuals from the region of the White Nile, probably Dinkas. Their visual fields for white were large and regular, being much more nearly circular than in Europeans. No fields for colour are given, but it is stated that the distribution of chromatic sensibility was the same as that of the European eye.

The observations on indirect vision, rough though they were, brought out one point beyond all doubt which appears to be in conflict with the other observations made with the tintometer and coloured wools. There was no doubt that the colour blue was recognized readily, even more readily than other colours. The colour of the patch used was saturated, but if the colour had been relatively dark to the peripheral retina of these people, one would certainly have expected the size of the field to be diminished. Schöler's more exact observations also show that in another race, presenting much the same defect of nomenclature for blue as existed in Torres Straits, blue was readily recognized in indirect vision, its limit being outside that for red.

The most ready way of reconciling the two sets of observations is to suppose that the defective sensibility to blue is due chiefly, or altogether, to the influence of the macula lutea. It is well known that owing to the yellow-red pigmentation of the region of direct vision, blue and green rays are absorbed more strongly than in the extra-macular regions of the retina. On this account blue is a less intense colour to the macular region of the normal eye than it is to the extra-macular region.

There is, so far as I know, no actual evidence that the yellow pigmentation of the macula is greater in black-skinned people than in the Caucasian races, but there is very little doubt that this must be the case. If so, the absorption of green and

[1] *Zeitsch. f. Ethnol.* Bd. XII. S. 59. 1880.

[2] *Archivio di Psichiatria*, vol. XVII. p. 349. 1896.

blue rays would be greater than in the European eye and may account for the relative insensitiveness to blue.

The patch of colour shown in the tintometer was 13 mm. in diameter at a distance of 32 cm. from the eye, *i.e.* with steady and direct fixation, the image of the patch would fall wholly within the macular region. During movements of the eye and when looking at the adjoining patch, the extra-macular regions of the retina would be stimulated, but the influence of the macular pigment in direct fixation would probably be of most importance.

If this view is correct the defective sensitiveness for blue is to be regarded as a function of the pigmentation rather than of the primitiveness of the Papuan visual organ. It is interesting in this connection that when Virchow[1] was examining natives in Berlin in 1878, he found that the difficulties in naming blue and green became very much less if he used large sheets of coloured paper instead of small patches.

Colour contrast.

There was no doubt that the natives could see contrast colours, but I believe that they saw them less vividly than the average European. I tested them with rotating discs on the colour top and with Meyer's experiment. By the former method[2] (wheel contrast) they only saw red as a contrast colour. On an orange disc one man saw the (objectively) grey rings as "kebe bulubulu," but with this exception the grey rings on red, yellow and blue backgrounds were described as pipi (grey), golegole (black), kakekakek (white) or zazerzazer (white).

With the green disc, on the other hand, the majority saw the objectively grey rings as mamamamam, kebe mamamamam, or dudu mamamamam. Some saw the contrast colour immediately and spontaneously, others only after being pressed to say if they saw any other colour besides that of the background. Others failed to see any coloration and described the grey rings as pipi or kakekakek. The fact that red was more readily seen than other colours in wheel contrast agrees with what is usually found among Europeans.

Meyer's experiment, in which grey paper on a coloured ground is covered with thin tissue paper, gave more definite results. The grey patch on a green ground covered with tissue paper was called mamamamam by all readily. On a blue ground, the (objectively) grey patch was called "bambam" by all except one man (Kudub), who described the colour as "suserisuseri," and two boys who called it "kebe kakekakek." Green as a contrast colour was much more doubtful; some saw it, but most described the grey patch on a red ground as colourless; one man called it sunursunur (bright), and one as "kobegud" usually used for grey. The patch on a yellow ground was called by nearly all "golegole." Only one man called it first "golegole" and later "bulubulu." Since "golegole" was often used for blue, this does not necessarily show that they did not see the colour, but they were all in the habit of calling blue

[1] *Zeitsch. f. Ethnol.* Bd. x. *Verhandl. Berlin. Gesellsch.* S. 333. 1878.

[2] See Schäfer's *Textbook of Physiology*, vol. II. p. 1065.

"bulubulu" when talking to me, and I have little doubt that they would have used the word if they had recognized a blue colour.

A grey patch on a black ground was called "kakekakek" or "pipi," while on a white ground all agreed in calling the same grey "golegole."

Meyer's experiment showed very clearly that the natives were able to recognize differences of apparent brightness due to contrast and also that they could see red and yellow fairly readily as contrast colours. Green was seen less readily, and it was doubtful whether blue was seen at all by the majority. Considering the capacity of the natives, however, as observers and the readiness with which they distinguished faint reds and yellows in the tintometer, the observations seem to indicate that contrast colours were not very pronounced for them, and were probably less vivid than for the average European.

This conclusion was very strongly corroborated by one result of the observations with the tintometer. When working with this instrument with Europeans to determine the threshold of colour in the way already described, I have continually met with instances where the aperture in which there is no glass has appeared in the contrast colour complementary to that of the aperture in which a coloured glass has been placed. Over and over again the contrast colour has been seen when the objective colour of the glass has not been recognized.

Thus to give a few instances, A. E. T. in 12 observations with the yellow glass in one aperture, saw the opposite aperture blue every time, although he only recognized the objective yellow six times; W. F. in ten observations with a blue glass saw the opposite aperture yellow four times while only recognizing blue three times; A. L. in ten observations with a red glass saw the opposite aperture green nine times while only recognizing the red colour five times. In many of these and other instances the subjective contrast colour was seen when the objective colour failed to be recognized.

The behaviour in Murray Island was very different. I was on the look out for this peculiarity and yet in many hundred observations, a colour was only stated to be seen on the wrong side 15 times. No less than six of these occurred with a blue glass when the opposite aperture was called "bambam"; in one case the opposite aperture was called red. The aperture opposite the red glass was called "bulubulu" four times and giazgiaz once; opposite a yellow glass, blue was seen twice, and red once.

Some of these were no doubt accidental, but it is interesting that the instance which occurred most often was when the objective colour was blue to which they seemed so insensitive.

There is just a possibility that the natives with their sharp powers of observation were always able to detect in which aperture a glass had been placed and limited their observation to this aperture, but it is by no means easy to do this, and I have very little doubt that the observations with the tintometer show that the natives perceived contrast colours less readily than the average European.

After-images.

Two methods were employed to ascertain if negative or complementary after-images could be seen.

In one a patch of coloured paper on a grey ground was removed after 10 to 20 seconds fixation, when the complementary colour would be seen on the grey background. In the other, which may be called the indirect method, a grey patch was fixed on a coloured background from 10 to 20 seconds, and then a grey surface was superposed on the whole, when an after-image of the original patch would be seen in the same colour as the original background while the surrounding part would be seen in the colour complementary to the background. The patches used in both cases were in zigzag form, and the native pointed with a pencil to the place where he saw the after-image colour. In all cases in which the natives said that they saw a colour after the original stimulus had been removed, this was described as being of the colour complementary to the original. Red here again was most readily seen, and blue was doubtful.

Of the two methods, there was no doubt that the after-image was seen most readily by the second or indirect method. Several men who failed to see an after-image at all by the direct method, saw it well by the indirect method. In this second method a coloured after-image is seen in an area of the visual field, which has only been objectively stimulated by white light, and may be regarded as an after-image of the contrast colour. It is a mixed phenomenon of after-image and contrast (or, as they may be called, "temporal and spatial induction[1]").

Preference for colour.

I endeavoured to find which colours the natives preferred by asking them to pick out the papers they liked best. In most cases they were told to choose the three papers they preferred, while in some cases I made them go through the whole set of papers in the order of preference. I felt less confidence in this than in almost any other of my investigations, owing to the absence of any means of finding out whether they really understood what I wanted. I have omitted the answers of several which seemed doubtful. One of these answers was distinctly interesting from another point of view. One man, Papi, when asked to give me the papers in the order in which he liked them, gave them in almost exactly the same order as that in which I had previously given them to him when ascertaining his names for colours. It was an interesting example of the good observation and memory of the natives, though unsatisfactory from the point of view which I had in mind.

I found it interesting to get several natives together and let them discuss the subject of preference among themselves. They would usually get very interested, and, after a discussion often lasting for some time, would give me their conclusions. They may, of course, have been discussing something else, but, except in a few cases, they gave me the idea of having thoroughly understood. It is interesting in these cases

[1] Schäfer's *Text-book of Physiology*, vol. II. p. 1062.

that they never finished by agreeing with one another, but each gave his independent opinion. This also occurred in two cases in which a man and his wife gave their opinions; thus after a friendly discussion between Debe Wali, our servant, and Kaima, his wife, Debe Wali chose red, violet, and purple in order, while Kaima chose purple, orange, red. Of another married pair, Wag chose purple, indigo and yellow, while his wife, Kamoni, chose red, purple, and yellow[1]. 20 men and two boys were questioned. Among these red was distinctly the favourite, having 9 firsts, 2 seconds, and 1 third; purple, 2 firsts, 5 seconds, and 3 thirds; indigo had 4 firsts, 5 seconds, and 1 third; black, 1 first, 4 seconds, and 3 thirds; yellow, 2 firsts, 3 seconds, and 2 thirds; while the green, blue and violet were rarely chosen.

Among the women, red and purple were the most popular, with 4 firsts, 3 seconds, and 2 thirds, while yellow and indigo were each chosen twice; black had the third place once, and green was not chosen at all.

As I have already said, these results were unsatisfactory, in that I had no means of testing how far they were reliable till it occurred to me to study the preference for colour in another way. On several Sundays I noted down the colours worn by the people in church. This was most easily done in the case of the men. The orthodox Sunday costume of the men in the absence of a coat consisted of a singlet and pair of trousers with scarves round the neck and waist. These scarves were purely in the nature of ornament, and should be a good indication of the preference of colour. It came out very clearly that black was the most popular. On three Sundays the numbers for the neck scarves were: black 24, and red 8; green, 4; blue, 2; for the waistbands: 7 black, 4 red, 6 pink, 8 green, 4 blue. Those who did not wear trousers wore loincloths, which were most often red. I did not note any black; 9 were red, 2 pink, 4 white, 1 blue, and 2 yellow. On other occasions when I did not keep a record I noted that black scarves were clearly the most numerous.

It was much more difficult to keep a record of the colours in the case of the women, owing to their dresses having more mixture of colour, but there was a very obvious preponderance of red. On two Sundays I noted 28 red dresses and 3 pink, while many white or whitish dresses had red edges, etc. Blue was the next most common colour, 16 being noted, while of yellow, 8 were noted. There was a marked absence of green.

I was inclined to regard the frequency of black among the papers chosen by the men as a very doubtful feature, and as indicating that they did not understand properly what was wanted, but when I found that black was so predominant in their personal adornment, it became no longer unsatisfactory, and may be taken as an indication of a real liking for this colour (or absence of colour). It is quite possible that the preference for black may have been a passing fashion, for the savage is as much under the sway of changing fashion as his European brethren. In any case I have no doubt that the liking for black is quite modern, and is due to European influence. It is possible that the frequency with which this colour was worn was due to the introduction of the idea of wearing black for mourning, but unfortunately I did not inquire into this

[1] These results were in agreement with many others, showing that these natives have a very considerable amount of independence of opinion and by no means follow blindly the opinions expressed by others.

point. The blues worn were saturated, and closely resembled in colour the indigo paper which so many preferred. The undoubted popularity of this colour may seem to be in conflict with the idea I have advocated that blue was a dull dark colour to these people, but when one also takes into account the popularity of black, no great importance can be attached to this point.

The two methods differed very distinctly in respect of green; the green papers were hardly ever chosen, while green was not at all unpopular as an adornment among the men. The difference is, however, readily explicable: the green ties and sashes worn were of a very brilliant, vivid colour, while the three green papers of Rothe's set are very dull and unsaturated. Indeed the chief fact shown by the two methods, in addition to the popularity of black, was that a colour must be brilliant and saturated to be popular, while among saturated colours red easily had the first place, followed by blue, while yellow and green were distinctly less favoured.

When two or more colours were worn together, these were usually fairly harmonious with one another. Complementary colours were commonly worn together, yellow with blue and green with red. Some men from Kiwai, who came one day in hideous red and yellow jerseys, presented a very striking contrast with the Murray Island inhabitants. We took with us from Thursday Island some very unaesthetic garments as trade, but none of the natives would look at them.

I tried to make a few observations on the appreciation of colour harmony, giving the natives combinations of different wools and asking which they liked best. There were obviously marked individual differences. When asked whether a yellow wool looked better with a scarlet or with a blue wool, Pasi preferred the latter, while his daughter was quite certain that the former was the prettier; the man certainly seemed to have the better taste. Unfortunately I had not time to make any extended observations on this point, but it is probably one that would be well worth attention.

Observations on Melanesians and Australians.

Four men from the Island of Tanna were tested and also three young men who had Tanna fathers and Mabuiag mothers. None were colour-blind, the matches with Holmgren's wools being of the same kind as those made by the Torres Straits people, *i.e.* they tended to confuse blue with green, red with pink, and to match violet with neutral wools. One man, Nauwi, matched one violet with the pink test in his first trial but on a second occasion was perfectly normal.

The men came from three different districts of Tanna and spoke different dialects. Two of the four men belonged to the Weasisi district, one to Kwamera and one to Inangi. The two Weasisi men agreed in calling black, tapen[1] or taben; white, taruan, and red, purple and orange, tarauaru. About the names of the other colours they did not agree; yellow was called tauia, tapuil and takilum; green was called tauia, tamimīta and tamemta; blues were called tamimita or tamemta; violet was called tapen (black), and takilum: the pale green and violet test wools were called taruanmatang

[1] The "t" in these words is verbal. "T-apen" means properly "it is black."

(whitish); browns were called tapen (black), tapenmatang (blackish) and takilum, a word used also for violet and yellow. The indigo paper was called manul by one man and margilum by the other, but the different form of these words suggests that they were not colour names.

The Kwamera man called black, rapita[1]; white, rabesan: red, tarueru: orange, nafarian: yellow and green, tamera; blue, rapita (black) and ramita: indigo, tamera: violet, ramita: browns, rapita and tamera. It will be noticed that this man used the same word for red as the Weasisi men. Tamera, used for yellow, green, indigo and brown, is derived from mera, blood, with the Weasisi prefix.

The Inangi man called black, rapen; white, ratuan; red, laulau[2]; purple, laulauakin and laulaumeruk; orange and yellow, lauiha and lauihameruk: green, ramimera; blue, ramimeraakin: indigo, ramimera-ramimera; violet, ramimerabuk; browns, rapenmeruk, rapenakin, and ramita, the last word having been used by the Kwamera man for blue and violet. The vocabulary of this man is remarkable for his free use of qualifying suffixes, red, purple, orange and yellow being all named by some modification of one word, while green, blue, and violet were named by some modification of another.

These vocabularies were obtained from too few individuals to be of any great value, but they agree with one another and with the Torres Straits languages in showing confusion between green and blue or between blue, violet and black. In none of the dialects did there appear to be a word for brown.

One native of "Duke of York" Island was tested. His colour vision was perfectly normal but he had left his native island so long that he could not give the "Duke of York" names for colours with any certainty.

One native of the island of Aneiteum who was examined had normal colour vision. The names he gave for colours agreed with those which are given by Inglis in his *Dictionary of the Aneityumese Language*, with the exception of those for blue and green. Inglis gives "emilmat" for both blue and green; my native gave this name to blue-green, and called the green papers mĕlemiseio, while the blue paper and wool were called ĕlĕmĕlemiseio, all being apparently modifications of the same word. Both violet and brown were called unjingunjing, also given by Inglis for both these colours.

One man was examined at Rockhampton from the small island of Nguna near Sandwich Island in the New Hebrides. He was not colour-blind, his matches with the wools being of the Torres Straits type. He called white, idari[3]; black, iloa; red and purple, imiala: yellow, lòlò[4]: green and blue either ngisakis or malinakis. Malin was said to mean "dark." He had been away from his native island for many years and his names must be taken with reserve.

Towards the end of our time in Torres Straits, I tested a man, named Sani, from Lifu in the Loyalty Group, and found that his matches with Holmgren's wools were distinctly indicative of red-green blindness. He matched red with brown: bright green

[1] The "r" and "ra" in this and the following dialect corresponds to the Weasisi "t." Ra-pita means "it is black."

[2] Codrington (*Melanesian Languages*) gives "lawlaw" as the word for red in several of the Banks' Islands.

[3] The prefix "i" is verbal; i-dari means properly "it is white."

[4] See Codrington.

with greens, but compared a yellow and a yellowish brown; he matched Holmgren's pink test-wool with blue and violet; Holmgren's green test with a salmon coloured wool; yellow was matched normally; blue was matched with violet and pink, and violet was compared with bluish-green wools. The next Lifu man whom I tested was a typical example of red-green blindness and I began to think that I might have come across a colour-blind race. I had unfortunately at this time no other means of testing, as the tintometer had been taken on to Sarawak, but I do not think there could be any doubt about the diagnosis.

I was able to examine one more Lifu man in Mabuiag but he was perfectly normal. Later I was able to find another Lifu man in Thursday Island and three men in Rockhampton. Two of these were perfectly normal; another was colour-blind, or at least had considerable weakness of the red-green sense; he closely compared the pink test with several blues and finally matched it with violet; he also matched violet with pink, and yellow with a yellowish green wool. The matches of the fourth man were suspicious, the pink test being compared with a blue wool though no faulty matches were actually made. Mr Seligmann found another Lifu man on Yam Island who was normal.

Of the eight Lifu natives tested, three were definitely colour-blind while the behaviour of a fourth was distinctly suspicious. When contrasted with the failure to find one case in Torres Straits, this fact is sufficiently striking. The difference certainly cannot be ascribed to any defect in the intelligence of the Lifu people. The natives I examined were certainly more intelligent than the average Torres Straits Islander, and I am inclined to regard them as the most intelligent natives that I came across. I may also mention that the colour-blind individuals were not related to one another, though one, Sani, and one of the normal natives were first cousins.

I was very anxious to find natives of Mare and Uea (or Uvea), the other two chief islands of the Loyalty group, but I was not able to do so. I was able, however, to test one man whose mother was a Mare woman (father Scotch), one boy whose father was a Mare man and one boy whose father was from Uea (mothers Mabuiag). The man compared the pink test with a violet wool on two trials, but otherwise his matches were of the Torres Straits type. The boys were both quite normal.

The number of Loyalty Islanders examined was of course too small to allow any definite conclusions to be drawn, but the observations certainly suggest that in this race colour-blindness was fairly common, and that races may exist in which colour-blindness is much more common than it is in European races.

The Loyalty people occupy, in some respects, an exceptional position among Melanesians. Mr S. H. Ray, to whom I am indebted for much information on the subject of Melanesian languages, tells me that the languages of Lifu, of Mare and of parts of New Caledonia have special and peculiar characters. There is also a considerable Polynesian element. It is, therefore, of considerable interest to find that these people appear to be exceptional in the nature of their colour vision, and the possibility is suggested that the examination of the colour sense may, in some cases, be of use in determining the affinities of different races.

The names for colours were obtained from both the normal and the abnormal Lifuans.

All the natives agreed in calling white, kawia[1], and black, kawĕtĕwĕt. The normal natives called red, kapalulu, kamunda and kamada. Mada or madra is the word for "blood," and munda was said to be the term for a ripe banana. Kamhint was used for orange and yellow; yellow was also called kahaith[2], a word used as well for brown and grey. One man called orange kamedimed, med or mhed being turmeric. Greens were called kahatuhatu, kahathihal, theilifa and maia. Blue, indigo and violet were called bulu, kawetewet (black), kamagau, kamungau and mungaukachau (nearly "mungau"). Browns were called kahaith, kawetewet (black), kahathihathi (hathi = smoke). The word "dĕla," which was said to be the name of the fur of the flying fox[3], was also used for brown and by one man was used for nearly all browns. It is the nearest approach which I have found among Melanesians and Polynesians to a word which could be regarded as a generic term for brown, but was only used in this way by one man.

The names were obtained from too few individuals to have much value, but it will be noticed that the tendency to confuse blue and black in nomenclature is distinctly present.

The names given by the colour-blind men tended to confirm the diagnosis of their condition. One called both red and indigo kapalulu, used by the others for red. Two men called both red and yellow kamunda, used by the normal individuals for red, and one of these called blue, indigo and violet ngunamaia, a word not used by any of the normal men but which, Mr Ray informs me, is usually used for purple.

Eighteen natives of Queensland were tested with Holmgren's wools and their names for colours obtained. Seven of these, examined on Mabuiag, came from the district of Seven Rivers on the east coast of the Gulf of Carpentaria; one came from Red Island; the remaining ten were examined at Rockhampton; eight of these belonged to the Fitzroy river district; another came from the McKenzie river and a boy from Connobie. The Fitzroy natives included two women.

The wool test was carried out with very little difficulty, the natives understanding readily what was required of them. Two men, one in Mabuiag and the other in Rockhampton, spontaneously arranged the wools before them in order of similarity and all took obvious interest in the process of matching. Their matches were of the same kind as those made by the Torres Straits natives. There was no red-green blindness; one man, Kurabarai, of Fitzroy, compared for a time a violet with the pink test-wool but refused to match it, and his other matches were quite normal. The same kinds of confusion occurred as in Torres Straits; four men were put down as perfectly normal, six put red and pink together, eight confused green and blue, five confused blue and violet, two put very faint pinks with violet, most matched wools of very faint saturation with Holmgren's green test, but all these matches were of the kind that can

[1] "Ka" is an adjectival prefix.

[2] The consonant which I have written "th" was a very soft sound, like the "th" in "the" but much softer. Mr Ray informs me that the missionaries use "j" for this sound. I found the sounds of the Lifu language much more difficult than those of any other Melanesian or Polynesian language of which I had experience and my spelling must be taken with reserve.

[3] The use of this word is interesting in that the reddish fur of the flying fox (Pteropus) is twisted by the natives of the Loyalty Islands into a cord which is used as currency. This is another example of the fact that it is mainly objects of practical importance which give rise to colour names (see p. 63).

be explained by the influence of language while they also point towards some degree of insensitiveness to blue and green as compared with other colours. The two women were very good; one was absolutely normal, while the other only confused blue and green slightly.

The eighteen natives examined spoke several languages and I was not able to examine a sufficient number in any one language to enable me to speak about the colour vocabularies with anything like the confidence that I feel in the case of the Torres Straits languages, but a certain number of points came out so definitely that there can be little doubt about them. There was rather more difficulty in getting the natives to understand that I wanted the names for colours than was experienced with the wool matching; they nearly all gave me their names for paper and calico respectively when I showed them the papers and wools. The difficulty in this respect was certainly greater than in Torres Straits, but was probably due to their very scanty acquaintance with English.

Three of the Seven Rivers natives agreed in calling red, purple and orange ŏti, said to be the word for blood; white, yellow, and the three green papers were called yŏpa; black, blue, indigo and violet were called either unma or manara. Two other natives, who both came from the district of Otiangu, called red owang or owangatidlau, but one of these called it also "ŏti." Black, blue, indigo and violet were called "unma"; white and pale colours were called "wăpŏk"; yellow and green were called ejin by one and ejin or wapok by the other. Ejin was also used by both for dull colours. Browns were called ejin or unma. Most of these natives, who probably spoke dialectical variations of one language, seemed to agree in having only three definite words in their colour vocabulary, viz. oti or owang for red and colours containing red, yopa or wapok for white and light colours, and unma, or manara, for black and dark colours. Manara was the word used for the colour of the skin.

Another native of the Seven Rivers district, Pantagitta, who said he came from a place called Rogovino on the Ducie River, gave altogether different names. He seemed very intelligent and I therefore give his names although they must be taken with all reserve. Red and purple were called meiwinta; yellow and green were called talowat; orange was called meiwinta and talowat; white, kawat; black and indigo were called ngo or arau; green and blue were called ngodop; violet was called ngo and arau and also awăti. The confusion of nomenclature for blue and black was distinctly present but the vocabulary appeared to be more extensive than that of the other natives, though it is of course possible that some of the words were not colour names at all.

The one man from Red Island, Jimmy Matauri, had a fairly extensive vocabulary. Red was called lokoko, meaning blood: orange, yeyia, meaning sunset; yellow, amoatiyeta, a flower; green, wŏwia (a cloud) or atia (a tree); blue, iping malu or malu; black was called manara and white yŏpa; browns were called manara. It will be noticed that his names for black and white were the same as those used by many of the Seven Rivers natives on the other side of the peninsula and that his word for red was derived from the word for "blood[1]." His other colour terms were probably

[1] His word for blue was almost certainly borrowed from Torres Straits.

of the same nature as those used so often in Mabuiag and were the names of natural objects suggested to him by the colours.

The eight Fitzroy River natives examined at Rockhampton agreed fairly well in their colour nomenclature; five called red kiran, two others tarir, and one both kiran and tarir; purple was called kiran or tarir by all but one, who called it namuru, said to mean pale. Orange and yellow were called kalmur or kalmurkalmur by nearly all: green and yellow-green were called kalmur by several and also guru (black), bura (white), moalmoal, kirpei, and wuralwural (one man called red, yellow and green kiran). Blue-green was called kalmur, moalmoal, guru, and guru-ndauer: blue was called guru (black) by all. Indigo was also called guru by most; one called it "bulu," another ngöinngöin, another both ngöin and bulu, while another native, to whom I suggested ngöin as a name, was very obviously pleased with its suitability. Violet was called guru, bulu and kalmur. All agreed in calling white bura, and black guru[1].

The native from the McKenzie River, an elderly man, called white boija: black, mita: red and purple, minma: yellow, namuru; greens, wobol and namuru; blue, indigo and violet, mita (black).

It will be noticed that, in addition to definite words for red, white and black, the Fitzroy natives had a name "kalmur" which they used for yellows and greens; it was also used by one man for violet and does not seem to have been so definite as the word for red. There seems to have been most variation in the names for green, but I was unable to discover the derivation of the various words used. Blue and indigo were called black by the majority; I do not know the meaning of the other word used for these colours, ngöin. Several of the Fitzroy natives who called red kiran, appeared to be wholly unacquainted with the word "tarir" which was used by others, and this word probably belonged to another dialect, or may possibly not have been a colour name. It will have been noticed that one Fitzroy native used the word "namuru" which was otherwise only used by the McKenzie River man.

The boy from the Connobie district who was examined had been taken away from his own district when young and did not know the colour names of his tribe.

I cannot guarantee the accuracy of these vocabularies as I can those of the Torres Straits languages, but I think there can be no doubt as to the main features of the colour terminology of these tribes. In all cases there were definite words for black, white and red, the word for red being used also for purple, and in some cases for orange. The Fitzroy natives seemed to differ from those of Seven Rivers in that a fairly definite name for yellow and green had also been evolved. Blue and violet were by nearly all given the same name as black. There appeared to be no trace of a word for brown.

These main features appear to be generally characteristic of Australian languages. Kirchhoff[2] found that some natives of the Frazer River in Queensland only had definite names for white, black and red, the word for black being used for blue and dark colours in general. In addition to these definite colour names, Kirchhoff obtained as

[1] It was very difficult to distinguish between the k and g of the natives. Kiran was often much more like giran and guru like kuru.

[2] *Das Ausland*, S. 546. 1883.

many as 70 names, which were almost certainly of the same kind as those used in Mabuiag, and it is possible that with more complete investigation I should have found the same with my natives. In the Middle Burnett district in Queensland, Semon[1] only gives names for black, white and coloured. Roth[2] states that the natives of North-West Central Queensland have definite names for red and yellow, and that blue is very often confounded with black, so far as nomenclature is concerned. It is perhaps worth noticing that in the comparative vocabulary given by Matthews in *Eaglehawk and Crow*, only the words for red, white and black are included.

The Australian languages present a lower stage of evolution than was found in Torres Straits. In what one may regard as the lowest of the three Papuan languages, viz. that of Kiwai, there were certainly definite terms for red and yellow, while green was probably in process of being distinguished by a special term. The Fitzroy language may seem, so far as my evidence goes, to be one in which a term has come into use for yellow and green, these colours being still classed together, while in the Seven Rivers languages the definite colour vocabulary appears to be limited to three terms. This stage of the evolution of colour language has been found in other parts of the world. The Todas of the Nilgiri Hills are said only to have words for white, black and red[3]. Riis[4] states that the people speaking the Akwapim dialect of the Tshi language in West Africa only have three adjectives for single colours, viz. fufu, white; tuntum, black; and koko, red. They call blue "brû," obviously a corruption of the English word. According to Buchner[5], the Bantu have only three words for colours, one for black, which also means blue, one for white, which also means yellow and light, and one for red. Moncelon[6] states that the natives of New Caledonia only have definite terms for black, white and red.

General results.

The first general result of these investigations on colour vision is to show that the ordinary form of colour-blindness in which red and green are confused does not occur or is extremely rare in Torres Straits. This opinion is based not only on the results of the tests with Holmgren's wools, but on the observations made with the tintometer. In every case examined with this instrument there was a high degree of sensitiveness to red, and the partial insensitiveness to red, which seems not uncommon among Europeans (apart from definite colour-blindness), was not once found in Torres Straits. The other tests used also failed to show any indication of red-green blindness. These results contrast very strongly with those obtained from the few natives of the island of Lifu examined. The numbers were too small to allow any generalization, but it is sufficiently striking that three out of eight Lifuans should be colour-blind while 150 natives of another race should be wholly free from this defect.

[1] *In the Australian Bush*, p. 219. 1899.

[2] *Ethnological Studies among the North-West Central Queensland Aborigines*, p. 116. 1897.

[3] Magnus, *Untersuch. ü. d. Farbensinn d. Naturvölker*, 1880.

[4] *Elemente des Akwapim-dialects der Odschi-sprache*, Basel, 1853.

[5] *Das Ausland*, Jg. LVI. S. 448. 1883.

[6] *Bull. d. l. Soc. d'Anthropol.*, Paris, IX. p. 708. 1886.

A considerable number of investigations have been made on different races, which all tend to show that colour-blindness is much rarer in many races than it is among Europeans.

Schellong[1] notes that the colour sense of the natives of German New Guinea is excellent, but no definite observations have been previously made on Papuans. With the exception of the observations already mentioned on inhabitants of the Loyalty Islands, we have no definite evidence as regards colour-blindness among the Melanesians.

In the African division of the Negroes, some observations have been made. Among 57 Congolese, 44 male and 13 female, examined by Pergens[2], none were colour-blind. Of about 50 Nubians examined at different times and by different investigators in Germany, none were found to be colour-blind except the one man already mentioned (p. 51), who was said to be an example of yellow-blue blindness.

König[3] examined three Zulus in Berlin, and these observations are interesting, in that the natives were examined with a spectral apparatus (Helmholtz's Leucoscope), and were found to have normal colour systems like those of Europeans.

Observations have also been made on the African negro in America. In the Sanitary Memoirs of the war of the American Rebellion[4], Gould gives the amount of colour-blindness among full blacks as 1·1 per cent., while among white soldiers it was 2·2 per cent., among sailors only ·4 per cent., and among students only ·3 per cent. His methods were, however, very unsatisfactory, and he includes cases of confusion between green and blue among his colour-blind. Burnett[5] examined 3040 Negro children by Holmgren's method, and found among 1349 boys 1·6 per cent. colour-blind, and among 1691 girls only ·11 per cent.

Among Polynesians a large number of observations have been made on Hawaians. Brigham[6] quotes (from the *Hawaian Gazette* of Nov. 16th, 1881), that among 394 males, five cases of colour-blindness had been found, viz. 1·25 per cent. There was no case among 103 females. Stephenson[7] examined 30 Hawaian men, 65 boys and 96 girls without finding one case. Seggel[8] found four Hawaians who were tested in Munich to be normal.

A large number of Chinese and Japanese have been examined. Fielde[9] examined with Thomson's arrangement of Holmgren's wools 600 Chinese men, finding 19 colour-blind (3·17 per cent.) and 600 women, of whom only one was colour-blind. These observations appear to have been very carefully made. Stephenson[10], on the other hand, only found one case of colour-blindness in 1059 Chinese, though all tended to confuse green and blue. According to a note in the *Lancet* (1882, I. p. 76) MacGowan examined 1000 Chinese without finding one case of colour-blindness.

[1] *Zeitsch. f. Ethnol.*, Bd. XXIII. S. 156. 1891.
[2] *Janus*, 1898, p. 459.
[3] *Verhandl. Berlin. physikal. Gesellsch.*, 1885, S. 16.
[4] *Military and Anthropological Statistics*, New York, 1869, p. 527.
[5] See Jeffries, *Colour-blindness*, Boston, 1879, p. 68.
[6] *Das Ausland*, 1882, S. 337.
[7] *Mitth. d. deutsch. Ges. f. Natur- und Völkerkunde Ostasiens in Tokio*, 1894, Bd. VI. S. 190.
[8] *Correspond.-Blatt. d. deutsch. Ges. f. Anthrop.*, 1894, Bd. XXV. S. 52.
[9] *The China Medical Missionary*, 1890, vol. IV. p. 61, quoted by Stephenson.
[10] *loc. cit.*

Stephenson also gives numerous observations on the Japanese, partly made by himself, partly by Prof. J. C. Berry, and partly from the official army reports. Among 2169 males from the different sources, 57 (2·6 per cent.) were either definitely colour-blind or had defective colour sense. Of 270 Japanese girls examined by Stephenson, one was colour-blind and three had weak colour sense (confused blue and purple).

Stephenson[1] also examined 50 Koreans and 213 Annamese without finding one case of colour-blindness. In 45 male and 35 female Siamese, he found one boy colour-blind.

Among 476 male Malays, Stephenson found only one boy colour-blind. He also gives observations on 121 Eurasians (whose mothers were probably Malay) whose colour vision was normal.

In North America the only observations with which I am acquainted are those by Webster Fox[2] on 250 young Amerinds of whom 161 were males. He found three cases of colour-blindness. Two were half-brothers, sons of a Cheyenne chief by different mothers, while the third belonged to the Sioux.

In South America, Rios[3] examined 1200 males and 320 females, natives of Argentina. Among the males he found 3 per cent. of the boys and 2·1 per cent. of the men colour-blind. There was no case among the women. Kotelmann[4] examined three Patagonians in Germany. Their colour vision was normal.

I have been able to find very few references to examinations for colour-blindness in India. I have examined at Kandy and Colombo 21 Tamils and six Sinhalese (all males) whose colour vision was normal. Stephenson[5] found two cases of colour-blindness among 55 Tamils. Kotelmann[6] examined 14 Sinhalese males, six Sinhalese females and three Hindu men, none of whom were colour-blind.

More extensive observations have been made on the races inhabiting the sub-Arctic regions. Among 125 Eskimo examined by Almquist[7] only one was found to be colour-blind, and of 18 Labrador Eskimo examined by myself in London, none were colour-blind[8].

Among 31 Aleuts (30 females and one male) examined by Stephenson[9] there was no case of colour-blindness.

Nine Lapps were examined by Kotelmann[10], 15 by Seggel[11] and 20 by Almquist, none of whom were colour-blind. On the other hand, Rabl-Rückhard[12] states that Swedish surgeons have found 6·32 per cent. of colour-blindness in 158 Lapp men and ·9 per cent. in 111 Lapp women.

[1] *loc. cit.*
[2] *Philadelphia Med. Times*, 1882, vol. XII. p. 346.
[3] Quoted by Havelock Ellis, *Man and Woman*, p. 143.
[4] *Berlin klin. Wochensch.*, XVI. S. 701. 1879.
[5] *loc. cit.*
[6] *Zeitsch. f. Ethnol.*, Bd. XVI. S. 164. 1884.
[7] Quoted by Holmgren, *Upsala Läkareförenings förhandlingar*, Bd. XV. p. 222. 1880.
[8] *Proc. Camb. Philos. Soc.* vol. XI. p. 143. 1901.
[9] *loc. cit.*
[10] *Berlin klin. Wochensch.*, 1879, p. 701.
[11] *Corresp.-Blatt. d. deutsch. Ges. f. Anthrop.*, XXV. S. 51. 1894.
[12] *Zeitsch. f. Ethnol.*, Bd. XII. S. 210. 1880.

Kirchhoff[1] found no colour-blindness in a group of Samoyeds, and Almquist found ten men of the same race normal.

Almquist[2] examined 300 Chukchis very carefully by Holmgren's method and found nine completely colour-blind (*i.e.* red-green blindness). In 18 others there was either incomplete colour-blindness or the result was uncertain.

Of the races of Central Asia, Kotelmann[3] examined 19 Kalmuks (11 males and eight females), all of whom had normal colour vision.

Giltschenko[4] examined 164 Ossets of the Caucasus, of whom none were colour-blind.

Before considering the foregoing results, it may perhaps be as well to sound a warning note about investigations for colour-blindness. Holmgren[5] in recommending his method for collective investigations suggested that it should be simplified, and thought that 100 individuals might be tested in an hour. Investigators who have gone to work among uncivilized races with this advice in their minds will probably have obtained very unsatisfactory results, and the very large numbers examined in some cases suggest that the difficulties and possible fallacies may not have been recognized.

I am quite certain that the influence of language in testing cannot be wholly excluded, however much one may try to do so and that faulty wools are sometimes put together, not because an individual really regards them as closely similar to one another but because he gives the same name to both. This fallacy, however, will not account for the absence of colour-blindness which is the striking feature of the investigations cited. It will have been noted that among some nations as the Chinese, discrepant results have been obtained. Many of the workers whom I have cited give no indication of their methods. In the case of China, Miss Fielde has given details of her method and results and there can be no doubt that, at any rate, some of her cases of colour-blindness were genuine. In the reports of MacGowan's and Stephenson's work, on the other hand, we have merely a bare statement of the fact that they found no or few cases. No indication is given that they observed any of the interesting features which a really careful examination would almost certainly have brought to light. Of the other investigations cited, the most complete and satisfactory appears to have been that of Almquist on the Chukchis. It is perhaps noteworthy that both in this investigation and in that of Fielde the proportion of cases of colour-blindness in males was not widely different from that found among Europeans (viz. about 4 per cent.) In many investigations which were no doubt satisfactory as regards method (such as those of Kotelmann and Pergens) the numbers are hardly sufficient to allow one to draw any definite conclusions. It certainly seems, however, as if colour-blindness must be distinctly rarer in many races than it is among Caucasian and Semitic peoples.

[1] *Das Ausland*, 1883, S. 546.
[2] *Die wiss. Ergebnisse d. Vega-expedition*, Bd. I. S. 42. 1883.
[3] *Zeitsch. f. Ethnol.*, Bd. XVI. S. 77. 1884.
[4] *Biolog. Centralbl.*, Bd. XV. S. 304. 1891.
[5] *Centralbl. f. prakt. Augenhlkd.*, 1878, S. 177.

The striking contrast presented by the natives of Lifu with those of Torres Straits at once suggests that the existence of colour-blindness in a race might be of great importance as an ethnic character, and the other data also tend to show that colour-blindness may be a characteristic of certain races and the existence or absence of this defect may help us in the difficult task of deciding on ethnic affinities.

In spite of large advances in our knowledge of red-green colour-blindness, we are still almost wholly ignorant of the physiological conditions upon which it depends. In the case of the rare condition, total colour-blindness (in which all colours are confused with one another), we now have a good clue to its physiological nature[1] but the common form of the defect is still shrouded in mystery. Some writers (Haycraft[2], Ladd Franklin[3]) have supposed that colour-blindness is an atavistic condition, and this view has been supported by the fact that the vision of the peripheral retina of the normal individual very closely resembles the vision of the colour-blind man. It has been supposed that at one stage of our development, the whole retina was red-green blind and that the power of seeing red and green has developed late and is still limited to the central region of the retina. The observations on the more primitive races of mankind give no support to this view. The evidence so far as it goes is rather in favour of the view that the sensibility for red developed earlier than that for other colours.

Although the ordinary form of colour-blindness was absent in Torres Straits, the colour vision of the Papuans and of certain other races examined was certainly not of the same type as that of Europeans. I may here shortly sum up the reasons which have led me to conclude that the colour vision of the Papuan is characterized by a certain degree of insensitiveness to blue (and probably green) as compared with that of Europeans. To start with the defect of language; the races examined by me had either no word for blue or an indefinite one, while their nomenclature for red, and usually that for yellow, was extremely definite. The philological argument is, however, not a very strong one, for the defect of language might depend on many factors of which, however, physiological insensitiveness may be one. One cannot, however, wholly ignore the fact that intelligent natives should regard it as perfectly natural to apply the same name to the brilliant blue of sky and sea which they give to the deepest black. I cannot help, too, attaching importance to some of the instances of nomenclature met with in Mabuiag. I have already described how many of the older natives of that island compared every colour to some natural object, apparently showing, as regards most colours, a high degree of appreciation of differences of hue and shade, and yet these natives would deliberately compare a brilliant and saturated blue to the colour of dirty water or to the darkness of a night in which nothing could be seen. Every detail of the behaviour of the natives in connection with the naming of colour was consistent with the idea that blue was to them a darker or a duller colour than it is to us.

The behaviour with Holmgren's wools pointed in the same direction; blue and

[1] See Schäfer's *Text-book of Physiology*, vol. II. p. 1102.

[2] *Proc. Roy. Soc.*, Bd. LIV. p. 272. 1893.

[3] *Proc. Internat. Congress Exp. Psych.*, London, 1892, p. 105.

green were constantly confused: violet was matched with neutral or faintly pinkish wools; a saturated blue was occasionally confused with dark, or dull colours; the matches, while showing that they could certainly see blue and distinguish it from other colours, were yet in most cases consistent with the view that there was a certain degree of insensitiveness to this colour.

The quantitative observations with the tintometer give still more definite evidence They show that the Murray Island natives distinguish red when very faint much more readily than blue, while, by the same method, to European vision there is little difference. Unfortunately one is only justified in using this test as a means of determining the relative degree of sensitiveness to red and blue, but the observations show either that the Murray Islander is relatively much more sensitive to red than the European, or much less sensitive to blue. Probably he is both more sensitive to red and less to blue, but the deficiency in the latter respect is probably much greater than the superiority in the former.

On the other hand, the fact that the native of Torres Straits recognizes a saturated blue readily in indirect vision, must be regarded as evidence in the opposite direction, and I have already mentioned the conclusion which this fact renders possible, if not probable, viz., that the defective sensibility to blue which I believe to characterize Papuan vision may be a function purely of his pigmentation, may be due to the relatively greater absorption of blue (and green) rays by the pigment of the region of central vision.

The bearing of this on the controversy mentioned at the beginning of this paper is obvious. In ancient literature, as among modern barbarous and savage races, it is the colour blue for which nomenclature is especially defective, and in Torres Straits this characteristic defect of nomenclature has been found to be associated with an appreciable degree of insensitiveness to this colour. The colour vision of the Torres Straits islander gives some support to the views of Gladstone, Geiger and Magnus[1] that the defective colour language of ancient literature may have been associated with a defective colour sense.

There can be very little doubt, however, that any physiological insensitiveness which may exist, can only be one of the factors determining the characteristic features of primitive colour nomenclature. The deficiency which I have found in Torres Straits is only partial, and even if one were to assume that other races would show the same peculiarity, this partial deficiency could not wholly account for the total absence of a word for blue which is a feature of so many languages. To the European eye there is a much closer resemblance between blue and black and between green and black than there is between red and black and yellow and black, and this psychological fact was the basis of the theory of colour put forward by Goethe. The fact that this difference exists, alone goes far to explain the earlier discrimination of red and yellow in primitive language.

Another important factor has probably been the distribution of pigments. I have

[1] I cannot here go into the whole question of the historical evolution of the colour sense in man. I have given a short account of the present state of the controversy in an article in the *Popular Science Monthly*, vol. LIX. p. 44. 1901.

already mentioned that it is a characteristic of primitive races to have special names for every natural object. If the savage has a special name for every coloured object, he will not require names for the abstract idea of colour. It is possible that it is only when he begins to use pigments that he begins to require names for colours. There can be very little doubt that the earliest pigments used by man were red, probably as a substitute for the blood which has so prominent a place in all savage rites and ceremonies. The wide distribution of red and yellow pigments probably helped to give these colours their prominent place. In Torres Straits there were both red and yellow pigments, but no green pigment was known, and the nearest approach to a blue pigment was a bluish-grey clay, "kobegud," which gave the derivation for one of the words used for grey, and in many other parts of the world blue pigments appear to be quite unknown.

Previous writers[1] have insisted on the importance of pigments in relation to colour nomenclature, but K. v. d. Steinen[2] believes that the distinction of colours by names to be later than the use of pigments, on the ground that among the Bakaïri of Central Brazil the names of colours (except red) do not belong to the original Carib language and have a form which bears the stamp of newness.

Another factor which may have contributed to the causation of the indefinite nomenclature for blue and green is the absence of æsthetic interest in nature on which I have already commented (p. 64). The blue of the sky, the green and blue of the sea, and the general green colour of vegetation do not appear to interest the savage. It is the individual objects which he can take in his hands and use in his daily life which interest him, and it is to the attributes of these that names are given.

[1] See Grant Allen, *The Colour Sense*, 1879, p. 254.

[2] *Unter. d. Naturvölkern Zentral-Brasiliens*, Berlin, 1894, S. 421.

4. VISUAL SPATIAL PERCEPTION.

VARIOUS observations were made on the perception of spatial relations. The subject investigated included:—binocular vision tested by means of Hering's fall experiment; double images; binocular movements in newly-born children; estimation of the length of a distance by the eye; accuracy of division of lines into two, three or more equal parts; quantitative estimation of two geometrical optical illusions, viz., that produced by the erroneous estimation of vertical as compared with horizontal distances, and the illusion known by the name of its first describer, Müller-Lyer. In addition rough observations were made on other geometrical optical illusions, on the apparent size of the sun and moon at horizon and zenith, the blind spot, and on the appearance of relief due to difference of colour.

BINOCULAR VISION.

The most satisfactory method of determining the existence of binocular vision is to use Hering's fall experiment. In this experiment the observer looks through a large tube at a fixation point placed on a thin vertical wire. Small objects such as balls are then made to fall through the field of view at different distances from the observer, who has to state whether the falling object is nearer or farther from himself than the fixation point. Those with binocular vision are able, when using both eyes, to estimate the relative distances of such objects even when quite close to the fixation point, while individuals without binocular vision are in the same position as normal individuals when only using one eye, and are unable to judge the relative distances of the falling objects even when much nearer or farther than the fixation point. The necessary apparatus was constructed of cardboard with the bead which was used as a fixation point at a distance of two feet from the eyes. Shot varying in size was used as the falling object.

In the first few observations I obtained indefinite results, but this was found to be due to the fact that we were using the English expressions "close up" and "far away." The former was equivocal and might mean "close to the fixation point" as well as "nearer than the fixation point." I then made use of the native expressions "maike" (near) and "murizge" (far) with perfectly satisfactory results.

Seventeen individuals, nearly all men, were examined and, with one exception, gave definite results. With both eyes open, they were able to say whether the falling shot was "maike" or "murizge" correctly every time or nearly every time; while, with only one eye open, they were as often wrong as right. The one exception was a man named Charlie Boro who suffered from a tumour of the right orbit. The visual acuity of the right eye was fairly good, viz. $\frac{7}{5}$ (E method) as compared with $\frac{8}{5}$ for the left eye, but he always wore a shade over this eye. He answered "maike" and "murizge" alternately all through. This man never cared about making visual observations (though ready enough in other matters) and it was possible that he was not trying to be correct, and I should not therefore like to say that his failure was due to disuse of one eye.

One or two features in the observations of the others may be mentioned. Wrong answers with both eyes open were only given when the falling shot was quite close to the fixation point, while answers were often wrong with one eye when the distance between the falling object and the fixation point was as much as one foot.

A few natives called the falling shot "murizge" when at the same distance as the fixation point, and "okakis" (equal distance) when it was really somewhat nearer. This only occurred in a few individuals, but with them it was constant, and no case was noted in which the falling shot at the same distance was called "maike" or in which it was called "okakis" when slightly farther. It is perhaps worth noticing that this result is in accordance with the concavity of the horopter[1] at the distance of two feet from the eyes. The falling objects were necessarily to one side of the fixation point, and the form of the horopter may very well have influenced the answers. The shot used in these observations were much smaller objects than those ordinarily used in Hering's fall experiment and this smallness would allow the concavity of the horopter to make its influence felt.

If one uses balls of different sizes in Hering's fall experiment it is found that in monocular vision the answers are influenced by the size; large balls tend to be estimated as nearer and small balls as farther. I observed no trace of the influence of this factor in Torres Straits, but the shot used only differed from each other slightly in size, and the difference may not have been sufficient to have any influence.

The fact that the experiment succeeded readily with such small objects as the shot used, may be taken as evidence of good acuity of vision or sharpness of observation. Unfortunately the test was not tried in any of the cases of marked subnormal acuity.

Another point, closely related to the preceding, which was tested in a few individuals, was the power of observing double images. I was unable to ascertain whether double images had ever been observed spontaneously by any of the natives, but I satisfied myself that both men and children were able to observe them.

[1] See Schäfer's *Textbook of Physiology*, vol. II. p. 1128.

The method used was to make the native look at his finger while I held a pencil nearer or beyond the finger and asked how many pencils he saw, while I watched his eyes to see that his fixation did not wander from the finger. Except in cases in which steady fixation was not kept up, two pencils were seen. I then covered one eye and asked which of the pencils had disappeared. In all cases the pencil that was said to disappear corresponded to the covered eye. The disappearance of the homonymous image when the pencil was farther than the finger, and of the heteronymous image when nearer, gave an objective means of determining the reality of the double vision, which one would otherwise have had to take on trust. It seemed as if the natives were capable of observing double images as readily as the average European.

The analogous experiment in the case of touch, known as Aristotle's experiment, was also found to succeed readily with these people.

Perhaps the main interest of these observations is to show that the Torres Straits people were certainly quite as good observers as the average European. Both these observations and also those previously described on the colour vision of the peripheral retina (p. 75) show that the natives were able to keep up for some time the effort of attention necessary for the steady fixation of an object even while observing objects in some other part of the field of vision.

It is generally agreed that the newly-born child of European parents does not show coordinated eye movements, while definite movements of binocular fixation are absent for about the first ten days of life. Donders and Engelmann[1] have, however, recorded definite binocular fixation with movements of convergence in one child within a few minutes after birth, but this was certainly an exceptional case. Several children were born while we were in Murray Island and I examined several as soon as possible after birth. In all except one case, the children were asleep or so sleepy that the point in question could not be investigated, but with one child I was more successful. This child was the younger of twins. I saw him three or four hours after birth, and then neither he nor his brother opened their eyes while I was present. When seen again about twelve hours after birth the younger was awake and showed good eye movements: in lateral movements the two eyes appeared to go well together. He was watched for a long time without any divergence of the eyes being seen. Occasional movements of convergence were seen but I could not satisfy myself that he definitely followed the movements of an object moved away from and towards him. The elder child continued in the same sleepy state as when seen earlier.

An isolated observation of this kind is not, of course, of much importance but it is interesting that a condition which appears to be very exceptional in European children should have been observed in one of the few opportunities which occurred of watching newly-born Papuan babies.

[1] *Archiv f. Ophthalmol.* Bd. XVII. Abth. II. S. 34.

Estimation of length by the eye.

A few observations were made with a piece of apparatus which I have used for some years in work on the visual estimation of length. It consists of a flat, ebonite rod, 28 cm. long, 10 mm. broad and 2·5 mm. thick. Along this rod there slides a cursor carrying an ivory plate of the same breadth as the rod, so that any given length of the black rod may be marked off. The back of the rod is graduated, and the moveable slide (cursor) carries on its posterior surface another scale with a pointer, so that the length of the distance marked off can be determined. The observer is given one of a number of similar flat rods varying in length from 3 to 20 cm., and has to move the cursor with its ivory plate till a given length of the rod is marked off which appears by the eye to be equal to the given rod (the standard). The length marked off is read on the scale at the back, and the operation is repeated a given number of times.

Unfortunately I did not begin to make observations with the apparatus till late in our stay in Murray Island, and I only give the figures of four elderly men in Table V*.

Table V*.

Name	Age	Standard	*A*	*B*	m.v.	*C*	m.v.
Harry (Mamus)...	over 60	80 mm.	74·6	88·6	3·48	60·6	3·52
		160 „	152·7	172·2	7·28	133·2	8·64
Ulai..................	55—60	80 „	79·75	81·5	5·8	78·0	0·8
		160 „	149·4	147·9	1·92	150·9	3·08
Jimmy Dei.........	45—50	80 „	76·8	77·5	2·2	76·1	·36
		160 „	160·1	164·6	3·36	155·6	1·92
Capsize	40—45	80 „	77·75	80·4	2·28	75·1	3·52
		160 „	153·45	166·6	3·28	140·3	3·36

Two standards were used in each case, one 8 cm. and the other 16 cm. in length. Ten measurements were made with each standard; in the first five observations, the moveable slide was moved inwards so as to shorten a long distance till it appeared equal to the standard; in the second five observations, the cursor was moved outwards, lengthening a short distance till again equal to the standard.

In Table V* the figures in column *A* give the averages for the whole ten observations; those in column *B*, the averages for the first five observations when moving the cursor inwards, and those in column *C*, the averages when moving the cursor outwards. The other columns give the mean variation of each set of observations.

The cases are very few in number, but one or two features are fairly constant. There was a distinct tendency to make the variable length shorter than the standard. Care was taken that both standard and variable should be seen at the same visual angle and the constant error was not due to the variable being nearer to the eye than the standard.

The starting-point of the cursor had a marked influence on the results. With one exception (Ulai, with standard 16 cm.) the variable was made larger when a long distance had to be shortened than when a short distance had to be lengthened, and in some cases the difference was very great. English observers when making similar observations are influenced in a similar way, and the same peculiarity is also very marked in the observations on the "Müller-Lyer" illusion to be described later (see p. 120).

The mean variations are very irregular; they are, on the whole, larger for the larger standard, but varying degrees in which the factors of practice and fatigue have come into play, prevent any regularity in the relation between the two.

Bisection of Lines.

A larger number of observations were made to show the degree of accuracy with which lines could be divided by the eye into two, three, or more equal parts. In all cases the lines used were 100 mm. in length.

In Murray Island observations on bisection of lines were made on 20 men and 12 boys, each of whom made a mark with a pencil at the point which appeared to him to be the middle of the line. Owing to the thickness of the pencil mark, it was in many cases not possible to measure the lengths of the two halves with any very great accuracy, and the results are not to be compared with those made by means of accurate apparatus. The difference between the two halves, however, usually amounted to more than a millimetre.

At first some observations were made with both eyes open, some with only the right eye open, and others with only the left eye open. It seemed, however, as if the extra trouble of keeping one eye shut or covered was sufficient to distract the attention from the main object, and as the observations made in a few cases did not show any obvious difference in the results for the two eyes, I discontinued the monocular method and all observations were made with both eyes open.

In dividing with both eyes, the average result for the 20 men was 51·4 : 48·6, *i.e.* the left half of the line was made too long; this occurred in 15 of the men, only four making the left half too short, while in one case the halves were equal.

Nine men had three or more trials and their results are given in Table VI. together with the mean variations of each set of three (or more) observations.

Sambo was tested on two different occasions, and each time he made the left half much too long. It will be seen that the average result for the nine individuals included in the table does not differ appreciably from that of the whole 20. The extreme individual measurements were 57 : 43 and 46 : 54 made by Sambo and the Mamus.

TABLE VI.

Name	Age	No. of measurements	Left half	Right half	m.v.
Mamus	over 60	3	48·7	51·3	2·23
Ulai	55—60	3	51·0	49·0	2·0
Groggy	35—40	4	50·0	50·0	1·5
Kaige	35—40	3	52·0	48·0	·66
Mabo	30—35	3	54·7	45·3	1·77
Sambo.........	30—35	5	55·0	45·0	1·2
Komaberi ...	20—25	3	52·0	48·0	·66
Zarob	20—25	3	51·0	49·0	1·33
Tepem.........	18	3	48·7	51·3	·43
Average		30	51·5	48·5	1·31

The average result for the 12 boys was 50·1 : 49·9. Six of the 12 made the left half too long, and six too short. The error which seemed to be fairly constant in the men was not present in the case of the boys. The extreme individual measurements were 56 : 44 and 42 : 58.

Six boys made six observations each. Their results and those of three boys who made three observations each are given in the following table.

The number of observations made was too few to allow any definite conclusions to be drawn, but there appeared to be a distinct tendency in the case of the men to make the left half too long, a tendency which was absent in the children. The average mean variation of the men was distinctly smaller than that of the children, showing that the difference was not due to greater inexactness and inconstancy of measurement in the former.

In dividing a line with the right hand, one is apt to cover with the hand part of

TABLE VII.

Name	Age	1st three observations			2nd three observations		
		L.	R.	m.v.	L.	R.	m.v.
Ebui	13	50·3	49·7	1·10	52·3	47·7	3·57
Biskak...............	11	49·7	50·3	5·10	51·3	48·7	·9
Nanai	10	48·7	51·3	1·10	48·3	51·7	·9
Dela.................	10	49·7	50·3	·43	48·3	51·7	·9
Jimmy Dauar ...	10	48·0	52·0	2·00	48·7	51·3	·43
Depoma	10	51·0	49·0	1·33	48·3	51·7	1·57
Tom (Tanu)	11½	51·0	49·0	1·33			
Charlie (Ako)......	11½	49·7	50·3	·9			
George (Pasi)......	11	52·0	48·0	2·66			
Average		50·01	49·99	1·77			

the right half of the line. It is possible that in some cases the greater length of one half may have been due to this, but in some cases in which one half was made much too long I have expressly noted that the line was not covered with the hand.

In Table VIII. are given the results of the Murray Island adults and children who made three observations, together with the results of fifteen English students of psychology and twelve school children from the village of Girton near Cambridge[1], also making three observations each. The latter ranged in age from 9 to 15, and were on the average slightly older than the Murray Island boys included in the table.

[1] I am very much indebted to Dr Lawrence, Rector of Girton, for his kind assistance in making these and other observations on the Girton children.

The extreme individual measurements of the students were 52 : 48 and 46 : 54. Those of the children were 53 : 47 and 45 : 55. The left half was made too small by eight of the fifteen students and by nine of the twelve children, and only in the case of the youngest boy was the left made distinctly longer than the right half. The error which was fairly constant in the English children was in the opposite direction to that of the Papuan men.

TABLE VIII.

	No.	L.	R.	Average m.v.
Murray Island men ...	9	51·46	48·54	1·31
Murray Island boys ...	9	50·01	49·99	1·77
Students..................	15	49·1	50·9	·56
Girton children	12	48·9	51·1	1·27

It will be seen from this table that in the English students there is a slight tendency to make the left half of the line too small, and that this tendency was distinctly more marked in the English children. In the Murray Island children this tendency was absent, while in the Murray Island men the error was of an opposite nature, the left half being made too large. The number of observations was too small and the method too rough to justify one in attaching much importance to these constant errors, and speculating as to their explanation. It is best to be content with recording the fact that nearly all the Murray Island men had a constant error in one direction, while the English individuals had an error in the opposite direction.

It is of more interest to notice the degree of accuracy and constancy with which the process of bisection was performed as shown by the mean variations. As might be expected, the average variation was much the smallest in the case of the students. There was, however, comparatively little difference between the average mean variations of the Girton children and those of the Murray Islanders. The Girton children were better than the Murray children, but the average for the latter was much raised by the very bad performance of one boy (Biskak)[1], and further, the Murray Island children were hardly representative, most of the older and more intelligent boys not having made these observations. I have not yet been able to make observations on uneducated English adults for results which should be in some measure comparable with those of the Murray Island adults. The results given here show that the Murray Island man and boy are able to perform the simple operation of dividing a line into two equal halves with nearly as much accuracy and constancy as the English village child.

[1] It will be seen in Table VII. that this boy improved very greatly in his second set of observations.

I have already mentioned that a certain number of observations were made on the accuracy of halving a line when only one eye was used. It has been found by Kundt[1] and others that the outer half is made too long, *i.e.* there is underestimation of the half whose image falls on the nasal side of the retina. The inaccuracy of division in Murray Island was very much increased when only one eye was used, but the error was in the same direction as in the case of binocular division. With the right eye the left half was made on the average 53·3 to 46·7 for the right half and with the left eye the figures were 52·46 to 47·54. The errors were in the same direction in the case of each eye. One man, Dela, made the left half as much as 60 mm. Only one individual, Madsa, a very intelligent young man, made the left half too short, viz. 49 mm. These results only seem to show that the distraction occasioned by covering or closing one eye made the operation more difficult and increased the tendency to make the left half too large.

The lines were also divided monocularly by a few children, their errors being much the same as in binocular division.

These monocular observations do not bring out any definite result in themselves, but they led to the observation of facts which are not without interest. If one asks a number of Europeans to close each eye independently, one finds that many individuals cannot do so, or do so very imperfectly. The defect is usually greater in the case of one eye than the other, many individuals being unable to close the right eye while keeping the left open. The same variations were found among the Murray Islanders. Some could close and open each eye independently without any difficulty; others could close one eye more readily than the other as shown by the accompanying facial movements, while others were not able to close one or the other eye, difficulty being more often experienced in closing the right than the left eye independently of the other. One man could close neither eye independently.

It is interesting that as regards this simple accomplishment, one finds the same variations as among Europeans. These people belong to a race who use the bow and arrow (now only used as an occasional game), but unfortunately I did not discover whether it was customary to close one eye while taking aim.

Division of lines into three and more equal parts.

A certain number of observations were also made to test the degree of accuracy with which lines could be divided into three or more equal parts. After having halved a line a native would be asked to divide a line into three parts equal to one another; most were unable to do this directly and made several unsuccessful attempts, chiefly owing to the fact that it was difficult for them to grasp the fact that in order to divide a line into three parts, it is only necessary to make two marks. Some, however, understood at once and divided the line with tolerable accuracy.

After having succeeded in dividing the line into three parts, they were told to divide it into four equal parts; most seemed to have learnt what was necessary and

[1] *Annal. d. Physik. u. Chem.* Bd. cxx. S. 118. 1863.

did this at the first attempt. The chief exception was the oldest man, who only succeeded when I suggested to him that he should first halve the line and then divide each half. It is noteworthy that no one spontaneously adopted this method of dividing the line into four equal parts, all beginning from one end or the other.

Most of those who had succeeded so far were readily able to divide the line into five equal parts, but at six parts some failed, and only three men were able to divide the line into seven and eight equal parts. Both in the case of six and eight parts, no one began by bisecting the line.

The fact that the natives had to divide a line successively into three, four, five and more parts made the problem very much easier than it would have been had they been asked directly to divide a line into a given number of parts. Unfortunately I did not ask anyone to divide a line into four or more parts who had not previously divided it into two or three parts, but I have little doubt that in such a case the attempt would have resulted in complete failure.

In Table IX. the accuracy of division is shown by the mean variation of the individual parts into which the line was divided. Thus in dividing a line of 100 mm. into three parts, Ulai's figures were 36, 29, and 35 mm., varying from 33·33 by 2·67,

TABLE IX.

Name	Age	3	4	5	6	7	8
Ulai............	55—60	2·89 (3)	2·0 (6)				
Groggy	35—40	3·07 (2)	1·0 (2)	2·4 (2)	2·4 (1)	1·57 (1)	1·75 (5)
Kaige	35—40	1·73 (1)	2·0 (2)	4·0 (1)	failed		
Mabo	30—35	2·4 (1)	3·0 (1)	2·8 (1)	1·3 (1)	failed	
Sambo.........	30—35	5·07 (3)	5·0 (1)	4·4 (1)	failed		
Giaz............	25—30	3·73 (1)	2·0 (1)	2·8 (1)	1·74 (2)	2·06 (2)	1·5 (1)
Komaberi ...	20—25	1·53 (3)	2·0 (1)	2·8 (2)	4·54 (1)	2·43 (1)	1·5 (1)
Tepem.........	18	3·53 (4)	2·0 (1)	2·4 (2)	·87 (1)	failed	
Average		2·99	2·36[1]	3·09	2·17	2·02	1·58

[1] Omitting Ulai, who only succeeded when he was told to first divide the whole line.

4·33, and 1·67 respectively and giving a mean variation of 2·89. In the third column of the Table are given the mean variations in dividing the line into three equal parts; in the fourth column, those for four equal parts and so on. The figures in brackets give the number of trials in each measurement.

In Table X. are given the mean variations of six Murray Island boys arranged in the same way as in Table IX.

TABLE X.

Name	Age	3	4	5	6	7
Ebui	13	·4 (2)	2·5 (1)	4·8 (1)	1·97 (1)	failed
Biskak................	11	7·07 (2)	·5 (2)	2·0 (1)	failed	
Nanai	10	1·73 (2)	5·5 (3)			
Dela....................	10	2·2 (1)	2·5 (1)	2·0 (2)		
Jimmy Dauar	10	·89 (2)	·5 (1)	1·2 (1)	failed	
Depoma	10	2·2 (3)	4·0 (1)	2·0 (1)	failed	
Average		2·41	2·58	2·4		
Average, 12 Girton children...		2·09	2·08	2·3		

It will be noted that all the boys with one exception required more than one trial before they succeeded in dividing into three parts. Not much importance can be attached to the averages under the circumstances, but it may be noted that those for the children are consistently smaller than for the adults, *i.e.* the accuracy of division was greater in the children.

At the end of Table X. I have added the average variations for twelve Girton village children, and it will be seen that these are slightly smaller than those of the Murray children. One is not justified in comparing the two directly, but so far as they go, they tend to show that as soon as the Papuan understood what he was to do, he was not very inferior to the English child. There is one point in which, to my surprise, the English children resembled the islanders. With one exception (the eldest girl), none divided a line into four parts by dividing first into halves and then subdividing these. Even the girl who did this in the case of quadrisection, did not do so when dividing into six equal parts but began at one end.

There were a few other points of interest. All the English children with one exception (the youngest girl) divided the lines from left to right, *i.e.* in the same direction as in reading. Of the eight Murray men, four went from left to right, three began at the right-hand end, while one did some lines in one direction and some in the other. All the six Murray Island children, on the other hand, began at the left-hand end and divided in the same direction as that customary in reading, and there can be little doubt that this was due to the influence of their school education.

Another feature which occurs in most cases is that the first division is made too small. This is more marked in division into four and five than into three parts, and is an obvious consequence of the procedure. After having divided into three parts, the observer knows that he has to make the divisions in the next case smaller, and there is a natural tendency to overdo this. The same tendency to make the first division too small was very marked in the Girton children.

Taking into account both the number of trials necessary before the lines could be divided successfully and the degree of accuracy as compared with the Girton children, we may conclude that the Torres Straits natives were distinctly deficient in this operation. When, however, one remembers the difficulty in language, and in understanding what was to be done, and secondly their deficiencies in numeration, the results were surprisingly good. It has already been mentioned that in their own language these people only have definite words for one and two, and are now accustomed to use English numerals, and their powers of counting are still very defective (see p. 33).

Estimation of vertical and horizontal lines.

The erroneous estimation of vertical as compared with horizontal lines was tested by giving a native a horizontal line 100 mm. in length and asking him to draw a vertical line from its central point and to make the vertical line of the same length as the horizontal line. He was then given another horizontal line and was asked to draw a similar vertical line at one end of the horizontal line. Finally he had to draw a vertical line through the middle of the horizontal line so as to make a cross of which the vertical should be equal in length to the horizontal limb. These three forms of the illusion will be spoken of as No. 1, No. 2, and No. 3.

Most of the natives understood the procedure readily. Several attempted to measure roughly with their fingers and a sharp look-out had to be kept that this was not done. After they had drawn the lines I endeavoured to ascertain whether they were satisfied that the lines were equal (okakis). If I had asked whether they had made the line too short or too long, I should obviously have run the danger of suggesting that the lines were not equal and I was therefore always careful to ask if the line was "taupai, pĭripĭri, or okakis" (short, long, or equal). If a native thought he had made the line "taupai," he was allowed to lengthen it; if "piripiri," I covered the upper part of the vertical till it appeared to him to be "okakis" and the new upper end was then marked. The vertical in No. 2 was usually made longer than in No. 1, and after doing No. 2, several of the natives returned to No. 1 spontaneously and lengthened the line. I allowed them to do this but marked off the original length of the line and have used that in the tabulation of my results.

As a test that the people had understood and had grasped the idea of making the two lines equal, I often allowed them to measure, usually with a piece of grass, after they had finished and they did this quite correctly. In many cases the vertical, especially of No. 1, was made so short that I suspected that they were making it equal to half the horizontal instead of the whole, and the way in which they measured allowed one to see whether this was the case or not. Several of the natives were very surprised and interested in their errors and several proceeded spontaneously to lengthen their lines, thus Dick Tui had first made No. 2 only 55 mm.: after measuring he lengthened it to 92, but then thought that he had made it too long. He also lengthened the vertical in No. 1 from 50 to 77 and from 58 to 85. Of the others who made the vertical in No. 1 very small, Meiti seemed to understand. He first made No. 1 only 50 mm. and I then caught him measuring with his fingers, after which he lengthened the line to 65 mm.; nevertheless, on doing the test a second time, he again made the vertical only 50 mm. in length. Wag first made No. 1 55 mm., and then lengthened it slightly after having done No. 2. Taibi who made No. 1 55 and 58 in two trials seemed to understand perfectly. Gi, on the other hand, was doubtful; he was always very slow and had a good deal of difficulty in understanding what was to be done, but he remained quite contented with his line of 49 mm., even after having been shown the lines which other natives had drawn. Dela who made his line in No. 1 only 50 mm. in length, measured perfectly correctly afterwards, and Jimmy Rice in his first trial made No. 1 72 mm. in length but he was certain that he had made it "piripiri" and shortened it to 63 mm. The very low figures were not due to misunderstanding but were made by natives in whom either the illusion was very marked or who were careless in making the two lines exactly equal.

The results of twenty Murray Island men are given in Table XI. The figures give in millimetres the lengths of the vertical lines which appeared to the men to be equal to a horizontal line 100 mm. in length.

In the case of those men marked with an asterisk the test was performed twice, and the figures are averages of two observations. In the case of one man, Sambo, the figures are the averages of three observations. It will be seen that there was no difference between the average and the median. As some men made two or more sets of observations and others only one, I have also given the average obtained by taking only the first observations of the former. It differs hardly at all from the other average which shows that there was no special tendency for the illusion to change when more than one observation was made. The figures for M.V.[1] give the mean of the deviations of the individuals from the average. It is distinctly larger in the case of the first observations only. This is of course perfectly natural, for when an individual makes two or more observations the average of these will in most cases be nearer the general average than will the individual observations.

[1] I may here recall the fact that m.v. in Tables V—VIII is used as a guide to the accuracy of an individual, while M.V. in this and following tables is used as a guide to the variability of the individuals making a given measurement (see Introduction, p. 6).

Table XI.

Horizontal line, 100 mm.

Name	Age	No. 1	No. 2	No. 3
Mamus	over 60	66	70	72
Ulai....................................	55—60	63	79	116
Gi..	40—45	49	81	76
Kaige*	35—40	69	70·5	97
Groggy	35—40	88	89	86
Jimmy Rice*........................	30—35	61·5	65·5	83·5
Sambo*	30—35	66·3	73·3	78
Mabo	30—35	88	81	75
Dick (Tui)*	30—35	54	62·5	91·5
Wag....................................	25—30	55	93	109
Dela....................................	25—30	50	65	94
Meiti*.................................	25—30	50	78	89
Giaz....................................	25—30	55	70	99
Komaberi	20—25	77	83	106
Zarob	20—25	81	82	89
Taibi*.................................	20—25	56·5	71	95·5
Tapau*	20—25	64·5	72	99·5
Tepem.................................	18	69	86	93
Madsa.................................	18	71	84	86
Berò*	17	71	85	92·5
Average		65·2	77·0	91·4
Median		65·2	78·5	92·0
M.V.		9·39	7·36	8·78
Average, 1st observations only		65·7	77·0	90·1
M.V., 1st observations only ...		10·13	7·85	9·75

TABLE XII.

Name	Age	No. 1	No. 2	No. 3
Liu*	13	60	68·5	97
Ebui*	13	78	83·5	113·5
Jimmy Rice*	12	87	94	91·5
Captain*	11	84·5	95	110·5
Charlie (Ako)	11	92	98	100
Tom (Tanu)	11	76	78	93
George (Pasi)	11	89	85	89
Biskak*	11	81	87·5	113
Nanai*	10	86·5	84·5	88
Dela*	10	73	76·5	82
Jimmy Dauar*	10	68·5	76·5	104·5
Depoma*	10	78·5	78	87·5
Average		79·5	83·7	97·5
Median		80	84	95
M.V.		7·27	6·92	12·05
Average, 1st observations		79·5	84·3	99·4
M.V.		7·67	7·93	12·84

The average length of the vertical line in No. 1 was distinctly smaller than in No. 2, and in No. 2 than in No. 3. There was great constancy in this respect; only one man (Mabo) made the vertical in No. 1 longer than in No. 2, and only three men made No. 3 shorter than No. 2.

It was in No. 1 form of the test that the very small verticals were drawn on which I have already commented. The figures given in the foregoing table support the view that these observations were genuine and not due to misunderstanding, for the table shows regular gradations between these low figures and the maximum (88). There is no break in the series as there should be if the lowest results were due to the fact that the vertical was made equal to only half the horizontal line. It may be noticed that only four of the 20 men made the vertical longer than 75 mm., *i.e.* in 16 out of 20 men the illusion exceeded 25 per cent.

In Table XII. are given the figures for 12 Murray Island boys. The figures for the majority (marked with asterisks) are the means of two observations, and as in Table XI. give the height of the vertical line in millimetres.

As in the case of the men, there was very little difference between the average and the median. The difference is most marked in the case of No. 3, which is quite natural when one looks over the figures and observes such measurements as those of Ebui, Captain and Biskak. The averages for the first observations do not differ greatly from those of the other averages, the difference again being most marked in the case of No. 3 form of the test.

The boys made the vertical line longer than did the men in all forms of the test, *i.e.* the illusion was apparently less marked. The figures for the three forms stood in the same relation to one another as in the case of the men, but the differences were much less marked and the individual observations were not quite so consistent, three boys making No. 1 longer than No. 2, although only one made No. 3 shorter than No. 2. The mean variation of the individuals from the average was less than that of the men in the case of No. 1, but very much greater in the case of No. 3.

Only two men did this test in Mabuiag. Of these, Waria was one of the most intelligent men in Torres Straits, and he did the tests more correctly than anyone else. His figures for two observations were 96 mm. in each case for No. 1; 99 mm. and 97 mm. for No. 2, and 94 mm. and 93 mm. for No. 3. The other man, Gigib, was not very bright; his figures were 80, 89·5 and 107·5 mm. respectively. The word used for short in Mabuiag was "taupaing," for long "kukitalunga," for equal "mataminar," and for middle "matadadal."

When at Bulaa in central British New Guinea, Mr Seligmann tried the test on seven young men ranging in age from 16 to 25. The results were similar to those in Torres Straits. In the first form of the test the average was 61·4 mm. with a maximum of 77 and a minimum of 50 mm. In the 2nd form the average was 90·3 with a maximum of 129 and a minimum of 71. The average in this case was very much pulled up by the maximum observations.

In the third form of the test no less than four made the vertical too long, and one as much as 147, the result being an average of 105 mm.; the minimum was 73. The results, though scanty, show the same general behaviour in doing the test as in Torres Straits.

A Fly River man was also tested in Murray Island. His observations were (i) 65, (ii) 74, (iii) 87.

One Samoan boy, age 14, was tested in Murray Island. His averages of two observations were (i) 76, (ii) 90·5, (iii) 110·5.

I have made observations on a number of English people by exactly the same method. In the following comparative table I have given the results for the same 15 students of psychology and 12 children of Girton village who made observations on line division. I have been unable at present to make similar observations on uneducated English adults. In both the students and the children there was no appreciable difference between the average and the median result and therefore I have not given the latter.

The maximum and minimum measurements made by any individual in each group, and for each form of the test, are also given.

TABLE XIII.

Comparative Results.

		No. 1			No. 2			No. 3		
	No.	Average	Max./Min.	M.V.	Average	Max./Min.	M.V.	Average	Max./Min.	M.V.
Murray Island men	20	65·7	88/49	10·13	77·0	89/55	7·85	90·1	111/75	9·75
Murray Island boys	12	79·5	97/66	7·67	84·3	109/63	7·93	99·4	129/85	12·84
English students...	15	89·0	101/73	5·73	92·5	112/81	4·37	94·5	106/81	3·43
Girton children ...	12	78·2	92/62	8·53	88·7	100/82	4·8	90·7	115/70	9·28

On comparing the four groups in Table XIII. it will be seen that the illusion was most marked in the case of the Murray Island men. They differ from the other groups especially in the first form of the test. The mean variation of the individuals from the average is large, viz. 10·13, but I have already given reasons for believing that the results were genuine and not due to misunderstanding.

There was little difference between the Murray Island and the Girton children, especially in the first two forms of the test. The results of the Murray Island boys in the third form of the test were not very satisfactory as the large mean variation shows. The largeness both of the average and of the variation was, however, chiefly due to the presence of four boys who made the vertical too long. The illusion was least pronounced in the case of the students of psychology. This must be partly ascribed to the fact that they were acquainted with the illusion, and in more than one case had been trained to overcome it.

I am not acquainted with any previous investigation of this illusion on a number of individuals, but numerous investigations have been carried out by individual workers. Chodin[1] found that the illusion varied with the length of the standard line and was most marked for a distance of 80 mm., in which case the illusion amounted to 9·5 per cent. Wundt states that the illusion is more marked in distances between points than with lines, and may in the former case amount to 20 per cent. This was approximately the extent of the illusion for the No. 1 form in both Murray Island and Girton children, while in three of the English students the illusion reached or exceeded this extent in this form of the test.

The most interesting fact, however, brought out in the comparative table is that all groups, Papuan and English, adults and children, agree in making the vertical line shorter when drawn from the middle of the horizontal line than when drawn at one end, and shorter in the latter form of the test than when it is drawn so as to form a cross. The difference is most marked in the case of the Murray Island men and least marked in the English students, while the black and white children occupy an intermediate place as they do in respect of the absolute amount of the illusion. So far as I am aware, this difference has not previously been observed.

The magnitude of the illusion in the No. 1 form is probably due to the fact that there is a tendency to compare the vertical line, not with the horizontal line as a whole, but with each of the halves into which the latter is divided.

Several English individuals who have done this test, and have made the vertical line very little shorter than the horizontal, have told me that they imagined the vertical line divided into two halves, and compared each of the halves with the halves of the horizontal line, and by this means were able to greatly lessen the illusion[2]. This observation illustrates very well one cause of difference between the results of the savage and the cultured measurements, for one may feel fairly confident that such an artificial method was not employed by the Murray Islander.

The second form of the test seems to be the simplest and gave the most uniform results. Except in the case of the Murray Island boys, the mean variation of the individual observers was much smaller than in the first form of the test. The second form of the test is probably most nearly a measure of the erroneous estimation of vertical as compared with horizontal lines uncomplicated by other factors.

The third form of the test gave results which I had not at all expected. In all the groups, the vertical line approached the horizontal line much more nearly in length.

In many cases (five of the Murray Island men, five of the Murray Island boys, four of the English students and one of the English children) the vertical limb of the cross was made longer than the horizontal. Some of the Murray Island individuals who did this were certainly careless and not among the best observers, but I do not think there was any doubt that they understood perfectly well what they were doing,

[1] *Arch. f. Ophthal.* Bd. xxiii. Abth. i. S. 92. 1877.

[2] The illusion would be lessened because the individual would get rid of the tendency to compare the whole vertical line with half the horizontal line and also, as Chodin has shown, the illusion is less marked for a line of 50 mm. than it is for one of 100 mm.

and did not see any very striking difference between the two lines. It is noteworthy that this feature occurred in all four groups and also in the New Guinea natives examined by Mr Seligmann but I cannot suggest any satisfactory explanation.

It is, however, readily intelligible that the illusion should be less marked in the cross than in the other forms of the test. It is natural to compare the halves of one line with the halves of the other line and, as already mentioned, the illusion is less for lines of 50 mm. than for lines of 100 mm.

In the second place, I think it is possible that, even in the case of the Murray Islander and the child, the cross may give an idea of a figure in which any difference in the relative lengths of the diagonals would produce an effect which would not be noticed in the lines themselves.

It occurred to me as possible that vertical distances below the horizontal might not be wrongly estimated in the same way, or to the same degree, as vertical distances above the horizontal, but in my own case there is no difference, and I have since found that Chodin[1] investigated this point and his figures show that there is no obvious difference in the erroneous estimation in the two positions. Fischer[2], on the other hand, found that the illusion was slightly greater in the case of the lower vertical arm of a cross than in that of the upper, the figures in the two cases being 14·67 per cent. and 11·66 per cent.

In comparing the individual results for the Papuans and the English students, there is one point of some interest. The average results of the latter showed the characteristic difference in the three forms of the illusion, but the English individuals were not so consistent in this respect as the Papuans. Seventeen out of the twenty Murray Island men made the vertical in No. 1 shorter than in No. 2, and in No. 2 shorter than in No. 3, but only eight of the fifteen students showed this feature. This is only one example of a point to which I have called attention in the Introduction, viz. that in some respects the results for students of psychology are less consistent than those of the Torres Straits islanders, and I am inclined to ascribe this result to the influence of a factor, viz. knowledge of the nature of the illusion, which is not present in the savage. The fact that some people make use of artificial aids, as in the observations I have cited, introduces another complicating factor in the case of the European.

I have used the same test on all the members (112 in number) of an elementary boys' school. Each boy made the three measurements once only. The observations differ from those already described in that each boy was not watched individually while drawing his lines. The average lengths of the vertical lines in the three forms were 88·7 mm., 94·0 mm. and 99·6 mm. respectively. The three forms of the test showed the characteristic difference, and as in the other groups a large number made the vertical in No. 3 longer than the horizontal. In all three forms, the vertical lines were made considerably longer than in the case of the Girton children, but this may be, at any rate partially, explained by the fact that, owing to absence of individual supervision, the boys were not given the chance of shortening their lines if they thought they had made them too long. In fact, my method was defective and I only mention these

[1] *loc. cit.*

[2] *Arch. f. Ophthal.* Bd. XXXVII. Abth. i. S. 102. 1891.

results because they show the characteristic relation between the three forms of the test.

Psychologists are very divided in their opinions as to the cause of the erroneous estimation of vertical as compared with horizontal distances[1]. The apparent difference in the lengths of two equal lines has been referred to the influence of the curvature of the retina: it has been supposed that the retina is more concave in one meridian than in the other, so that the extremities of equal lines stimulate retinal points at different distances from one another in the two meridians. If any such difference in the curvature of the retina exists, it is certainly far too slight to account for the great difference between horizontal and vertical lines which appear equal to one another.

Perhaps the most popular explanation is that which refers the illusion to the influence of eye movements. It is supposed that vertical movements of the eye require a greater muscular strain than those in the horizontal direction, and that the sensations arising from the greater muscular strain form the basis of the idea of greater length. The influence of sensations arising from movements of the eyes in spatial perception has been greatly overrated[2], but in this case I think there is little doubt that, in looking at a figure representing the illusion, one seems to take in the horizontal distance at a glance while one's idea of the vertical distance is gained more slowly, and this difference may be one of the factors producing the illusion. It cannot, however, wholly explain the illusion, for this is present when a figure is instantaneously exposed.

A factor, which is probably of some influence, is the size of the field of vision. Even in monocular vision the field is not circular but oval, the shortest diameter being vertical. In binocular vision, the oval shape of the field of vision (or field of sight) is still more pronounced and it seems quite possible that a vertical distance may be overestimated as compared with an equal horizontal distance because it forms a larger proportion of the field of vision.

By many the illusion is given a purely psychological explanation. This and other illusions are referred to certain psychological tendencies which influence the process of perception. Thus, Lipps[3] supposes that we ascribe certain mechanical activities to geometrical figures and believes that we ascribe activity more readily to vertical than to horizontal lines.

So far as I am aware, it is not generally recognized by psychologists that the illusion in question and other similar illusions are extremely pronounced in children. My attention was first called to this point by Mr W. H. Winch, and I have since found that teachers are well acquainted with the fact. The pronounced character of the illusion in children and in people in the stage of mental culture of the Murray Islanders shows that the illusion is primitive and deeply seated, and that its source is to be

[1] It would of course be equally correct to say "erroneous estimation of horizontal as compared with vertical distances."

[2] See Schäfer's *Textbook of Physiology*, vol. II. p. 1136.

[3] *Beiträge zur Psych. u. Phys. d. Sinnesorgane* (Helmholtz Festgruss), S. 219. 1891.

sought in some physiological condition, or if it is at present necessary to be content with a psychological explanation, this must be of a simple and primitive character.

The Müller-Lyer illusion.

Another visual illusion which I investigated quantitatively, was that first described by Müller-Lyer[1], which has since been the subject of much controversy.

In Fig. 2 the distance *BC* appears much longer than the distance *AB* owing to the influence of the adjoining oblique lines.

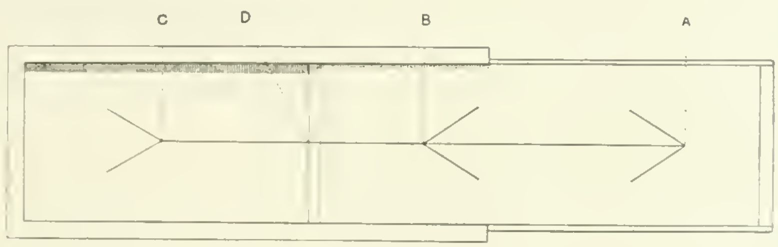


Fig. 2.

In investigating this illusion, I adopted the method first employed by Heymans[2]; the figure was drawn on a surface consisting of two parts, of which one fitted into a groove above the other like the lid of a box so that the upper could slide over the lower part.

The distance *AB* was constant and the distance *BC* was variable.

The line from *A* to a point *D* was drawn on the sliding portion while the rest of the figure was drawn on the underlying surface so that the line *BC* could be made of any desired length by sliding the cover backwards and forwards. The instrument was constructed of brass with the figure painted in black on a white background.

The constant length of *AB* was 75 mm.; the oblique lines were each 20 mm. in length and were at an angle of 30° to the chief line. The thickness of the lines throughout was 2 mm. This thickness is greater than is desirable, especially owing to the fact that the lines tend to encroach on the distance *AB* and thereby increase the illusion. The instrument was constructed for me under great pressure of time and was not exactly accurate, and the results obtained in using it may not be directly comparable with those obtained by others, especially if thinner lines are used. The observations on both Papuans and Europeans described in this communication were, however, made with the same model and are strictly comparable.

The problem given to a native was to slide the moveable part *AD* till *BC* appeared to him to be equal to *AB*; the result of his comparison could then be read off on a graduated scale on the back of the instrument. I first gave the instrument with the slide out as far as possible and told the native to slide it in till the lines were equal (okakis). When this operation had been repeated five times, the

[1] Du Bois-Reymond's *Arch. f. Physiol.* 1889. Supplement-Band. S. 263.

[2] *Zeitsch. f. Psychol. u. Physiol. d. Sinnesorgane*, Bd. ix. S. 221. 1896.

instrument was given with the slide pushed in and the native was told to pull it out till the lines were "okakis." This was also repeated five times. The slide was in all cases moved with the right hand and the instrument was so placed that the line *AC* was horizontal. Several of the natives wished to turn the instrument round or to hold it in other positions but I thought it best that all the measurements should be done with the instrument in one position.

A certain number of men had their blood pressure tested with Hill and Barnard's sphygmomanometer by Mr McDougall while they were making the observations, for comparison with the results of other kinds of mental and muscular exercise. In these cases the slide was moved and adjusted by myself in response to the wishes of the men expressed by means of the words taupai, piripiri and okakis. In Tables XIV. and XV. I have marked the individuals tested in this way with an asterisk, and it will be seen that there was no obvious difference between their measurements and those of the people who adjusted the slide themselves.

The people understood readily what was to be done. As in the case of the illusion already described, a sharp look-out had to be kept to see that they did not measure with their fingers or with a piece of grass. After they had finished, the natives were asked to point out the lines they had been making equal and if there seemed to be any doubt, they were asked to measure so as to make sure that they had understood. There were two chief dangers. A native might notice a mark or irregularity on the lower surface in one measurement and make use of it as an indication in his future measurements. One native who made *BC* exactly the same length in several successive measurements was probably going by some indication of this kind. The other danger was that they might think they had to make *DC* equal to *AB*. I have met with this mistake in English children as well as in Murray Island and a few unsatisfactory results which I obtained in Murray Island, before I was alive to this danger, may have been due to this error. The line of junction of the two parts of the instrument should be as inconspicuous as possible, but unfortunately in my hastily prepared instrument, the bevelled edge of the sliding portion was somewhat too obvious. I have found that English observers sometimes notice the length of *CD* in one measurement and are influenced by this in succeeding measurements, thus making their mean variations smaller than they would otherwise be.

In Table XIV. the figures in column *A* give the average of the whole ten observations; those in column *B*, the average of the first five when moving the slide from without inwards, the next column gives the mean variation of these five observations; column *C* gives the average of the five observations when moving from within outwards and the next column the mean variation of these.

It will be seen that all the individuals made *BC* considerably shorter than *AB*, the average length of *BC* being almost exactly $\frac{4}{5}$ths of *AB*, *i.e.* the two lines appeared equal to these natives when their real lengths were as 4 : 5.

The observations of a few individuals are not included in this table. Three men made *BC* longer than *AB*, their average results being 82·2, 79·9 and 86·4. One of these was a very dull youth who probably misunderstood but the others were good observers. They were, however, among the first cases I examined and I am afraid that I may not have been sufficiently on my guard against the danger already mentioned of making *CD* equal to *AB*. Their mean variations were also very large, viz. 7·28 and 4·72, 5·2 and 7·04, 4·0 and 8·96; and it would be misleading to include them in the Table.

TABLE XIV.

Murray Island men.

Name	Age	*A*	*B*	m.v.	*C*	m.v.
Wanu*	50—55	54·4	50·0	4·80	58·8	1·76
Smoke	45—50	49·8	51·2	3·36	48·4	6·08
Papi	40—45	50·8	53·6	3·12	48·0	4·40
Magi	40—45	64·7	66·6	2·64	62·8	1·44
Billy Gasu	35—40	61·1	62·2	6·32	60·0	6·40
Debe Wali*	35—40	64·1	69·8	3·84	58·4	1·92
Barsa	35—40	64·6	66·2	3·76	63·0	1·60
Dick Tui*	30—35	60·0	61·8	2·24	58·2	1·44
Mabo	30—35	55·0	55·2	2·64	54·8	3·68
Dela	25—30	59·3	61·2	2·24	57·4	·52
Beni	25—30	60·6	62·6	1·28	58·6	·72
Loko	25—30	63·8	72·0	4·80	55·6	2·16
Jimmy Wailu	25—30	59·3	60·0	3·20	58·6	2·72
Meiti	25—30	63·2	64·4	1·28	62·0	1·20
Komaberi	25—30	64·7	65·2	1·92	64·2	·32
Dawita	19	57·6	59·8	3·04	55·4	1·52
Madsa	18	60·1	62·2	·32	58·0	1·20
Baudu	17	63·6	66·6	3·68	60·6	1·36
Berò	17	68·8	76·0	3·60	61·6	3·36
Average		60·29	62·45	3·057	58·13	2·305

The figures of another man, Tapau, are also excluded. His figures were *A* 74·9; *B* 74·7, m.v. ·4; *C* 75·0, m.v. ·8. He was almost exactly right every time. He was, however, the first individual whom I tested and it is possible that he was using a mark or some other indication on the slide and unfortunately I did not test him on a second occasion.

One very striking result of these observations is that the final measurement is influenced to a considerable extent by the position of the slide at the beginning. When the part *BC* of the figure is shortened till it appears equal to *AB*, the former is made consistently (by all except one man) longer than when the apparatus was presented to the native with the slide pushed in, so that *BC* had to be made equal to *AB* by lengthening it. The result is of exactly the same kind as was found in the process of eye measuring (see p. 101).

TABLE XV.

Name	Age	*A*	*C*	m.v.	*B*	m.v.
Ulai..............	55—60	66·7	64·8	6·24	68·6	4·08
Jimmy Dei......	45—50	69·1	64·8	1·12	73·4	1·52
Wasalgi*	40—45	62·8	60·6	2·32	65·0	2·8
Capsize	40—45	72·3	67·4	4·32	77·2	·64
Pasi*	40—45	56·3	53·2	2·16	59·4	1·68
Kaige	35—40	64·2	63·0	1·6	65·4	1·52
Jimmy Rice ...	30—35	64·7	66·6	3·52	62·8	1·44
Dick Tui.........	30—35	53·7	52·4	2·88	55·0	1·6
Jimmy Wailu...	25—30	60·8	58·4	3·36	63·2	1·76
Dubwai	20—25	63·7	63·2	1·36	64·2	·64
Berò	17	63·8	60·8	2·72	66·8	2·56
Average		63·46	61·38	2·87	65·54	1·84

When a variable length is made equal to a standard, there is a distinct tendency towards a positive error if the former is made equal by a process of shortening and towards a negative error when made equal by a process of lengthening.

This constant result with the Müller-Lyer illusion would seem to show that in making the two lines apparently equal, the natives were influenced by the idea of the length with which they had started. There is, however, another possibility. It is possible that the illusion tended to increase as a succession of measurements were made, in which case the smaller length of *BC* in the second five observations would be due to increase in the amount of the illusion.

In order to find out if this was or was not the case, another series of observations were made in which the order was reversed; the first five observations were made equal by moving the slide from within outwards and the second five from without inwards. The results in Table XV. show the same difference as in Table XIV., the second five observations giving in this case the greater length of the variable line.

Table XV. shows very clearly that the differences in the measurements of the illusion are not due to the order in which they were made. The figures are 62·45 : 58·13 in the first series and 65·54 : 61·38 in the second and only one man (Jimmy Rice) in the second series departed from the rule. One man, Wasalgi, made a third series of five measurements beginning with the slide in, of which the average was 61·6, m.v. 1·28. It is difficult to see how the differences can be explained in any other way than by referring them to the fact that the line *BC* was made equal to *AB* in one case by a process of shortening and in the other by a process of lengthening.

It may be noted that, except in the case of one man, Wanu, in Table XIV., the difference in question occurred in those cases in which the slide was moved by myself, *i.e.* the difference did not depend on a difference in the motor processes of adjustment. The line *BC* was apparently seen longer in one case and shorter in the other.

On comparing Tables XIV. and XV., it will be noticed that the illusion seems to have been less marked to the individuals in the second series. The latter were quite as intelligent and careful, if not better, observers than those included in Table XIV. and as will be noticed their average mean variations are very distinctly smaller. Three individuals, Jimmy Wailu, Dick Tui, and Berò, were tested twice and come into both tables. The observations of the first-named differed very slightly on the two occasions, while in Berò's case the illusion seems to have been more marked on the second trial, his mean variation being also distinctly less. Dick Tui's first measurements are those recorded in Table XV. so that the illusion was less marked in his second observations. The fact, however, that in the latter he did not move the slide himself may have had some influence. The average in Table XV. is distinctly raised by the figures for two men, Jimmy Dei and Capsize. The former was one of the most intelligent and conscientious observers in the island, and he performed this measurement with extraordinary care and attention, taking twenty minutes to make the ten observations, and having too a very small mean variation. The illusion seems to have been very slight, especially when moving the slide inwards, but he told me afterwards that he took into account the fact that *BC* was made up of two parts and endeavoured to make *BD* and *DC* together equal to *AB*. Such a procedure would tend to concentrate his attention on the central line so that he would have been less influenced by the other parts of the figure, and the small amount of the illusion may have been due to this. The other man, Capsize, made his observations carefully and his mean variation was not very large. I made him repeat the measurement, when his second result closely resembled the first, the figures being:—*A* 73·3, *C* 70·4, m.v. 1·28, *B* 76·2, m.v. ·96. I could not discover whether there had been anything unusual in his procedure but it is possible that he may have had the same idea as Jimmy Dei.

The following tables give the results for ten Murray Island boys and nine girls, the letters having the same meaning as in the previous tables.

Table XVI.

Murray Island boys.

Name	Age	*A*	*B*	m.v.	*C*	m.v.
Jacob (Gabi) ...	13	63·1	62·8	1·04	63·4	2·08
Poï (Pasi)	13	64·0	63·4	2·72	64·6	3·28
Jimmy Rice ...	12	52·8	52·0	2·00	53·6	·88
Captain	11	61·1	62·2	·64	60·0	1·20
Tom (Tanu) ...	11	51·4	56·2	2·72	46·6	·88
William (Tat)...	11	61·3	64·2	1·04	58·4	1·28
Sailor (Gabi) ...	11	64·8	67·4	2·08	62·2	1·84
Manowar	11	65·9	67·8	4·24	64·0	2·80
Harry (Mamus)	10	55·8	56·0	4·40	55·6	2·88
Depoma	10	71·4	68·6	2·08	74·2	1·44
Average		61·16	62·06	2·296	60·26	1·856

Table XVII.

Murray Island girls.

Name	Age	*A*	*B*	m.v.	*C*	m.v.
Mary (Kailu) ...	14	60·1	61·4	·88	58·8	1·72
Sidoï	14	62·9	64·6	2·72	61·2	1·28
Maletta (Joani)	13	62·5	63·2	2·72	61·8	1·44
Godaia	13	63·2	63·6	2·88	62·8	3·76
Nei	13	70·2	72·8	2·96	67·6	1·92
Kaunur	12	63·1	67·2	1·76	59·0	·80
Maima............	11	62·0	64·0	2·00	60·0	1·20
Gada	10	63·9	65·8	2·24	62·0	·40
Maletta (Gabi)	10	55·1	57·6	5·92	52·6	2·08
Average		62·55	64·47	2·68	60·64	1·62

The boys included in the above table moved the slide from without inwards in the first series and in the opposite direction in the second. In addition two boys were tested in the reversed order. Their figures were:—

George (Pasi), 45·8, In 47·6, m.v. ·88, Out 44·0, m.v. ·8.

Jimmy Dauar, 59·0, In 57·6, m.v. 1·92, Out 60·4, m.v. 2·32.

There appears to have been no important difference in the amount of the illusion in the children and adults. The mean variations were distinctly smaller than those of the first series of men, though not differing greatly from those of the second series in Table XV. The girls unanimously showed the characteristic difference due to the position of the slide at the beginning of the measurement, but the boys were much less uniform, no less than five out of twelve boys failing to show this feature. It is perhaps interesting that of these five boys, four (Jacob, Jimmy Rice and the two sons of Pasi) were among the cleverest boys in the school, while the fifth Depoma, was more or less exceptional in everything he did. This boy had also the highest result among the children, but he understood perfectly and appeared to make his measurements in the same way as the others, and his mean variations were each below the average.

In the following table are given the results of observations on English adults and children for comparison with those of the Murray Islanders. I have divided the English adult observers into two groups, the first group (*A*) being made up of students and others well acquainted with the illusion (who, nevertheless, tried not to be influenced by their knowledge), and the second group is made up of individuals who had no special knowledge of the illusion, though several were more or less acquainted with the figure owing to its use as an advertisement. As in the case of the other illusion, I have not as yet been able to make observations on people as totally unacquainted with the illusion as were the people of Torres Straits.

TABLE XVIII.

MÜLLER-LYER ILLUSION.

Comparative Results.

	No.	*A*	Max.	Median	Min.	*B*	m.v.	*C*	m.v.	M.V.
Murray Island men	19	60·3	68·8	60·6	49·8	62·5	3·06	58·1	2·3	3·82
Murray Island boys	10	61·2	71·4	62·2	51·4	62·1	2·3	60·3	1·86	4·7
Murray Island girls	9	62·6	70·2	62·9	55·1	64·5	2·68	60·6	1·62	2·33
English adults, A.	15	55·4	67·2	55·8	45·6	57·0	1·79	53·8	1·42	5·99
English adults, B.	15	55·8	66·4	54·7	48·4	56·8	2·01	54·8	1·6	3·67
Girton children ...	12	55·8	68·4	56·3	43·5	58·9	2·56	52·7	1·76	6·05
Murray Island	38	61·1	71·4	62·2	49·8	62·8	2·77	59·3	2·03	3·89
English	42	55·6	68·4	55·8	43·5	57·4	2·09	53·8	1·58	5·02

The three Murray Island groups show a remarkable correspondence with one another, and the three English groups show a similar agreement with one another. The English and the Papuan groups, on the other hand, are distinctly separated. The correspondence and the difference are shown equally well in columns *A*, *B*, and *C*. The close agreement of the different groups of the two sets of observers allows one to attach more importance to the want of agreement of the two sets with one another than might perhaps be otherwise justifiable. The illusion appears to be distinctly less marked to Murray Islanders than to the Europeans. This is shown not only by the average but by the maximum and minimum observations, and also by the median observations, which differ but slightly from the averages.

The characteristic relations between the figures in columns *B* and *C* come out clearly in every group, *i.e.* in every group the average measurement when the slide was pushed inwards was distinctly larger than when the slide was pulled outwards. The difference was least marked in the Murray Island boys, and the English group who were not especially familiar with the illusion and was most marked in the English children. The English and the Papuan groups, each taken as a whole, show no obvious difference in this respect.

The average mean variations of the different groups in making their measurements show a distinct superiority of the English over the Papuan observers, but it will be noticed that the Murray Island children do not differ appreciably from the English children and the unpractised group of English adults. It is the difference between the Murray Island men and the English group *A* (all practised observers) which makes the average mean variation of the English observers superior to that of the Papuans. Taking this fact into account, the average mean variations of the Murray Islanders show that they performed the operations involved in the test with a degree of constancy and accuracy, very slightly inferior to an equal number of English people.

All groups agreed in having a smaller average mean variation in the second set of five observations than in the first set. This difference was present in the same degree among the Murray Islanders who reversed the order in which the slide was moved (Table XV.). The improvement was slightly greater for the Murray Island than for the English observers, *i.e.* 26·7 per cent. : 24·4 per cent., and was distinctly more marked in the Papuan than in the English adults. The fact that the mean variation shows a greater decrease in the second set of observations may mean that the Papuans improved more by practice or that they were less influenced by fatigue, slackening of interest and loss of concentration of attention. There can be little doubt that it was the former factor which had the most influence.

As I have already mentioned, the results obtained by my instrument are not to be exactly compared with those obtained by other methods owing to differences in the thickness of the lines, etc. Heymans[1], however, found that, with a figure, in which the angle of the slanting lines was 30° and their length 20 mm., the illusion amounted to 23·2 per cent. This is less than the amount of the illusion in my English observers, viz. 25·9 per cent., but is distinctly greater than that of the Murray Islanders, viz. 18·5 per cent. Heymans' observations were only made on a few individuals, chiefly professors and students, and the figure given above is the result of one observer. So far as I have been able to find, Binet[2] is the only previous worker who has measured the illusion in a number of individuals. His observations were made on 105 children. He used a different method to that employed by me, and

[1] *loc. cit.*
[2] *Revue philos. T.* XL. p. 11. 1895.

obtained different results according to the size of his model. With a standard line 10 cm. in length, he found that the illusion amounted to 18·8 per cent. in the older children, who varied in age from 10 to 14 years. With a smaller standard, 2 cm. in length, the illusion was still more marked.

In a group of younger children, ranging in age from 7 to 12 years, the illusion was more marked, amounting to 24 per cent.

In Binet's figure the slanting lines were at an angle of 45°, the line with obtuse angles was the standard and that with acute angles was variable. Binet's results cannot be directly compared with mine, but the per centage illusion does not differ in any marked degree from those obtained with my instrument, that for the elder children agreeing almost exactly with the Murray Island figures, and that for the younger children agreeing closely with that of my English observers. The average mean variations of Binet's children were very distinctly larger than those of any of my groups, the former amounting in one case to over 10 per cent. of the standard while the maximum mean variation of my subjects, viz. that of the Murray Island adults, was only 4·1 per cent.

Binet's results, though obtained by a method quite different from mine, showed the same characteristic difference in the measurements according to whether the variable was presented in order of increasing or of decreasing magnitude. Binet found that the illusion was greater when the lines were made equal by a process of shortening. This is exactly the opposite result to mine, but the difference is only apparent, and is due to the fact that the line with acute angles (*AB* of my figure) was the variable. *AB* was made smaller when it was presented in order of increasing length than when it was presented in order of decreasing length, the characteristic difference being present in both groups of children and with both the large and small model.

This illusion is most satisfactorily explained by a factor which may be expressed in several ways. Auerbach[1] ascribes it to the influence of indirect vision. The apparent length of the lines *AB* and *BC* is influenced by imaginary lines filling the spaces on either side of the chief line. These will be shorter than the chief line in the case of *AB* and longer in the case of *BC*. Auerbach found that alterations in the figure tending to render the chief lines more prominent, reduced the illusion, while alterations tending to make the slanting lines more prominent increased the illusion.

Another way of expressing the same fact is to suppose that the idea of the length of the line *AB* is influenced by the size of the figure as a whole, and similarly with the idea of the length of the line *BC*. There are other examples of figures in which the appearance of part of a figure is influenced by the appearance of the figure as a whole.

There is no reason why a simple factor of this kind should not influence the Papuan as well as the European. The fact that the illusion seemed to be distinctly less marked to the Papuan than to the European may possibly be due to the fact that the former concentrated his attention more completely on the special task he was given to perform, viz. to make the lines *AB* and *BC* equal to one another, and tended to

[1] *Zeitsch. f. Psych. u. Physiol. d. Sinnesorgane*, Bd. VII. S. 152. 1894.

disregard the other lines present in the figure. The European, on the other hand, probably recognizes at once that he is dealing with more than the simple problem of the relative length of two lines and tends to regard the figure as a whole.

As I have already more than once mentioned, I believe that the consistency of the results in Murray Island was due to the fact that the natives limited their attention strictly to the task they were given to perform, and the explanation which I suggest is in accordance with this belief.

The figures in the last column of Table XVIII., under the heading M.V., indicate the degree of the variation of the individual results within each group from the average result of the group. M.V. is an index of the variability of the individuals within each group.

It will be seen that there is a distinct difference between the Papuan and the English observers, the former having the smaller mean variation, *i.e.*, a number of Papuans gave results which were more consistent with one another than those of an almost equal number of English people, and the group of Murray Island men[1] varied from one another very much less than the group of practised English observers.

This is another example of the fact that in some respects the unpractised and wholly ignorant inhabitants of Murray Island give more consistent results than Europeans practised in psychological observation. In the Introduction I have suggested that the greater consistence of the Murray Islanders may have been due to their total ignorance and to the fact that they gave their whole minds to the special operation they had to perform, and were not influenced by speculations founded on knowledge, in this case on knowledge of the illusion.

There is, however, another possibility. It is possible that the members of a small isolated community such as that of Murray Island may differ less from one another than the members of a highly complex community not only in physical characters, but in the mental characters involved in such an operation as they had in this case to perform. In general character and temperament we found that the natives of Murray Island differed from one another very widely, but it is possible that in the simpler mental features they may present more uniformity than is found among the members of a highly civilized community.

The whole subject is obviously an extremely complex one which I hope to consider in a future Report, in which the variability of the natives of Torres Straits will be studied on the basis of all the data, both mental and physical, collected by the Expedition. I must content myself here with a suggestion of some of the factors involved in the problem.

I have in the Introduction stated that the trustworthiness of the observations made by the natives of Torres Straits will be shown in most of the quantitative investigations both by the smallness of the mean variations and by the general consistency of the results. The figures given in Table XVIII. will, I hope, be held to support this statement. The very slight inferiority to the English observers in accuracy as shown by a comparison of the average mean variations (m.v.) and the remarkable

[1] It is true that the observations of four individuals were excluded from the Murray Island group (see p. 118), but these observations were so obviously unsatisfactory that it would not have been fair to include them.

correspondence of the three Murray Island groups with one another would have been impossible if the Murray Islanders had not applied their full attention to their tasks or if they had failed to understand what they were told to do.

Other visual illusions.

In addition to the quantitative observations made on the two examples of visual illusion, rough observations were made with several other examples with the object of ascertaining whether the illusion was present or not. For this purpose I used the collection found in the "Pseudoptics" sold by the Bradley Martin Co. I may mention in passing that the natives were extremely interested in many of the experiments which can be shown with this collection, and anyone living among uncivilized races would probably find the collection very useful in interesting and amusing natives quite apart from any scientific aim.

Care had naturally to be taken not to suggest the illusion and the natives were therefore asked first simply to describe what they saw or were asked if there was any difference in different parts of a figure. Several of the natives showed their appreciation by measuring as they had done in the cases of the quantitative observations already described.

In showing Zöllner's and the allied figures, I pointed to different parts of Fig. 3, and to the middle and ends of the parallel lines in Fig. 4 and Fig. 5, and asked if the distances were okakis (equal) or not. Several natives described different (really equal) distances as taupai (short) or piripiri (long) quite in accordance with the normal appearance of the illusion, and some illustrated the apparent divergence and convergence of the lines by gestures which left no doubt that they saw the illusion. This was the case, not only with intelligent young men and boys, but also with two of the older men, Ulai and Sisa. On the other hand, Pasi, one of the most intelligent men, failed to see or, at any rate, to describe the illusion.

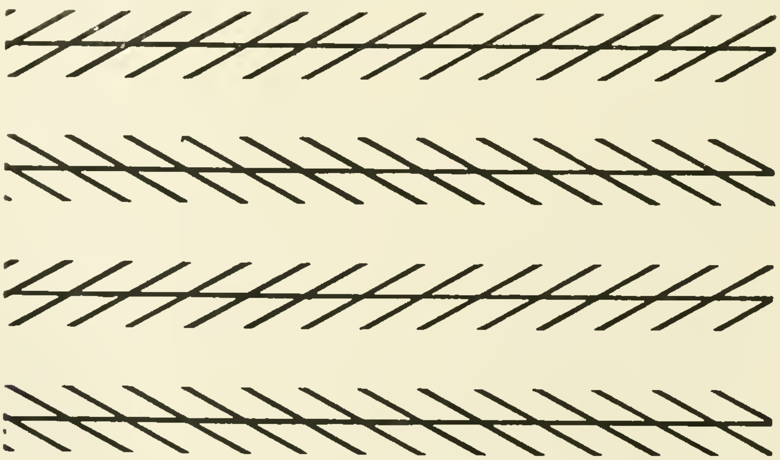


Fig. 3.

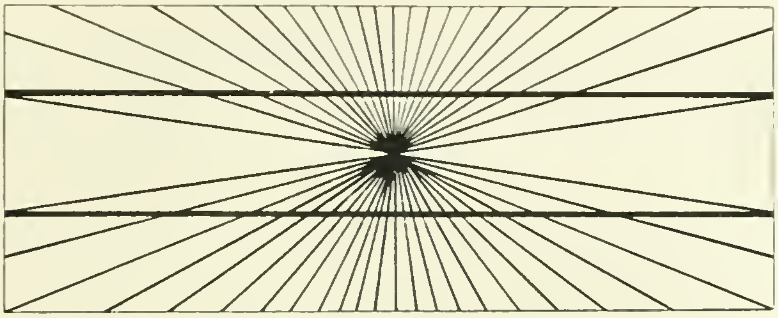


Fig. 4.

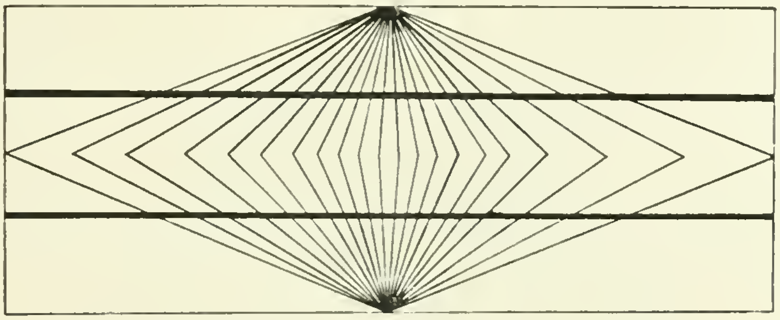


Fig. 5

None of the natives observed the apparent difference in the shape of two squares filled with parallel lines when these were vertical in one square and horizontal in the other. Several persisted that they could see no difference, even after leading questions had been put.

There were also many failures to see the illusion in Fig. 6 which is so very marked for European eyes.

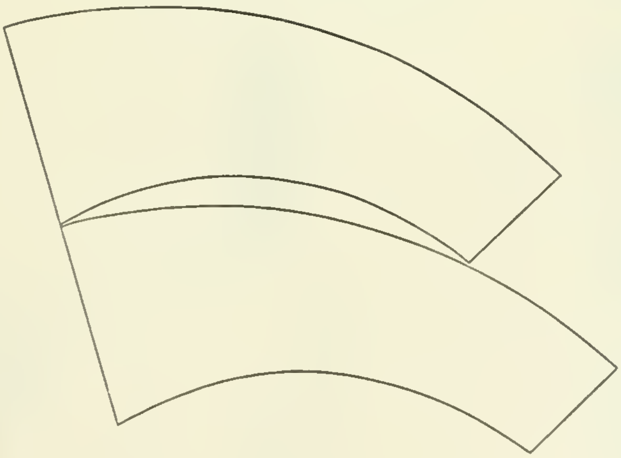


Fig. 6.

No single native saw any difference in the size of a white square on a black ground and an equal black square on a white ground. Very good observers, who saw nearly all the other illusions readily, failed to see any difference here, and I cannot help attaching some importance to this observation and believing that it shows that irradiation was less marked to the Papuan than to the European eye. The question is one of great importance in relation to visual acuity, and if it were established that irradiation is less marked in primitive races, it would help to explain any superiority in visual acuity which these races show. On the other hand, there is little doubt that irradiation depends largely on the refractive condition of the eyes and on the size of the pupils, and it may be that the absence or slight degree of irradiation is associated with one or other or both of these factors.

The illusion of Fig. 7 (known as the chess-board illusion, first described by Münsterberg) was not seen by intelligent natives to whom it was shown. This illusion almost certainly depends on irradiation and it is therefore of interest that it was not observed.

To my surprise the illusion shown in Fig. 8 did not succeed, except in the case of one of the most intelligent younger natives and a Samoan boy. I expected that the man would by all be seen as bigger. Most of the natives, however, took less interest in this illusion than in most of the others; if I had had a similar figure representing two Murray Islanders, I have very little doubt that it would have been most popular and the illusion would also probably have succeeded.

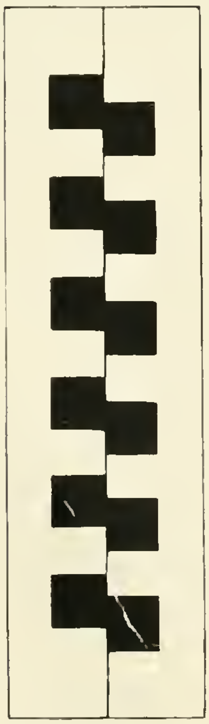


Fig. 7.

Fig. 8.

The appearances which were most successfully seen were those of a rotating spiral and of Fig. 9, illustrating visual perception of movement. The after-image appearances after looking at a rotating spiral were described readily and spontaneously by nearly all. I usually told them to look at my face after they had watched the spiral and they were all very excited and amused at the apparent swelling of the face which is seen after looking at inward rotation of the spiral. The men evidently saw the appearance readily and many described it very graphically with hand gestures, and it certainly seemed to me that they saw the appearance more readily than most Europeans to whom I have shown the same experiment. The appearance is, however, materially assisted by a good illumination and this may have accounted for the distinctness with which the natives seemed to see it. The apparent shrinking which follows outward rotation of the spiral was not observed so readily, and by some not at all, and this agrees with my experience among Europeans that the apparent swelling is more readily seen.

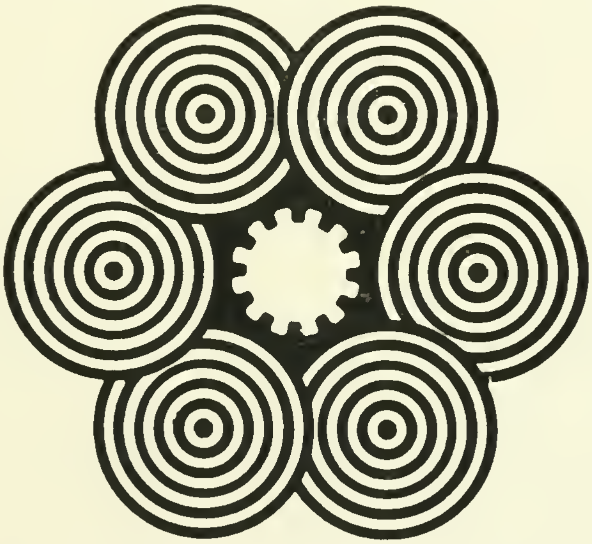


Fig. 9.

These observations brought out very distinctly the marked individual differences in temperament which one found among these natives. Most were extremely demonstrative and showed their astonishment and amusement in a very obvious manner, while a few looked stolidly at the rotating disc and at my face and described the appearances correctly while betraying as little interest or amusement as one would expect from the average English rustic.

Another allied appearance which was seen readily by nearly all was that of Fig. 9, the contrast movement of the central toothed circle when the whole figure is given a rinsing movement. In nearly all cases the natives observed the apparent movement of the central part of the figure and described it correctly as being in the opposite direction to that of the surrounding circles and as slower.

When in Mabuiag, I asked several natives if they had noticed any difference in the size of the sun and moon at the horizon and zenith respectively. Some had observed the difference and some had not. The drawings represented in Fig. 10 were made by Waria to show how he saw the sun and moon in the two situations.

It will be noticed that he has not only represented both sun and moon as much larger at the horizon but also as flattened. These drawings add another indication to those already given of the excellent powers of observation of these people.

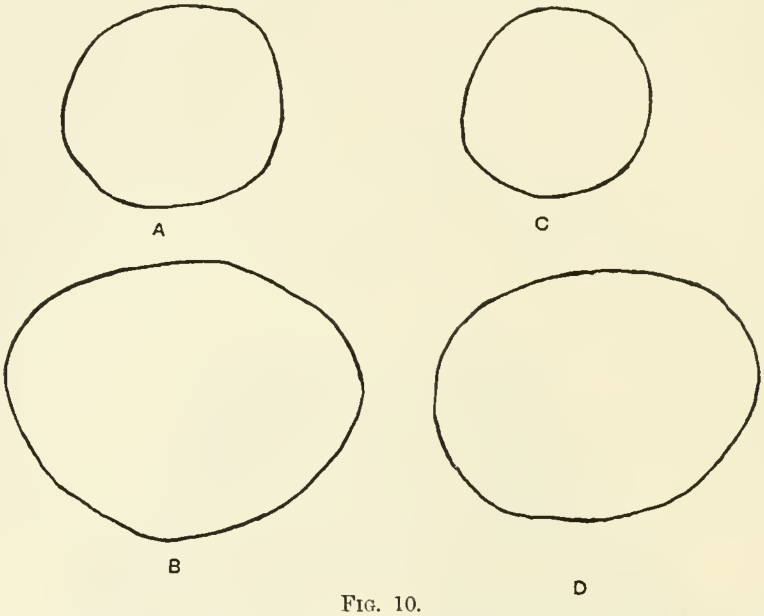


Fig. 10.

A. Sun at zenith. B. Sun at horizon. C. Moon at zenith. D. Moon at horizon.

A few observations were made with the object of ascertaining if the natives could observe the existence of the blind spot. For this purpose I used the figures provided in the Milton-Bradley collection. The experiment certainly seemed to succeed with several natives and owing to their power of steady fixation of the eyes (see p. 99) there is no reason why it should not do so. The difficulty was to obtain some kind of control over the statements of the natives and the only one I found practicable was to note the distances from the eyes at which an object was said to disappear and reappear. In the case of several natives, this agreed closely with the distances for my own eyes and I believe that the objects became invisible to these people, though I do not feel the same confidence in this experiment as in the others recorded.

Another illusion on which a few observations were made was that of the appearance of relief of different colours. A black velvet surface was used on which were pasted letters in red and blue, and the natives were asked whether they noticed any difference—whether they were "maike," "murizge," or "okakis" (nearer or farther away or same distance). As is well known, some individuals see red in relief, the colour standing out in front of blue often very considerably, others see blue in front of red, the difference depending mainly on the eccentricity of the pupils, those with nasal pupils seeing blue in front and those with temporal pupils seeing red in front.

Of those tested several saw no difference while several others said they saw blue "maike" and red "murizge"; only one boy saw red "maike." Of four natives who saw blue nearer than red, three had markedly nasal pupils and in another they were slightly nasal; in the fourth the pupils were median. The boy who saw red nearer had median pupils (see p. 11). Unfortunately I had no means of checking their statements, but I am inclined to think that the answers were genuine.

APPENDIX.

By C. G. SELIGMANN.

The Vision of Natives of British New Guinea.

Visual Acuity.

The E method was employed throughout in the manner already described by Dr Rivers, except on one occasion at the mission school at Vatorata where Snellen's test types were used. All observations were made in the open air, either under a verandah or completely in the open. Observations among coast folk were begun at a distance of 15 metres from the type; this was, however, diminished to 12 metres when examining women and inland tribes. As a general rule little difficulty was experienced in making natives understand the process, but three Garia youths who had successfully gone through the tests for colour vision, whether from shyness, stupidity or fear could not be made to understand what was required of them. Similarly a Bulaa woman, Derapa, who was quite unusually fat for a Papuan, could not or would not understand, although the process was carefully explained to her in the Bulaa dialect. Again, in the only marked case of myopia seen, occurring in a Yule Islander with a reputation for cleverness among the local missionaries, considerable difficulty—which might easily have been mistaken for lack of comprehension—was experienced in persuading the subject to allow himself to be even partially tested.

Another source of fallacy was learning by heart, which occasionally was very quickly done. A Motuan who had been educated in the mission school was found to have learnt the line of No. 5 type after being taken through it twice, and to be able to repeat it correctly with his back turned to it. Another similarly educated Motuan repeated the line backwards correctly after a very short time. An attempt was made to ascertain how this was done, but I was unable to satisfy myself that he visualized the line, though possibly this occurred.

It was several times noted that just beyond the limit of accurate vision the two horizontal positions ш and m were mistaken for each other, as were the vertical positions E and Ǝ, while a horizontal position was never mistaken for a vertical or *vice versâ*.

Some 50 Papuans, all natives of British New Guinea, were tested. Throughout these observations the ages of the subjects were judged by their general appearance.

At Bulaa ten males, all judged to be between 16 and 25, were tested. In all of these V was greater than $\frac{10}{5}$. The average visual acuity of seven of these was $\frac{13 \cdot 7}{5}$, the median $\frac{14}{5}$ and the maximum $\frac{18}{5}$.

Two male albinos, judged to be about 45, were also examined at Bulaa; one of them who had lost one eye could decipher $\frac{12}{6}$, the other $\frac{8}{6}$, but in the latter case it was not clear that his limit had been reached.

Ten Bulaa girls had an average of $\frac{11 \cdot 1}{5}$, a median of $\frac{10 \cdot 5}{5}$ and a maximum of $\frac{19}{5}$. At Yule Island, as already mentioned, a single instance of myopia was seen; the subject in this case wrinkling his lids and narrowing the palpebral fissure when asked to look at a distant object, as among European myopes. Here too a case of marked hyperacuity of vision, exceeding anything met with in Torres Straits and approaching that of Kotelmann's Kalmuks, was seen. This man could read $\frac{22}{5}$ without hesitation, and if it had been possible to test him further would probably have shown even more marked keenness of vision.

Four Yule Islanders, including the above instance of hyperacuity, gave $\frac{5}{5}$, $\frac{6}{5}$, $\frac{9}{5}$, $\frac{22}{5}$. Two Waima men could read $\frac{10}{6}$ and $\frac{8}{6}$. Three Motuans examined at Vatorata could read $\frac{14}{5}$, $\frac{17}{5}$ and $\frac{18}{5}$ respectively. Of inland tribes, nine Sinaugolo men had an average acuity of $\frac{8 \cdot 1}{5}$, with a median of $\frac{8}{5}$, and a maximum of $\frac{13}{5}$. The acuity of two Sinaugolo women was $\frac{8}{5}$ and $\frac{9}{5}$.

Six hill men from the Sogeri country, some 25 miles inland from Port Moresby, were examined. Five of these gave $\frac{5}{5}$, $\frac{7}{6}$, $\frac{8}{5}$, $\frac{8}{5}$, $\frac{8}{5}$; the sixth man could easily read $\frac{11}{10}$, probably about $\frac{10}{6}$ represented his visual acuity.

Two Tatikaro men could both read $\frac{5}{5}$, a third (unfinished) could read $\frac{10}{6}$ but not $\frac{10}{5}$. Owing to their newness to civilization and the ease with which their attention was distracted it was not found possible to determine with absolute accuracy the visual acuity of the members of the last two tribes. It is however believed that the above figures may be taken as approximately true, but erring perhaps on the side of unduly diminishing their visual acuity.

It will be readily seen from the above figures that the visual acuity of members of coast tribes was generally greater than that of inland folk. Omitting the Sogeri and Tatikaro men there remain nine Sinaugolo men examined under the most favourable conditions with an average visual acuity of $\frac{8 \cdot 1}{5}$ against seven Bulaa men with an average acuity of $\frac{13 \cdot 7}{5}$ and, excluding a marked myope, a mixed group of 14 coast men from Bulaa, Port Moresby and Yule Island with an average acuity of at least $\frac{13 \cdot 3}{5}$.

The following table, of the same nature as that already given by Dr Rivers (p. 25), further brings out these differences.

As regards sexual differences ten Bulaa girls and women had an average visual acuity less by 2·5 metres than the average of seven Bulaa men, while among the Sinaugolo the only two women examined were within a metre of the average of nine men. Although the above numbers are too small to allow a definite opinion, it would appear that at Bulaa at any rate, the visual acuity of women was less than that of the men. It is perhaps noteworthy that the average of the Bulaa women agrees closely with that of the Murray Island girls tested by Dr Rivers, while that of the Bulaa men is distinctly superior to that of the Murray Island men.

This might be regarded as an expression of smaller racial variability among women, but it must be remembered that all the Bulaa men were young and that

	No.	Average acuity	$V=1$ or <1	$V=1\cdot1$ to 2	$V=2\cdot1$ to 3	$V=3\cdot1$ to 4	$V=4\cdot1$ to 6	$V>1$
Yule Island and Waima	7		28·5	57·1	0	0	14·3	71·4
Motu	3	$\frac{16\cdot3}{5}$	0	0	33·3	66·6	0	100
Bulaa ♂	10		0	30	50	20	0	100
Bulaa ♀	10	$\frac{11\cdot1}{5}$	0	40	50	10	0	100
Total coast tribes.........	30		6·6	36·6	36·6	16·6	3·3	93·3
Sinaugolo	9	$\frac{8\cdot1}{5}$	11·1	77·7	11·1	0	0	88·8
Sogeri........................	6		16·3	83·6	0	0	0	83·3
Tatikaro	3		66·6	33·3	0	0	0	33·3
Total inland tribes	18		22·2	72·2	5·5	0	0	77·7

Dr Rivers found that in Torres Straits the visual acuity begins to fall off at an early age. If the Bulaa men are compared with the Torres Straits men between the ages of 15 and 35 (see Table II. on p. 29) there is no marked difference between the two groups.

Colour Vision.

Holmgren's wools were employed, the three test-wools commonly used being, at Dr Rivers' suggestion, supplemented by the four others which he had found useful (p. 49), while the process of examination was as far as possible identical with that employed by him.

Thirty-four men, one an albino, and five women were examined, all readily appreciating what they were required to do. There seemed little tendency to put together wools to which the same name would be applied, and with the exception of Ola, a native of Bulaa, no real difficulty was experienced by anyone in matching the test wools. The Sinaugolo and Tatikaro tribes were specially quick and correct, a point of interest, since the former have the most incomplete and indefinite colour vocabulary met with in British New Guinea.

The Bulaa natives were perhaps the least accurate; purple was generally matched slowly and after much hesitation, while the green test was commonly matched with greens or green-blues of varying saturation. Ola may be taken to have had some degree of colour-blindness, although on being given a pale green or yellow wool he matched either easily enough. Red was matched quickly and correctly, then after some hesitation violets and purples of about the same saturation were placed by the type. Pink was matched with a number of blues and violets mostly more saturated than the type. On being asked to name the colour of this test he said marawa, the term applied by his fellow tribesmen to blues and blue-greens. The blue type was matched with a pink wool of about the same saturation, while a pale mauve test was placed by the side of more saturated pinks and blues.

Definite names for red, white, and black, were found everywhere, and purple was almost always called by the same name as red.

Orange and yellow commonly had a name of their own, while the names for the other colours were often vaguely defined and indefinitely applied. This was most marked amongst the Sinaugolo—an inland tribe in the Rigo district—where dubaduba, black, said to be derived from duba, a dark cloud, or kewau, rainbow, were the names commonly given alike to green, blue, indigo, violet, and black. Nearly everywhere all colour names were identical with, or formed from, the names of natural objects, and this explains the fact that the rarer colour names, used by only a few of the individuals questioned, were usually understood by the rest of the village.

Eastwards of Yule Island, as far as Bulaa, colour names were for the most part formed by reduplication[1], and this was specially marked for those colour names which were most definitely applied. Over this area reduplication is used to suggest intensification of the most obvious or important qualities of an object; thus at Bulaa where kalova meant fire, kalovakalova besides meaning red was employed to signify glowing embers, while among the Sinaugolo where kulo signified the white cockatoo, kulokulo meant both white and the distinguishing head-dress made of cockatoo feathers worn only by successful homicides. Rarely among the Motu the name for a definite and saturated colour would be qualified by the slowly drawled adjective momo, meaning plenty, and probably in a colour sense used to express pure or very. This was perhaps done by way of explanation, and it seemed doubtful whether the people would among themselves make use of this, one of their favourite adjectives, in describing a colour.

Among these people, who employ reduplication extensively, the affix *ka* is used to diminish the force of a colour name, and has the signification of our *-ish*. It was, however, found that a name so weakened might be reduplicated, when it seemed that it had all the force of the reduplication of the original term; thus gadokagadoka and gadogado seemed to be indifferently applied to the same object.

Westwards of Yule Island reduplication played but a small part in colour nomenclature, and at Waima, according to the late Père de Reycke—a most careful observer—gave the force of the affix *-ish*.

[1] It is probable that an exception to this generalization will be found among certain inland tribes in the neighbourhood of Port Moresby. An attempt to obtain colour names from some Sogeri and Koiari men resulted in lists of words which showed little trace of reduplication.

As far as could be determined, there was the same absence of reduplication among the Toaripi and other Gulf tribes, but it was found by Dr Rivers to occur among the Western Papuans of Kiwai and at Murray Island in Torres Straits.

As regards the objects from which colour names were derived, the sea, as far as could be determined, played an important part only among the Motuans and among the coast folk at Bulaa, both of whom are essentially seafaring folk. The former people, besides deriving their words for green and blue from the sea, have as their word for black the reduplicated name of a black holothurian common on the reefs, this being the only example of a coast people east of Cape Possession where the word for black was not commonly derived from the universally employed mourning pigment—made from burnt coconut husks—although this substance was so used among them.

Throughout the Mekeo district the word for red was the name for the female of the parrot, Eclectus polychlorus. At Bulaa the term for this parrot was verala, and the same word was applied to its tail feathers, which were much in demand for dancing head-dresses, especially when their red colour had been rendered yellow by prolonged feeding for three or four years with roast food to which a species of ginger had been added, and this name was occasionally used to designate an orange-coloured paper.

This is an interesting example of the origin of a colour name from the same object among people who could scarcely have come into contact with each other. Another widely spread example was the word for black, which, as already stated, among most of the tribes investigated was derived from burnt coconut husks. In the Western Tribe of Torres Straits the common term for black was similarly found by Dr Rivers to signify charcoal.

At Bulaa red was called kalovakalova—literally glowing embers—by all of the six men examined separately, and the same term was applied to purple by all except Ola, who called it marawa, and, as already mentioned, was probably to some extent colour-blind.

Yellow and orange were called polapola—pola, turmeric—rarely kalovakalova or verala—the name for the female of the parrot Eclectus polychlorus—or lupalupa—explained as the colour of a Papuan's skin, and perhaps the same as duba, a black cloud. Meramera, the term for ripe banana skin, was also used.

The various shades of green and blue, including indigo, were generally called marawamarawa from marawa the deep sea, much more rarely lupalupa, polapola, kavukavu (wood ashes) and even once kalova.

Violet was called milomilo, meaning the burnt husk of the coconut, which when made into a paste with water, is smeared over the body as a sign of mourning, less commonly lupalupa or marawamarawa.

Black was also called milomilo and rarely lupalupa.

White was always called kulokulo, from kulo, the white cockatoo. Keraikerai, explained as the colour of a limewashed wall, was also said to be used.

Among the Motuans of Port Moresby, red, purple, and rarely orange were called kakakaka, the term raborarabora from rabora, turmeric, being usually applied to orange and yellow.

Green and yellow-green were called gadogado from gado, the deep sea. All shades of green, green-blue, and blue being often called gadoka or gadokagadoka, the affix *ka* having the force of the termination *-ish*.

Indigo and violet occasionally derived from gado, were generally called hururu, literally flame.

Black was called koremakorema; the unreduplicated word being the name for a black holothurian commonly found in shallow pools.

White was called kulokulo from kulo, the white cockatoo.

Among the Sinaugolo red and purple were invariably called kakarakakara, and this term was usually applied to orange, which was rarely called borabora (bora, turmeric) or paiira.

Yellow was always called borabora as, for the most part, were the yellower shades of green, though these were sometimes termed meramera, from the colour of ripe banana skin, kulokulo, or margeta korokoro, the term for a special kind of banana leaf.

Green was called by any of these terms, except borabora, and it was sometimes termed kewau, meaning rainbow. Brilliantly green banana leaves were however called dubaduba, dubaradubara, or dubara kuku from duba, a dark cloud, and Mr A. C. English, Government Agent for the Rigo district, to whom my best thanks are due for much kindly aid in drawing up colour vocabularies of the Sinaugolo and Bulaa tribes, tells me that the former habitually use any of these words to describe the vivid green of a flourishing banana crop. Green-blue was usually called dubaduba, less often borabora or meramera.

Blue and indigo, commonly called dubaduba, were sometimes called kewau or margeta korokoro, while indigo was once called guruma, the name for the black pigment used as already described as a sign of mourning.

Black was called dubaduba, dubara or dubaradubara.

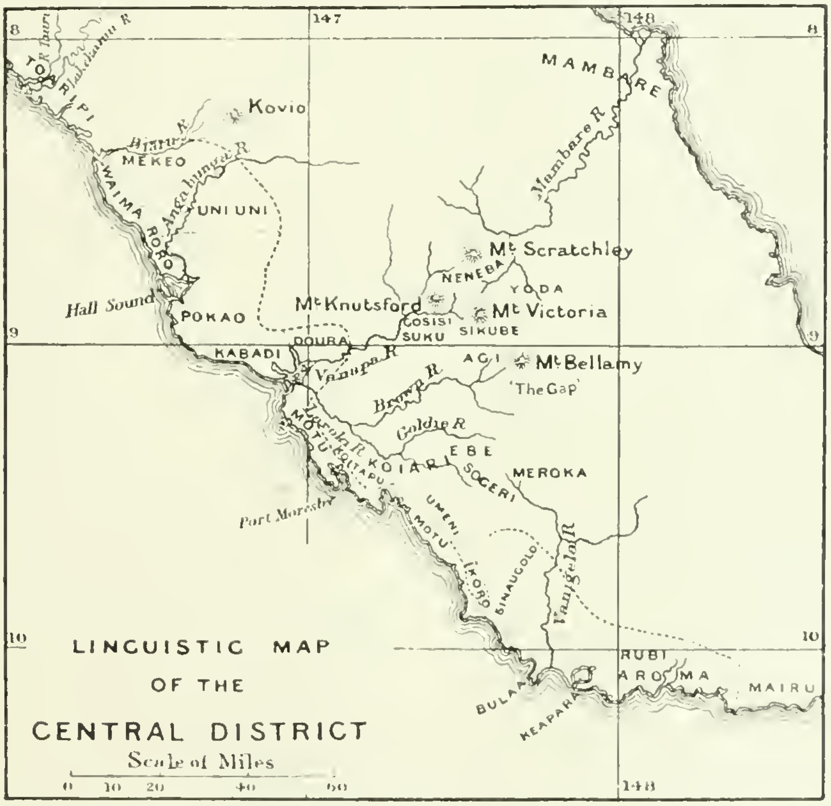
White was called kulokulo from kulo, the white cockatoo.

The remaining three vocabularies—for those of Mohu and Rabao are so much alike that they may be regarded as one—are from the Mekeo district. Inawabui is inland some 10 miles up the Angabunga (St Joseph River). Its colour names, with the exception of that for black are entirely different from those current among the coast tribes of Roro, Mohu, and Waima. On the other hand its terms for red and violet are closely similar to those in use for these colours at Tatikaro, an inland village on the Biaru river in the Papuan Gulf district. The tribal history of Tatikaro, as well as various objects obtained there, suggests that this may be explained by their being more closely related to the natives living on the banks of the higher reaches of the St Joseph River than to the coast folk of the Gulf who are their nearest neighbours and with whom they have largely intermarried. At Waima, which is a collection of family groups spread over a considerable area where there is probably a strong Gulf element, the colour names obtained were of the Mekeo coast type. Possibly if individuals of the different constituent groups were carefully and separately questioned, it would be found that the colour vocabulary varied and names akin to those of the Gulf might be obtained.

At Rabao, or Yule Island, red and purple were called biro (Eclectus polychlorus, female), never awaiabu, turmeric, which was strictly limited to yellow and orange. The pink wool was once called birona porena, *i.e.* red-white. Green, blue, violet and black were commonly called uma or umuna—mourning pigment—and these were the terms invariably applied to the green of coconut and banana leaves; rarely were green and blue called ariari. White was called pore. These people belong to the Roro tribe.

The Mohu names were for the most part formed from the above by adding the affix *na*.

At Waima only three men were questioned. Red was called biro, also opo, red ochre, and iruba, flame, the latter name being also applied to the brilliantly red stems of a species of Ricinus. Purple was also called biro or birobiro; and a red wool was once called biro tohana, meaning pure red, to distinguish it from purple. Orange and yellow were called aiabu, turmeric. Green, blue and violet were called ekoba[1]. Black was called umu (mourning pigment) or wapura (night, also perhaps dark, darkness). Umu was not suggested, and, as far as the late Père de Reyeke knew, was not used for green or blue; it is however probable that examination of a larger number of individuals would show some such use of umu. As in Yule Island, white was called pore.



The Rigo District includes the Rubi, Sinaugolo, Ikoro, Umeni, and part of the Motu.

At Inawabui a few colour names were obtained. Red was called pitonga, perhaps also ifa, blood, which was the term applied to purple. Orange and yellow were called laofanga. Green was called kulua koa, said to be the name for the skin of a green frog. Blue and black were called umunga, from umu, the mourning pigment. Violet was called umimi, which is probably another form of the same word or may possibly be the name of a fruit. White was called kelanga.

[1] Guis (*Les Missions Catholiques*, 1898, page 178) gives ekoba as a Yule Island term for green and mentions the word eziezi as used for chestnut and notes that white hair is called ezi. He further notes that the sky and a bottle of ink are both called umu, black.

Of Tatikaro colour-names bitonga may be assumed to be the same as the Inawabui pitonga, similarly omini and omunga—stated to mean blue and black respectively—are probably the same as umimi and umunga. The terms for orange and yellow, daupa, green, augi, and white, ibi, do not on the other hand seem to be related to any of the Mekeo terms.

At Jokea meuru applied to blue, violet or black is probably the same as the Toaripi meauru, a dark cloud; while the few Jokea colour-names obtained closely resemble those of Toaripi.

SKETCH MAP OF THE MEKEO DISTRICT

REPORTS

OF THE

CAMBRIDGE ANTHROPOLOGICAL EXPEDITION

TO

TORRES STRAITS.

VOLUME II.

PHYSIOLOGY AND PSYCHOLOGY.

PART II.

HEARING, SMELL, TASTE, CUTANEOUS SENSATIONS, MUSCULAR SENSE, VARIATIONS OF BLOOD-PRESSURE, REACTION-TIMES.

CAMBRIDGE:
AT THE UNIVERSITY PRESS.
1903

Price ~~Seven Shillings~~ net

London: C. J. CLAY AND SONS,
CAMBRIDGE UNIVERSITY PRESS WAREHOUSE,
AVE MARIA LANE,

AND

H. K. LEWIS,
136, GOWER STREET, W.C.

Glasgow: 50, WELLINGTON STREET.
Leipzig: F. A. BROCKHAUS.
New York: THE MACMILLAN COMPANY.
Bombay and Calcutta: MACMILLAN AND CO., Ltd.

REPORTS

OF THE

CAMBRIDGE ANTHROPOLOGICAL EXPEDITION

TO

TORRES STRAITS.

VOLUME II.

PHYSIOLOGY AND PSYCHOLOGY.

CAMBRIDGE:
AT THE UNIVERSITY PRESS.
1903

Cambridge:
PRINTED BY J. AND C. F. CLAY,
AT THE UNIVERSITY PRESS.

PART II.

II. HEARING.

By CHARLES S. MYERS.

My experimental work on the natives of the Torres Straits was limited to the Murray Islanders[1]. As regards Hearing, it comprised an investigation of (i) their auditory acuity, (ii) their upper tone-limit, and (iii) the smallest tone-difference which they could appreciate. The pursuits and habits of the people were not such as would be expected to develop any one of these faculties in a high degree. The children attended school daily, the adults tilled the ground or left the island to dive for pearl-shell. Hence they were not engaged in occupations requiring exceedingly acute hearing; they were not particularly accustomed to hear very high tones; nor were they in the least practised in detecting minute differences of pitch. The musical ability and taste of the islanders, which will later receive separate treatment, are referred to in this volume only so far as they may be supposed to have influenced the faculty under examination.

1. PATHOLOGICAL CONDITION OF THE EARS.

I have here grouped together the pathological affections of the middle and inner ear, which were found to modify the acuity of hearing.

During a stay of over four months in Murray Island only one case of otorrhœa came under our treatment. Seeing how intractable purulent discharges from the middle ear are apt to become in the young, one may, I think, reasonably infer that for the past several years the disease had not been common in the island. Usually the adults were somewhat reticent in speaking of bygone ear-trouble. Altogether I heard only of four natives who had formerly had otorrhœa.

I cannot remember any islander in whom the presence of adenoid growths in the throat might have been suspected.

The island was free from all exanthematous epidemics during our visit. Many years ago there had been outbreaks of measles, which may partly account for the very defective hearing observed among several adult islanders.

But a more important cause of partial deafness lay in their practice of diving after pearl-shell. Until the recent legislation enacted by the Queensland Government, natives

[1] Throughout it had the advantage of Dr Rivers' ready assistance and encouragement.

were induced to dive, without dress or helmet, into such deep water that deaths were of frequent occurrence. At the time of our visit, the hospital at Thursday Island contained several cases of paralysis, which had arisen from diving in excessively deep water.

The effect of deep diving upon many islanders was to cause a noticeable amount of immediate hæmorrhage from one or both ears. "Ear he burst; red stuff come out," was a common reply to my enquiry as to what happened when first they dived. A subsequent purulent discharge occurred in two islanders, Zarob (L. E.) and Jimmy Dei (R. E.[1]). Bleeding from the mouth or nose only or from both was noticed by Komaberi, Zarob, Jimmy Dei and Oroto, from the ears only by Madsa and Groggy, from the ears and from the mouth or nose or from all three by Dubwai, Canoe, Wanu, and Smoke. The following islanders did not observe any hæmorrhage after diving—Wasalgi, Poï, Babelu, Billy Kuris, Alo, Tibi, Billy Gasu.

Politzer[2], quoting the observations of Brigade-Surgeon Chimani, states that in thirty-four of thirty-eight cases of ruptured tympanic membrane produced by boxes on the ear "perfect recovery without any functional disturbance resulted: in four cases no complete cure was effected. . . . . The bleeding was in no case so considerable as to be perceived by the patient." On the other hand, of the six cases of Chimani, in which the membrane had been ruptured owing to falls upon the head, "the bleeding was in three cases so considerable that the patients had their attention drawn to the injury of the ear by the blood flowing from it. In two cases, in spite of the perforation being healed, a considerable hardness of hearing, and in one case a labyrinthine affection, remained."

I examined with the aural speculum several of the islanders whose ears had been injured by sea-diving. In no case had the diving been recent, and in no case could I with certainty detect a rupture of or a cicatrix in the tympanic membrane. Such alterations in texture and transparency of the membrane as I met with will be noted in Table XIX. beside the estimations of auditory acuity.

My observations thus confirm Politzer's statement[3] that the membrana tympani usually regains its normal appearance within a few weeks after rupture. But they seem in direct contradiction to his view that "in most cases disturbances of hearing caused by traumatic ruptures disappear completely." There can be no doubt that in the majority of the islanders diving had caused a considerable amount of deafness. It may be that the sudden rise of pressure within the tympanic cavity produced an effect internally upon the labyrinth as well as externally upon the tympanic membrane; unfortunately I have no evidence indicative of labyrinthine lesion or disease in these cases. Of eighteen men who to my knowledge had dived, the hearing in nine was defective in one ear, in two in both ears, not only in regard to general acuity, but also in regard to the upper limit of pitch.

[1] I use L. E., R. E. and B. E. throughout for the left, right and both ears.
[2] Politzer's *Diseases of the Ear* (Eng. trans.), London, 1894, pp. 249, 250.
[3] *Ibid.* p. 246.

2. AUDITORY ACUITY.

It is scarcely necessary to point out that the stories, which travellers relate about the remarkable capacity possessed by primitive people for distinguishing faint sounds amid familiar surroundings, cannot be accepted as evidence of an unusually acute hearing. Little or nothing concerning auditory acuity can be safely inferred from such a description as that of László Magyar[1], who, travelling among the Kimbunda tribes of South Africa, noted that "they are able to distinguish very accurately sounds which are heard from a great distance, and at once recognize their nature and direction"; nor from such an observation as P. Paulitschke's[2], who found the Somali hunters to have a very delicate sense of hearing, the slightest noise awakening their attention, its direction being recognized with certainty.

Reports of this kind might be cited again and again[3]. They merely show how the savage will take an interest in, and make an inference from a sound, which may be meaningless to, and perhaps neglected by the European ear. We need but imagine such an individual transported to the streets of a busy city, to obtain a complete reversal of the phenomena, the primitive man heedlessly passing various noises which would be full of significance to his more civilized companion.

Nor, indeed, are travellers unanimous in crediting savages with an unusually keen sense of hearing. Sir G. S. Robertson[4], for instance, states—"as the result of very many observations of an unscientific kind, I could never discover that the Káfirs displayed any superiority to other races in . . . . certainty of hearing." Francis Galton[5] also remarks—"my own experience, so far as it goes, of Hottentots, Damaras, and some other wild races, went to show that their sense-discrimination was not superior to that of white men . . ." Georg Schweinfurth[6] similarly failed to find any marked superiority of hearing-power among the many tribes of Central Africa which he has visited[7].

It is exceedingly rare to meet with opinions that have been formed after subjecting the ear to a definite test which could be repeated on other ears. I know only of the experiments of two travellers. N. W. Giltschenko[8] observes that "the distance at which an Osset hears the tick of a watch is not greater than with other people. In the open, on the other hand, both on the plain and on the hills, the Osset perceives definite

[1] *Reisen in Sud-Afrika in den Jahren* 1849—1857 (deutsche Uebersetz.), Pest u. Leipzig, 1860, S. 343.

[2] *Ethnographie Nordost-afrikas*, Berlin, 1896, Bd. II. S. 3.

[3] Cf. the remarks of Carl Lumholtz, *Bull. de la Soc. d'Anth. de Paris*, Tome XI. 3me Série, 1888, p. 650, of G. L. Bink, *ibid.* p. 388, and of Godel, *ibid.* Tome III. 4me Sér. 1892, p. 161. Also cf. *From my Verandah in New Guinea*, H. H. Romilly, C.M.G., London, 1889, p. 55; *In the Forbidden Land*, H. Savage Landor, London, 1898, Vol. I. p. 25.

[4] *The Káfirs of the Hindu Kush*, London, 1896, p. 174.

[5] *Inquiries into Human Faculty and its Development*, London, 1883, p. 32.

[6] In a private letter kindly sent me by Dr Schweinfurth.

[7] The experiences of my friend Mr Stanley Gardiner, who has kindly communicated them to me, are not without interest in this connexion. An American clock hung from the roof of his bungalow in the Maldive Islands. The natives, who had never seen the like before, would approach to a distance of two yards from the clock before they took notice of its ticks. Then they spent some time before they could rightly localize the sound. On the shore he found he could frequently pass behind a native, without attracting the attention of the latter, who might have been expected invariably to distiuguish between the Englishman's booted tread and that of the bare foot on the sand.

[8] *Biolog. Centralbl.* Bd. XI. 1891, S. 304—318.

sounds, understands spoken words, etc., at a quite extraordinary distance." M. Hyades[1] in his study of the Fuegians says that their "hearing has the same acuity and range as that of the majority of Europeans (experiments with the watch, tuning-fork, etc.)," but gives no details of the facts upon which he bases this opinion.

Methods of testing Auditory Acuity.

Auditory stimuli are divisible into three classes, viz., simple tones, compound tones and noises. Although little is known as to the psychical relation of these three kinds of stimuli to one another, it is certain that in cases where the sensibility to one kind is noticeably diminished, the sensibility to one or both of the other kinds may be scarcely impaired. Hence it is essential that the class of sound which has been used to test the auditory acuity of any race or individual should be clearly stated.

In estimating the acuity of a sense-organ, it is naturally desirable that the experimental conditions should be reduced to the simplest possible. A noise, obviously, is far too complex and unsafe a stimulus. Nor is the voice more suitable, as it varies greatly in distinctness, volume and quality, not only for different individuals, but also for the same individual, however careful he be, at different times. Moreover, some words are audible at a greater distance than others, according to the relative number, arrangement and nature of the contained vowels and consonants.

The watch has been the most usual instrument for testing auditory acuity. But, in the first place, the results obtained by one observer are incomparable with those obtained by others, owing to the different degrees of loudness of the ticks of different watches. And secondly, it is highly desirable that the sounds chosen should be under greater control than are the ticks of a watch. The data, obtained by gradually removing a ticking watch from the ear until it can no longer be heard, are in every respect as fallacious as those which would result, were the test-types, commonly used in the estimation of visual acuity, to be slowly withdrawn from the observer, until he could no longer recognize a letter of given size[2].

My first experiments among the Murray Islanders were carried on with an ordinary watch. But I quickly recognized the difficulty felt by the natives in accurately fixing the point where, as the watch was removed from the ear, its ticks could no longer be heard. This drawback disappears with the use of a stop-watch, or of an entirely different instrument, in the manner presently to be described.

I had the lenses removed from an ordinary telescope and the tube fitted to stand vertically on a suitable support. The top of the tube was provided with a funnel-shaped aperture, which would just admit of the introduction of a small pith-ball. Near the base within the tube was placed an obliquely inclined disc of felt, on to which the pith-ball fell, there rebounding to escape by a window cut in the side of the tube, and falling noiselessly on a piece of velvet. The velocity of the fall of the ball, and hence the intensity of the sound produced by its impact against the felt-disc, could be varied at will by altering the height of the telescopic tube.

[1] *Mission Scientifique du Cap Horn*, Tome VII., Paris, 1891, p. 209.

[2] The same objection holds good for the method of allowing a tuning-fork to 'ring off' until the subject no longer hears it.

The objections which attend the use of a watch are likewise remedied in Politzer's Hörmesser. It consists essentially of a hollow horizontally-fixed steel cylinder, 28 mm. in length, 4·5 mm. in thickness, emitting the tone *c*, when struck by a small percussion-hammer, which is allowed to fall on it from a small and constant height.

The acuity of hearing, probably more than that of most other senses, varies considerably from hour to hour and from day to day, according to the physiological condition of the observer. For this reason it seems hardly worth while here to follow the example of those otologists who attempt to express auditory acuity in the form of a fraction, whereof the denominator denotes the distance at which the sound should be heard by an ear of average hearing-power, the numerator giving the distance at which it is actually heard by the ear under examination.

A far greater disturbing influence, however, consists in the distraction resulting from various adventitious noises. Through the lack of a suitable room in Murray Island, I was forced to conduct my experiments in the open air. Here the constant rustle of the palm-leaves and the beating of the surf on the sea-shore compelled me to lay aside my telescopic apparatus and Politzer's Hörmesser in favour of a stop-watch.

I used a Runne's clock, which could be made to tick five times a second, and could be easily stopped or set going at will. The loudness of the ticks was found to be much diminished, and to vary noticeably when the clock had 'run down.' The clock was hence always fully wound up before being used for testing. The disturbing noises, to which I have just alluded, varied so obviously from day to day, that it was impossible to compare the results obtained from islanders on one day with those obtained from others on the next. The estimations of auditory acuity must have proved meaningless unless I had tested some fixed person or persons simultaneously with the natives. Dr Rivers kindly came to my assistance. Either he or I was tested along with the islanders; one of us holding the clock, the other standing with his back to the subject under investigation, at the same distance from the clock, and indicating by gesture whether he heard the ticks. The clock was started after irregular periods of silence and was allowed to sound for about three seconds. The threshold was determined, partly by the number of incorrect answers when at a given distance the subject failed to detect the ticks, and partly by the number of illusions when at that distance he imagined that he heard ticks during periods of actual silence. In this way I was able roughly to estimate the relative auditory acuity of thirty-five islanders, compared with that of Dr Rivers or myself, towards the same stimulus under the same conditions of distraction.

It was not to be expected that the natives would evince as much interest in determinations of their auditory acuity as they took in many others of our psychological experiments. Some of the islanders were no doubt conscious of their partial deafness, and, feeling that they were not doing well, did not give their utmost attention to the experiment. In these few instances greater attention would have produced better results. On the whole, however, we were confident that the people were doing their best, and that the appended Tables, XIX. and XX., give a very fair measure of their power of hearing.

The figures, ranged in the two columns under R. E. and L. E., express the distance in metres at which the threshold is reached for hearing the given stimulus. They were obtained after the following method, which I adopted as the most reliable after the trial of various others.

Table XIX.

Murray Island Boys, tested by Runne's Clock.

Date	Name	Age	R. E.	L. E.	Standard-observer	Remarks
Aug. 2	Jimmy Dauar...	10	3·00	4·00	worse than C. S. M.	
Aug. 3	Dela...............	10	2·50	2·75	same as C. S. M.	
July 19	Aki	10½	2·75	2·75	C. S. M. L. E. = 5·00 m. W. H. R. R. L. E. = 1·75 m.	
Aug. 3	,, ...	,,	0·50	1·50	much worse than C. S. M.	
July 19	Tom (Maboali)	11	2·75	3·00	C. S. M. L. E. = 5·00 m. W. H. R. R. L. E. = 1·75 m.	
Aug. 3	,, ,, ...	,,	3·00	2·50	R. E. slightly worse than C. S. M. L. E. same as C. S. M.	
Aug. 1	Marau............	11	3·50	4·50	same as C. S. M.	
July 17	William (Tat)...	11½	0·75	0·75	C. S. M. L. E. = 6·00 m.	
?	Sailor	11½	4·00	4·00	worse than C. S. M.	
Aug. 3	Tom (Tanu) ...	11½	2·75	3·00	not quite equal to C. S. M.	
,,	Sagigi	11½	1·50	1·25	R. E. slightly worse than C. S. M. L. E. same as C. S. M.	
July 17	Poï (Pasi)	13	4·50	5·00	C. S. M. L. E. = 6·00 m. (Poï, James, Apori)	
,,	James	13	2·00	2·00		
,,	Apori	14	3·00	3·00		

Murray Island Girls, tested by Runne's Clock.

Date	Name	Age	R. E.	L. E.	Standard-observer	Remarks
July 15	Maima	11	2·00	2·25	W. H. R. R. L. E. = 2·25 m. (Maima, Gigai, Seba)	
,,	Gigai	11½	1·75	2·00		
,,	Seba	12	2·00	3·00		
Aug. 3	Nei	13	3·00	?	W. H. R. R. B. E. = 1·00 m. (Nei, Maletta)	
,,	Maletta	13½	1·00	3·00	......	nothing abnormal noticed otoscopically.
,,	Sidoi	14	1·50	1·50	W. H. R. R. B. E. = 0·75 m.	otorrhœa formerly.
,,	Mary	14	2·75	?	not quite equal to C. S. M.	

Murray Island Men, tested by Runne's Clock.

Date	Name	Age	R. E.	L. E.	Standard-observer	Remarks
Aug. 2	Charlie (Pasi)...	16	1·50	1·50	....	has never dived.
,,	Berò	17	5·00	2·00	....	
July 20	Tepem............	18	4·25	4·25	C. S. M. B. E. = 5·00 m.	
,,	Josiah	18	0·05	2·75	W. H. R. R. B. E. = 0·60 m.	
Aug. 1	Zarob	20	—	—	....	dived æt. 14. White discharge followed.
May 27	Gauul	30	—	—	....	has dived. L.E. opaque tympanic membrane. Hörmesser 1 m.
July 15	Jimmy Rice ...	30-35	6·50	3·30	W. H. R. R. L. E. = 2·25 m.	
July 20	Babelu............	30-35	2·25	2·75	C. S. M. B. E. = 5·00 m.	has dived: no discharge.
,,	Boa	35-40	0·75	0·80	W. H. R. R. B. E. = 0·60 m.	
July 19	Charlie Boro ...	35	1·00	1·00	C. S. M. L. E. = 5·00 m. W. H. R. R. R. E. = 1·75 m.	
,,	Komaberi	50	1·75	2·00	....	has dived 6–10 fathoms: blood from nose and mouth.
Aug. 2	Tibi...............	45–50	0·85	2·20	....	has dived 1–2 fathoms: no discharge.
Aug. 1	Alo	50	—	—	....	has dived 7–8 fathoms: no discharge. Watch, R. E. 18 ins., L. E. 9 inches.
Aug. 2	Kriba	50	4·00	—	....	has dived. Opaque tympanic membranes.
Aug. 1	Canoe	50	2·00	2·00	....	has dived; blood from nose and ears.
July 20	Enoka............	55–60	1·00	1·00	C. S. M. B. E. = 5·00 m. W. H. R. R. B. E. = 0·60 m.	

The distance from the subject to the Runne's clock (or Hörmesser) was marked along the ground or floor in half-metres. One ear of the individual was stopped with cotton-wool, the other being directed towards the source of sound. The subject indicated, preferably by a movement of the hand, when he heard the stimulus employed. The instrument was first held at a distance well within his limit, and was then withdrawn from that point, at first metre by metre, later half-metre by half-metre, until the limit of hearing was passed. The instrument was then brought nearer until the sound became once more audible. At every point in the neighbourhood of the threshold five trials of the sound were made. Where more than one out of five successively given sounds were missed, the threshold must be considered as having been reached or passed.

It will almost invariably be found that the sound can be heard one or two (or even more) half-metres further when the watch is being withdrawn from the subject, than when the watch is made to approach towards him. The distance midway between the point where the audible sound just becomes inaudible, and the point where the inaudible sound just becomes audible to the subject, may be taken as indicating the acuity of his hearing.

In the column headed 'standard observer' will be found the estimations simultaneously determined for one or other of three members of the expedition, Dr Rivers (W. H. R. R.), Mr Seligmann (C. G. S.), or myself (C. S. M.).

Estimations of Auditory Acuity in Mabuiag.

Dr Rivers found sufficient quiet in this island, which I did not visit, to enable him to make several observations with the Hörmesser. They were conducted at night in the old disused church near the sea-shore. At first the noise of the surf and trees was very

TABLE XX.

Mabuiag Men tested by Hörmesser (by W. H. R. Rivers).

Date	Name	Age	R. E.	L. E.	Standard-observer	Remarks
Sept. 23	Urma	30–35	1·50	7·00	C. G. S. B. E. = 9 m.	weather rather windy.
,,	Josiah	17	8·00	8·00	C. G. S. B. E. = 10 m.	
,,	Min	20	2·50	1·50	much worse than C. G. S.	
,,	Gigib	20–25	4·00	3·50	....	
Sept. 28	Tom	30–35	5·00+	4·00+	C. G. S. R. E. = 8 m., L. E. = 9 m.	more windy and variable: hence probably the difference in the two ears.
Sept. 30	Waria	35	7·00+	13·00+	C. G. S. B. E. = 16+ m.	no wind: almost complete silence.
,,	Baira	30–35	6·00	3·00+	much worse than C. G. S.	
,,	Waiat	20	2·00	6·00		
,,	Peter	35	8·00	5·00		
,,	Wame	35	0·75	2·00	W. H. R. R. B. E. = 2½ m.	
,,	Monday	20	1·50	0·50		
Oct. 2	Alis	20	6·00+	3·00+	C. G. S. B. E. = 18+ m.	no wind.
	William (of Murray I.)	20–25	0·75	0·75		

disturbing, but later the wind dropped so that he "was able to make very satisfactory observations in almost complete silence." When kindly communicating to me the results of his experiments for publication beside my own, he reminded me of a fact which I had also noticed, that with Runne's clock the natives had illusory sensations of stimuli during actual silence far more frequently than when tested with the Hörmesser. There can be no doubt that under suitable conditions, the latter is by far the preferable instrument. But a stop-watch should never be omitted as a last resource, the ordinary watch being, as I have explained, almost useless for determining auditory acuity.

Dr Rivers also sends me the following note. "On one evening I made a few observations to compare the results with Politzer's Hörmesser and Runne's clock. It was far more difficult to obtain definite results with the latter, but it was clear that its sound could only be heard at a much smaller distance than that of the Hörmesser; thus on the evening on which Mr Seligmann heard the sound of the Hörmesser at 7 metres, he only heard Runne's clock at 2 metres eight times in ten, and failed to hear it altogether at 3 metres."

Conclusions.

Of twelve Murray Island boys only five could hear as far or nearly as far as I could, the remaining seven being clearly inferior in auditory acuity. Of five Murray Island adults with whom I compared myself, all save one had remarkably low auditory acuity. The hearing of three Murray Island girls was about the same as that of Dr Rivers, while the hearing of three others was distinctly better. Dr Rivers, however, was certainly suffering from partial deafness when these estimations were made.

Not one of the ten young Mabuiag adults with whom Mr Seligmann later compared himself, could hear as far as he could. Two others could not hear as far as Dr Rivers, whose auditory acuity even by this time had not much improved.

The question arises, Can the above three standards of acuity of hearing be accepted as typical of Europeans generally? If we attempted to reply by testing ourselves among a series of Englishmen at the present time[1], our answers would be necessarily based on the supposition that our auditory acuity in the Torres Straits and in England was the same. In Murray Island certainly our general health was more or less 'below par.' Dr Rivers, as I have just said, knows that he had temporarily subnormal hearing, and I have reason to believe that my own hearing was slightly affected in Murray Island.

In the case of the Torres Straits children the hearing was not very different in the two ears. A great number of adults, on the other hand, proved to be distinctly deafer in one ear than in the other. The remarkably low acuity of the general adult hearing must hence be attributed to pathological conditions. Yet, as the children show a similar, although less marked, deficiency, one is forced to conclude that the general auditory acuity of the islanders in the Torres Straits is inferior to that of Europeans.

[1] Since our return, Mr Seligmann and I have been tested along with a few English adults. The results are probably numerous enough to indicate that our hearing, although not phenomenally acute, is slightly better than that of the average person.

3. THE UPPER LIMIT OF HEARING.

The Galton-whistle which I used was made by Hawksley of Oxford Street, London. The patterns of foreign makers differ considerably from Galton's original design. Its bore was 1 millimetre in diameter. Its length could be varied by sliding in or out the solid rod which closely fitted the tube of the whistle. The exposed end of this movable rod was fitted with a milled head, beneath which rested a graduated ivory scale giving the corresponding length of the whistle in millimetres at any position of the milled head. My own hearing is sufficiently acute to hear the notes produced by the whistle-tube when only 2·25 mm. in length. I therefore asked Mr Hawksley to make me a similar instrument, but of a still smaller bore, for use in the Torres Straits. The instrument was made, but as no audible note could be produced from it I had to confine myself to the use of the wider and more usual whistle. I attached a small india-rubber bulb to its mouth-piece, and after a little practice could so compress it as to give successive blasts of sufficiently unvarying force.

The amount of force with which the whistle is blown determines not only the intensity, but also the pitch of the tone emitted. I have elsewhere[1] published a series of experiments made by me with the Hawksley pattern of Galton-whistle, expressly in order to determine the changes in pitch produced by changes in the force of the air-blast employed. With long pipe-lengths a rise of air-pressure does not necessarily produce a tone of higher pitch; on the contrary a lower tone is under certain conditions emitted. Thus a pipe-length of five millimetres produces a tone of 12,784 vibrations per second, when an air-pressure equal to thirty-two millimetres of water is used: a tone of 9,464 vibr. per sec. when the air-pressure is raised to fifty millimetres: and a tone of 13,704 vibr. per sec. when it reaches four hundred millimetres. As a general rule, however, a greater wind-blast of course produces a higher pitched note.

The force of air employed by compression of the rubber-bulb attached to a Galton-whistle is not easily calculable. In the above-mentioned experiments, in which various wind-pressures were employed, air was driven through the whistle before the force of tap-water, which could accurately be controlled at will. There are reasons for believing that compression of the rubber-bulb generates a momentary pressure of at least 400 mm. of water. But before and after this maximum pressure is reached the whistle is responding to lower air-pressures. Consequently, the pitch of the whistle-tone at any given length varies in height while it is being blown, and, "in order to estimate the pitch of the highest audible tone, either the wind-pressure must be taken into account at the moment both of the physiological and of the physical determination, or the lowest obtainable tone emitted by the whistle with a given pipe-length (at relatively low wind-pressures) must be assumed to be the tone actually heard by the subject at that pipe-length[2]." Near his upper limit of hearing everyone hears a tone just when air is being admitted to the whistle, and often just after it has been shut off. These are moments when the pressure is low and tones of lower vibration-frequency are emitted. The

[1] *Journ. of Physiol.* Vol. XXVIII. 1902, pp. 417 ff.

[2] *Ibid.*

inability to hear a tone during the middle-period of blowing the whistle is no doubt also largely due to the masking effects of the noise of the blast.

The Galton-whistle was originally graduated by its inventor according to the formula $n = \frac{v}{4l}$, where n is the vibration-frequency, v the velocity of sound in air, l the whistle pipe-length. It has, however, been proved beyond doubt that this theoretical formula will not hold in practice even for such a minute bore of tube as that with which English Galton-whistles are made. I find the following to be the vibration-frequency (v) of the tones emitted by wind-pressures (p) from pipe-length (l) of the Hawksley pattern of Galton-whistle. The determinations were objectively made by the methods of sensitive flames and of Kundt's tubes.

l	p	v
5 mm.	32 mm. water	12,784 vibrations per second
,,	50 ,, ,, ...	9,464 ,, ,,
,,	400 ,, ,, ...	13,704 ,, ,,
4 mm.	40 ,, ,, ...	15,159 ,, ,,
,,	70 ,, ,, ...	9,360 ,, ,,
,,	92 ,, ,, ...	11,896 ,, ,,
3 mm.	40 ,, ,, ...	18,419 ,, ,,
,,	130 ,, ,, ...	19,033 ,, ,,
,,	? (blown with rubber-ball)	24,812 ,, ,,
2·5 mm.	58 mm. water	19,466 ,, ,,
,,	800 ,, ,, ...	22,540 ,, ,,
2·25 mm.	68 ,, ,, ...	20,639 ,, ,,
,,	800 ,, ,, ...	22,840 ,, ,,
2·125 mm.	72 ,, ,, ...	23,466 ,, ,,
2 mm.	68 ,, ,, ...	25,190 ,, ,,
,,	? (blown very powerfully with rubber-ball)	27,629 ,, ,,
1·75 mm.	84 mm. water	25,955 ,, ,,
,,	136 ,, ,, ...	28,082 ,, ,,
,,	? (blown very powerfully with rubber-ball)	30,050 ,, ,,

The results of my experiments with the Galton-whistle in the Torres Straits and elsewhere are expressed in pipe-lengths, not in vibration-frequencies. Their value rests on the supposition that after considerable practice with the instrument I am able again and again to produce the same force of blast. I have no doubt as to the general reliability of the figures given. Time after time I have tested my own limit, and that of various friends, and have obtained results sufficiently consistent to warrant confidence in the supposition.

Procedure.

My first aim was to make the subject appreciate the difference between the tone of the whistle-note and the noise of the wind-puff which unfortunately is almost always audible with it. A whistle-note was called *komelag*, a noise of wind is *wag* in the Miriam language. I began thus. Pulling out the solid tube so as to use the greater part of the whistle-tube, I blew a clear, weak, relatively low-pitched note. "That *komelag*," I explained, "no *wag*." I blew the same note with a stronger blast. "That *komelag* and small-fellow *wag*," I said, as the note was now accompanied by a perceptible noise of wind. Then sliding the inner rod 'well home,' I produced a loud noise of wind without a whistle-tone, and exclaimed, "That no *komelag*, that plenty *wag*." Of the fifty-one islanders, whose upper limit of hearing I investigated, only one (Smoke) could not in this way be made to understand the difference between *komelag* and *wag*; and he failed, I have little doubt, from lack rather of interest than of intelligence.

When I had fully assured myself that this difference had become quite clear to the subject, I began the determination of the upper limit of his hearing. His two ears were separately investigated. He sat at a distance of one metre from the whistle, which was held directly opposite to his external auditory meatus. The ear which was not being tested was plugged with cotton-wool; I cannot hope thereby to have altogether excluded binaural hearing, but the procedure was sufficiently effectual to indicate in many adults a difference of sensibility to high tones between the two ears. Five or six determinations for each ear were made in the following way. Starting from above the threshold, I gradually shortened the whistle-length and determined the point where the just audible whistle-note was lost in the noise of the wind-puff. Then, starting from below the threshold, I gradually lengthened the whistle, and determined the point where a sound of the highest audible pitch just emerged from the noise of the wind-puff.

The following is a record of a single experiment. The signs ⟵ and ⟶, indicate that the figures following them (expressing the whistle-length in millimetres) were arrived at by shortening and lengthening the whistle, respectively.

May 27, a.m. Madsa, æt. 18. (He dived a few years ago: "first time red stuff come out of both ears: now he all right." Auditory acuity normal, as tested by watch.)

R. E.	⟵ 2·75,	⟶ 2·50,	⟵ 2·75,	⟶ 2·50,	⟶ 2·50,	⟵ 2·50	av. 2·58.
L. E.	⟵ 2·50,	⟶ 2·50,	⟵ 2·50,	⟵ 2·50,	⟶ 3·00,	⟶ 2·50	

It is interesting to compare the above data with others obtained from him at a later sitting. There can be no doubt that the upper limit of hearing, like auditory acuity, varies slightly from day to day in the same individual. The limit of improvement by practice is, in my opinion, very quickly reached at the first sitting.

June 6, p.m. Madsa (v. supra).

R. E.	⟵ 3·00,	⟶ 2·62,	⟵ 2·62,	⟶ 2·62,	⟵ 2·75,	⟶ 3·00	av. 2·93.
L. E.	⟵ 3·00,	⟵ 3·25,	⟶ 3·00,	⟵ 3·25,	⟶ 3·00,	⟶ 3·00	

Experimental data[1].

The following table gives the results obtained from investigations among the boys and girls of Murray Island and of Aberdeenshire in the manner just described. In no case were the two series of data given by each ear sensibly different; therefore only the average limit for the two ears combined need be here recorded.

[1] The data and hence their interpretation will be found to be somewhat different from those published by me earlier in a brief abstract (*Archives of Otology*, Vol. XXXI. 1902, pp. 281 ff.). These differences are mainly due to the fact that I have here 'ruled out' more rigidly the results obtained from partially deaf individuals.

TABLE XXI.

Children	Number	Ages	Whistle-length in millimetres, producing highest audible tone	Av.	M. V.
In Murray Island...	2	5–9	2·06, 2·40	2·23	—
"	15	10–15	2·00, 2·00, 2·12, 2·33, 2·16, 2·33, 2·08, 2·06, 1·90, 2·00, 2·00, 1·90, 1·90, 2·19, 2·05	2·07	0·11
In Aberdeenshire...	4	5–9	1·80, 1·90, 2·08, 2·10	1·97	—
"	18	10–15	2·45, 2·15, 1·92, 1·75, 1·80, 1·90, 1·85, 1·87, 2·20, 2·17, 2·21, 2·02, 2·00, 1·64, 2·00, 1·95, 1·90, 1·95	1·99	0·15

From these data it appears that there is only a small difference in the limit of the highest audible tone between the children of Murray Island and of Aberdeenshire, and that this small difference is in favour of the latter.

Comparison is more difficult between the male adults of the two races. Most of the Murray Islanders had in times past dived for pearl-shell and bêche-de-mer; a few of them had dived more recently, probably in shallower water (see page 142). I have thought it best to divide into seven classes the adult islanders examined. Class A comprises men who had not noticed any ill effects in the ear from diving. Those in whom diving had caused a hæmorrhagic or purulent discharge from one ear are grouped in Class B, a discharge from both ears in Class C, hæmorrhage from the mouth and nose only in Class D. I have placed in Class E those whose hearing in one or both ears was defective from some other cause. The men who had never dived are in Class F. Those about whom I have no information are in Class G. Where the upper limit of hearing differs in the two ears, the results given by each ear are recorded, the results for the right preceding those for the left ear.

It is commonly stated that in affections of the middle ear the appreciation of high tones is unchanged. T. J. Harris[1], after testing over 1,600 cases with the Hartmann-series of tuning-forks, agreed with Politzer[2] that while in diseases of the middle ear the upper limit of hearing is as a rule scarcely altered, in diseases of the inner ear the upper limit is more affected than the lower limit of hearing. With greater caution H. A. Alderton[3] had previously concluded that the upper limit was disturbed to a greater degree in internal than in middle ear-disease, and that in combined disease of the middle and internal ear the most marked changes occurred in that limit. Bezold[4], on the other hand, has urged the extreme view that high tones are conducted to the internal ear independently of the ossicles of the middle ear, so slightly impaired did he find the audibility of such tones in cases of destruction or of anchylosis of the ossicles. As I have already said, I made no attempt to diagnose affections of the internal from those of the middle

[1] *Archives of Otology*, Vol. xxvi. 1897, pp. 1—25.
[2] *Arch. f. Ohrenhlk.* Bd. vi. 1871, S. 43.
[3] *Archives of Otology*, Vol. xxv. 1896, pp. 45 ff.
[4] *Ueber d. funktionelle Prüfung d. menschl. Gehörorg.*, Wiesbaden, 1897, S. 121.

ear among the divers of Murray Island. It is possible, as I have suggested, that the great and sudden changes of air-pressure in the middle ear arising from deep diving may in certain cases have affected the labyrinth as well as the tympanic membrane.

TABLE XXII.

Age	Murray Island			Aberdeenshire
	Name	Class	Whistle-length	Whistle-length
16–19	Zarau	G	2·25	—
	Charlie (Pasi).	F	2·05	—
	Berò	E	3·22, 2·75	—
	Madsa	C	2·75	—
20–29	Zarob	B	3·50, ?	2·27
	Tapau	G	2·00	2·27
	Dubwai.........	C	2·86	2·11
	Poi...............	A	4·00, 3·08	—
	Komaberi, jun.	G	3·50	—
	Jimmy Wailu.	G	2·87	—
	Loko	B	3·80, 3·18	—
30–39	Dick Tui	E	4·09, 3·52	2·90
	Gauul	B	3·65, 6·07	2·86
	Babelu	D	3·25, 2·94	2·60, 3·00
	Mabo............	F	3·10	2·35
	Oroto	D	3·51	2·42
	Jimmy Rice...	G	2·60	-
30–39	Billy Kuris ...	A	2·84	—
	Groggy	B	6·23, 5·40	—
40–49	Gi	E	4·44, 5·50	2·82
	Pasi	G	2·73	7·00, 3·25
	Wasalgi.........	A	3·31	2·38
	Smoke	B	?	3·28
	Jimmy Dei ...	B	4·80, 3·52	4·22, 5·27
	Tibi	A	3·62, 2·96	—
	Azò	A	4·25	—
50–59	Kriba	C	7·12, ?	3·44
	Canoe	C	5·25	4·06
	Alo	A	3·94, 5·75	4·12, 5·27
	Komaberi......	D	3·13	—
	Wanu	C	4·39	—
	Wali	E	4·00, 6·00	
	Lui...............	G	5·87	—
over 60	Mamus	G	6·16	4·00, 3·47

If the Murray Island and Aberdeenshire adults be compared, irrespectively of any aural lesion or disease produced by diving or other causes, the following results are obtained. (Two men, Groggy and Kriba, have been omitted.)

TABLE XXIII.

Age	Murray Island	Aberdeenshire
16–19	2·25	—
20–29	3·00	2·22
30–39	3·17	2·63
40–49	3·53	3·19
over 50	4·68	3·77

The following table gives the average whistle-length in millimetres, at which the highest tone could just be heard by those adults of Murray Island and Scotland who, so far as I could judge, had normal hearing in one or both ears.

TABLE XXIV.

Age	Murray Island	Aberdeenshire
16–19	2·15	—
20–29	2·58	2·22
30–39	2·84	2·63
40–49	3·00	2·93
over 50	3·86	3·77

CONCLUSIONS.

The results given by the Murray Islanders are very nearly identical with those given by the people of Aberdeenshire (Tables XXI. and XXIV.). Possibly the small existing differences in favour of the latter would have been absent, had it been possible to take observations on a greater number of subjects. The children of both communities hear a higher tone than the adults, the upper limit of hearing becoming gradually lower with increase of years[1].

[1] Cf. Zwaardemaker, *Arch. f. Ohrenhlk.* Bd. XXXII. 1891, S. 53 ff.; *Ztsch. f. Psych.* Bd. VII. 1894, S. 11 ff.

4. THE SMALLEST PERCEPTIBLE TONE-DIFFERENCE.

The determination of the least perceptible difference of pitch among a primitive people has not hitherto been attempted. Recent experiments in this direction upon Europeans have been usually confined to select classes of observers, and have had some other end in view than the mere determination of least perceptible differences. In most cases they have been performed upon trained observers[1], to investigate tone-memory, to discover the smallest appreciable deviation from untempered intervals, to find out how far the Weber-Fechner law holds good for judgments of tone-differences in various regions of the tone-range, or the like. Occasionally they have been performed less precisely with the pianoforte upon exceedingly unmusical people[2], their aim then being to determine what proportion of errors such observers would make for relatively gross differences of pitch. The only investigations, so far as I know, which resemble my own in having been conducted on an entirely unselected group of subjects, are such as were made by J. Allen Gilbert[3] upon school-children. Unfortunately our respective methods of tone-production and general procedure are so different that a comparison of our results is altogether impossible[4].

The influence of experience and of musical ability upon the smallest perceptible tone-difference is, of course, enormous. W. Preyer[5], for instance, remarked that even with little practice a difference of eight vibrations per second became appreciable between tones of the once-accented octave ($c' = 256$ vibr. per sec.). produced by his metal tongues; while he found that a highly practised observer could detect a difference of about 0·3 vibr. per sec., a limit which Luft[6] and his colleague, v. Tchisch, using tuning-forks, later reduced to 0·232 and 0·229 vibr. per sec. for the same tone-region.

I was compelled to devote a considerable part of my time in Murray Island to seeking a suitable method of experiment, as I found that the procedure adopted by earlier workers either was described by them in insufficient detail or was too complex or too unreliable, for me straightway to begin work with my tuning-forks on the Torres Straits islanders. Neither the method of right and wrong cases nor the method of the just perceptible difference as used in experimental psychology proved to be in and by

[1] Cf. H. K. Wolfe, in *Wundt's Philosophische Studien*, Leipzig, Bd. III. 1887, S. 534 ff.; E. Luft, *ibid.* Bd. IV. 1888, S. 511 ff.; I. Schischmánnow, *ibid.* Bd. V. 1889, S. 558 ff.; C. Lorenz, *ibid.* Bd. VI. 1890, S. 26 ff.; M. Meyer, *Ztsch. f. Psych.* Bd. XVI. 1898, S. 352 ff.; Angel and Harwood, *Amer. Journ. of Psych.*, Vol. XI. 1899, pp. 67 ff., Vol. XII. 1900, pp. 58 ff.; etc.

[2] Cf. C. Stumpf, *Tonpsychologie*, Leipzig, 1883, Bd. I. S. 313 ff.

[3] *Studies from the Yale Psych. Laboratory*, Vol. II. 1891, pp. 40 ff. A comparison of the results obtained by the use of gradually changing (continuous) and of interrupted (discrete) pitch-differences has been attempted by L. W. Stern, *Ztsch. f. Psych.* Bd. XXI. 1899, S. 371 ff.

[4] Other methods, all more or less unsatisfactory, are described by Percy Hughes, *Psych. Rev.* Vol. IX. 1902, pp. 603—609.

[5] *Physiolog. Abhandlungen, Ueber d. Grenzen d. Tonwahrnehmung*, Jena, 1876, S. 26—37, where a bibliography of the earlier work will be found.

[6] *Loc. cit.* S. 532. Joachim and another violinist could even appreciate an interval of "about the $\frac{1}{25}$th part of a semitone" in the same tone-region, according to G. Engel, *Aesthetik d. Tonkunst*, Berlin, 1884, S. 294—295.

itself free from objection. Finally I adopted a modified form of the latter, a method which is to a certain extent a combination of both methods, which works sufficiently simply and reliably for me to recommend it to future workers in this field. I have described it in detail below.

In order to obtain comparative data, I found it necessary to repeat with the same tuning-forks and with the same procedure a similar series of experiments upon an unselected group of Europeans. For this purpose I visited a small village of Aberdeenshire, where in the course of several weeks I examined the hearing of twelve Scots children and twenty-one adults.

The general education of the Murray Island children was not very different from that of British school-children. They had been taught European airs in class-time, and sang them with remarkably correct intonation. Consequently the results obtained in my experiments on the children of Murray Island and of Aberdeenshire allow of very close comparison. The adults, however, stand on a different footing. The island school-children were more used to singing European than Papuan airs; the adult islanders, on the other hand, confined themselves almost entirely to the latter, their knowledge of European music being generally limited to church-hymns. Many of the Aberdeenshire adults examined belonged to a highly educated class. Six of them played a musical instrument, and of these three had had the valuable previous experience of tuning the violin, and one the violoncello. The musical, unmusical, and doubtfully musical subjects are grouped separately; but I ought to add that at most only one or two could be termed 'highly musical.' Several of the Murray Islanders examined passed as composers of various native songs. The drum was the only instrument by which their songs were ever accompanied.

Procedure.

I used two forks of the same pitch, $c' = 256$ vibrations per second. An arm of one of the forks (called hereafter the *variable* fork) carried a sliding metal bar which could be firmly clamped at any desired position. The arm of this fork being graduated to scale, its pitch could be made to vary at will by definitely great or small amounts from that of the other or *fixed* fork.

After my return to England, I estimated the vibration-number of the tones of the variable fork by directly counting the beats produced by sounding it with a fork of known and nearly equal pitch[1]. The fixed fork was assumed to give a tone of exactly 256 vibr. per sec. The beat-counting was done on several cool summer days. Repeating it in warmer weather, I obtained results which were not sensibly different. I have therefore assumed that any alterations in pitch, due to changes in temperature during these determinations and during the experiments described later, affected the fixed and variable forks equally and hence produced no appreciable change in the size of their interval. In order to estimate the larger intervals, a third fork of intermediate pitch, the relation

[1] My thanks are due to Mr J. F. Cameron, of Gonville and Caius College, for help from the mathematical side and to Mr G. T. Bennett, of Emmanuel College, from whose considerable experience in beat-counting I obtained much assistance.

of which to the fixed fork had been previously determined, was introduced and sounded with the variable fork. Finally the largest intervals were determined by weighting the third fork with wax.

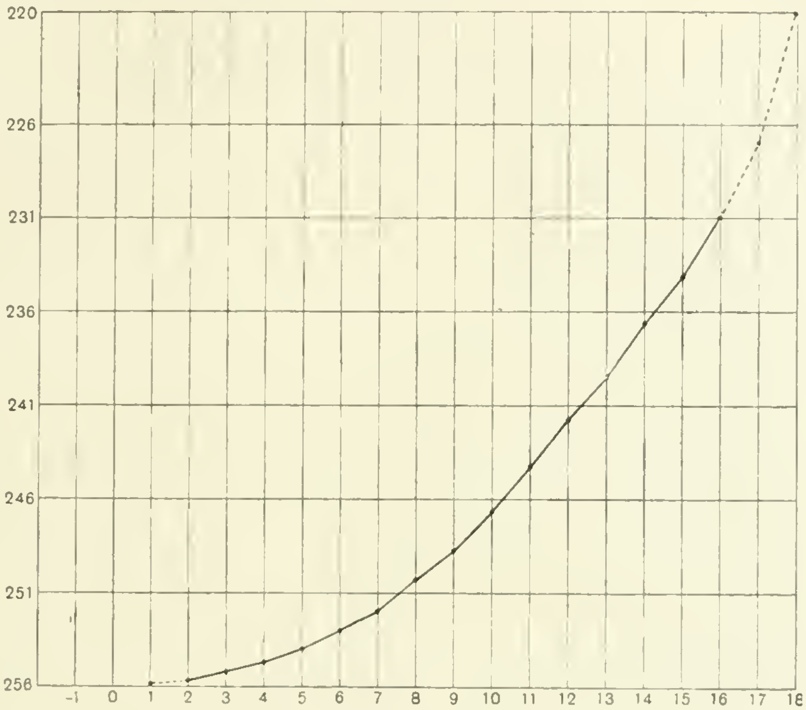


FIG. 11.

From a mathematical study of these results (Fig. 11), there can be no doubt that they are to a sufficient approximation correct. At the lowest and at the two highest of the eighteen positions of the clamp, the vibration-frequencies were theoretically calculated from the form of the curve obtained by determining the vibration-frequencies at the sixteen remaining positions. Estimated in this way, the pitch of the various tones, which were presented to the individual under investigation, is here given: fractions of vibration-numbers are disregarded, except in the case of tones differing by less than five vibrations per second from the pitch of the fixed fork.

256·00 (= fixed fork), 255·86, 255·67, 255·20, 254·75, 254·00, 253·01, 252·00, 250, 249, 247, 244, 242, 240, 237, 234, 231, 227, 220.

In my preliminary experiments on the Murray Islanders I mounted the forks on resonance-chambers and played them with a violin-bow. I found however that far better results were obtained by dispensing with the resonance-chambers and striking instead of bowing the forks. For it was important to produce sounds which were time after time of approximately constant intensity, so that inequalities in loudness might not mislead the subject's judgment of a difference of pitch[1]. A little practice enabled me

[1] Cf. Stumpf, *Tonpsychologie*, Bd. I. S. 237.

to overcome this difficulty satisfactorily. Moreover, I took care invariably to listen myself to the forks before applying them to his ear, rejecting sounds which for any reason appeared undesirable. The experiments were conducted in a small secluded room, tolerably free from external noise. The subject always sat with his back towards me. In one or two suspicious cases his eyes were kept closed; but it is quite certain that the islanders invariably disregarded the movements of my hands, depending for their judgment solely on the nature of the sounds which were presented to them. Sometimes the fixed, sometimes the variable fork was sounded first; the influence of the order of presentation of the forks will be discussed later. The forks were allowed to sound only with very moderate intensity, whereby the possible influence of accompanying overtones was reduced to a minimum. The two forks were successively held about 15 centimetres from the ear, each sounding there for about two seconds. The interval between the withdrawal of the first and the presentation of the second fork was likewise about two seconds, during which the second fork was being thrown into vibration[1]. The subject was asked, immediately after the second sound had been withdrawn, which of the two he considered the higher, and occasionally (see next page) whether he thought they were of the same pitch. His answers were given thus:—"first one high," or "second one high," or "both all same," according as a judgment of difference or of identity had been formed. Save in a few early experiments and in one or two suspicious cases alluded to hereafter, the same sound was never given twice consecutively; there was always therefore a difference (*i.e.* a musical interval), and when the subject returned the answer "both all same," he failed to detect it.

After numerous trials of various methods, I found that the experiments were best conducted in the following manner. Having assured myself that the subject thoroughly understood what was required of him, I began by presenting an interval so large that he could not fail to appreciate it. Next, I rapidly and roughly arrived at an interval which was too small for his correct appreciation. I worked then gradually towards the discrimination-threshold from a point at a little distance above it. Having reached and passed below the threshold, I gradually increased the interval between the forks again, until once more I arrived at the point of just perceptible difference. At each position of the clamp I applied the two forks at least five times (unless the pitch-difference in question was clearly well above or below the threshold), and I was not satisfied that the subject had correctly appreciated the interval unless he gave at least four of five successive answers correctly at the corresponding position of the clamp. To determine the effect of practice, many of the adults and nearly all of the children were examined during the following six weeks on two or three (in two cases on four) different occasions. Here the method of procedure was usually modified. I began the experiment by presenting an interval distinctly smaller than that which the previous experiments had shown to be (for him) the least perceptible. From that point I gradually increased the interval until I had passed above the threshold. Once again I diminished the interval until I had finally determined a new threshold.

[1] Angel and Harwood (*loc. cit.* pp. 67 ff.) found that there was little or no falling off in accuracy of judgment with increase of time-intervals within certain limits.

Twenty-three male adults and twelve boys were investigated in Murray Island. With two exceptions, I had no difficulty in making them realize the distinction between a high and a low tone. It was as a rule sufficient to produce several times on the forks two quickly following sounds more than a tone apart. A few subjects, mostly adults, were very slow in comprehending even this difference; but with them in the end I succeeded, by repeatedly singing a very high and a very low note, asking them which was the higher. There can be no doubt that in these experiments their judgment of pitch-differences was being exercised for the first time. The two adults, who after repeated attempts proved useless for my experiments, were Smoke, and Harry, the elder Mamus. The latter, possibly from lack of will, seemed quite unable to understand what was required of him. The former could generally appreciate a difference of pitch in sounds not less than three tones apart, but was even then uncertain in the lower tone-regions: he resembles many "pitch-deaf" people in Europe.

Each sitting lasted from twenty to thirty minutes. It was broken off earlier whenever signs of fatigue were manifested: these could readily be detected. Considering how monotonous and wearisome the islanders must have found the work of judging between so many successive pairs of sounds, they bestowed upon it a remarkable degree of attention. Of all our physiological and psychological experiments, this estimation of the least perceptible pitch-difference was certainly the most distasteful to them. I endeavoured in many cases to increase their interest towards the close of the sitting, by telling them if their judgments were right or wrong after I had, without so doing, arrived at an approximate determination of the threshold. I have carefully noted in the tables the cases in which the threshold was changed by this procedure.

Judgments of identity ("both all same") were treated as wrong judgments. They were not often given, owing doubtless to the form which my question took. I always asked, "Which one you think high?" save when the subject was clearly hesitating. Then I encouraged him with the remark, "Perhaps you think him all same?" It is, however, possible that the answers "first one high," when the second fork was really the higher, and *vice versa*, were occasionally due to accidental inequalities of tone-intensity. Yet such inequalities must have affected right and wrong judgments equally often.

I cannot confirm the experience of Preyer[1], Wolfe[2] and others who, employing the vibrations of metal tongues, could observe indefinable differences between two nearly unisonant tones, while they were still unable to judge which of the two was the higher or the lower. I find myself here in agreement with Max Meyer[3], and, although disbelieving in his *à priori* argument, am inclined to attribute the phenomenon, as he has done, to difference of quality (*i.e.* to the presence of unequal numbers and intensities of overtones) in the tones produced. König[4] and others held that tuning-forks can produce sounds absolutely free from overtones. Later work[5], however, makes it more than doubtful if any source of sound can be devised that does not simultaneously generate at least the first overtone. During the many thousand occasions on which I listened to the above tuning-forks, I have repeatedly but always unsuccessfully endeavoured to detect a difference

[1] *loc. cit.* S. 34.
[2] *loc. cit.* S. 542.
[3] *loc. cit.* S. 359—360.
[4] *Annalen d. Physik und Chemie*, Bd. CLVII. 1876, S. 177.
[5] Cf. Stumpf, *ibid.* N. F. Bd. LVII. 1896, S. 660.

of quality between the tones produced by them. I have also vainly asked my musical subjects (none of whom, however, was probably as 'highly musical' as I am), if they could detect any such difference. There can, of course, be no doubt that, *ceteris paribus*, a clamped and an unclamped fork of identical pitch do not produce the same overtones with equal intensity. But, as I took care to sound the forks only with moderate loudness, I cannot believe that this was a disturbing factor. Even in the case of the Aberdeenshire adult P., during his third sitting, I could still further lower the clamp[1] so as to produce a no longer appreciable tone-difference; whereas, if his judgments had depended on differences of quality instead of on differences of pitch between the tones, he would still have been able to make a constant distinction between the forks.

It is surprising how distinct is the demarcation of the threshold by the use of the above-described method. Three examples, taken almost at random from my note-book, will show with what clearness the point of just perceptible difference is usually indicated.

R indicates a right answer, W a wrong answer, S a judgment of identity. The vibration-number of the fixed fork was 256, as already mentioned; that of the variable is given, each time it was changed. *hl*, *lh* indicate the order of application of the forks, according as the higher preceded or followed the lower fork. The letter A shows the point where I began to tell the subject if his judgments were right or wrong.

Jimmy Dauar. June 30th, a.m. First sitting. Least perceptible difference, 14 vibr. per sec.

237, *hl* R, *hl* R, *lh* R, *lh* R, *lh* R; 247, *lh* W, *hl* W, *lh* W, *hl* W, *lh* W; 240, *lh* W, *hl* R, *hl* R, *hl* R, *lh* R; 242, *hl* R, *lh* R, *hl* R, *hl* R, *lh* W; 244, *lh* W, *hl* W, *hl* R, *hl* R, *hl* W; A, 244, *lh* W, *hl* W, *hl* R, *hl* W; 242, *hl* W, *lh* R, *hl* R, *lh* R, *lh* R, *lh* R; 244, *lh* R, *hl* W, *hl* W, *lh* W.

Capsize. July 17th, a.m. First sitting. Least perceptible difference, 14 vibr. per sec.

234, *hl* R, *hl* R, *lh* R, *lh* R, *hl* R; 247, *hl* W, *lh* R, *lh* S, *hl* W, *lh* S; 237, *hl* R, *lh* R, *lh* R, *hl* R, *lh* R; 240, *lh* R, *hl* R, *lh* R, *lh* R, *lh* R; 242, *lh* R, *hl* R, *hl* W, *hl* R, *hl* W; *lh* R, *lh* R, *hl* W, *lh* R, *hl* R; 244, *hl* W, *lh* R, *hl* W, *lh* W, *hl* W; *lh* W, *hl* W, *lh* W, *hl* R, *hl* W; A, *lh* R, *hl* W, *lh* W, *lh* R, *lh* R; 242, *hl* W, *hl* R, *hl* W, *lh* W, *lh* R; 240, *hl* R, *lh* R, *lh* R, *lh* R, *hl* R.

Charlie (Pasi). May 31st, p.m. Second sitting. Least perceptible difference, 4 vibr. per sec.

253·01, *lh* S, *lh* R, *lh* R, *lh* W, *lh* W; 252·00, *lh* S, *hl* W, *hl* R, *lh* R, *lh* R, *lh* R, *hl* W; 250, *hl* R, *lh* R, *lh* R, *hl* R, *lh* R; 252·00, *lh* R, *lh* R, *hl* R, *lh* R, *lh* S; 253·01, *lh* R, *hl* S, *hl* W, *lh* S, *hl* S.

The data furnished by these experiments in Murray Island and in Scotland are presented in a concise form in the four following tables. The columns L_1, L_2, L_1', L_2', etc., give the vibration-frequency of that tone, produced by the variable fork, which could just be adjudged correctly lower than the fixed tone ($c' = 256$ vibr. per sec.) produced

[1] The zero-point for the clamp was situated a short distance above the point of origin of the arms of the fork.

TABLE XXV.

Murray Island Children.

Name	Age	L_1	N_1	L_2	N_2	L_3	N_3	L_4	N_4	Remarks
Jimmy Dauar ...	10	242	$\frac{16-20}{39}$ A	242	$\frac{36-40}{55}$ A	...	...	...	...	
Depoma	10	247	$\frac{1-5}{18}$	242	$\frac{36-40}{49}$ A	...	...	...	...	Inattentive towards close of first sitting.
Harry	$10\frac{1}{2}$	240	$\frac{23-27}{33}$	240	$\frac{21-25}{40}$ A	...	...	...	...	
Manowar	11	253	$\frac{32-36}{37}$	...	...	...	...	...	...	
Abau	11	237	$\frac{25-29}{49}$	234	$\frac{21-25}{61}$	237	$\frac{16-20}{30}$ A	...	...	
Tom (Tanu)	$11\frac{1}{2}$	240	$\frac{11-18}{25}$	250	$\frac{31-35}{35}$	250	$\frac{11-15}{29}$	252	$\frac{26-30}{30}$	Method of procedure slightly different at the first sitting.
William (Tat ...	$11\frac{1}{2}$	240	$\frac{2-6}{22}$	244	$\frac{21-25}{35}$	242	$\frac{11-15}{38}$ A	...	...	Inattentive towards close of first sitting.
Captain	$11\frac{1}{2}$	242	$\frac{11-15}{15}$	247	$\frac{6-10}{15}$	247	$\frac{46-50}{70}$ A	...	...	Had forgotten at the third sitting what was required of him.
Jimmy Rice, jun.	$12\frac{1}{2}$	240	$\frac{15-19}{26}$	240	$\frac{23-27}{33}$	252 254 A	$\frac{76-80}{89}$ A	...	...	
James	13	244	$\frac{27-31}{61}$ A	247	$\frac{1-5}{15}$ A	...	...	...	...	Complains of fatigue at the end of first sitting.
Poi (Pasi)	13	253	$\frac{36-40}{78}$ A	...	...	...	...	...	...	
Apori	14	247	$\frac{16-21}{21}$	252	$\frac{56-60}{65}$ A	253·01 254·75 A	$\frac{66-70}{100}$ A	250	$\frac{46-50}{54}$ A	Method of procedure slightly different at the first sitting.

TABLE XXVI.

Aberdeenshire Children.

Identification-letter, Sex and Age	L_1'	N_1'	L_2'	N_2'	L_3'	N_3'	Remarks
A. ♂ $9\frac{1}{2}$	247	$\frac{6-10}{50}$ A	242 241 A	$\frac{18-22}{28}$ A	250	$\frac{22-26}{38}$ A	Too inattentive at a sitting between the last and penultimate sittings to obtain a result.
B. ♂ $10\frac{1}{4}$	237	$\frac{14-18}{40}$ A	252	$\frac{46-50}{55}$ A	...	...	
C. ♀ $10\frac{1}{4}$	247 249 A	$\frac{56-60}{75}$ A	...	...	...	...	
D. ♂ 11	237	$\frac{11-15}{25}$	240	$\frac{3-7}{25}$ A	237	$\frac{12-16}{23}$ A	Had forgotten at the third sitting what was required of him.
E. ♀ $11\frac{1}{2}$	253	$\frac{31-35}{46}$ A	...	...	...	...	
F. ♂ 12	249	$\frac{26-30}{60}$ A	249 252 A	$\frac{27-31}{36}$ A	...	...	
G. ♀ 12	237 240 A	$\frac{26-30}{30}$ A	...	...	...	...	
H. ♀ 12	242	$\frac{26-30}{40}$ A	249 252 A	$\frac{46-50}{52}$ A	252	$\frac{13-17}{27}$ A	
J. ♀ $12\frac{1}{2}$	253·01	$\frac{50-55}{75}$ A	...	...	...	...	
K. ♂ $12\frac{3}{4}$	244	$\frac{11-15}{35}$ A	252 253·01 A	$\frac{23-28}{33}$ A	...	...	
L. ♂ 13	249	$\frac{46-50}{65}$	255·67	$\frac{52-57}{70}$	252 253·01 A	$\frac{36-40}{45}$ A	Not so attentive as before at the last sitting.
M. ♀ $13\frac{1}{2}$	249 252 A	$\frac{66-70}{75}$ A	250	$\frac{9-13}{45}$ A	...	...	

TABLE XXVII. *Murray Island Adults.*

Name	Age	L_1	N_1	L_2	N_2	L_3	N_3	Remarks
Charlie (Pasi)...	16	...	...	252	$\frac{8-12}{28}$	...	...	First sitting incomplete.
Berò..............	17	234	$\frac{7-11}{17}$	244 247 A	$\frac{51-55}{60}$ A	...	...	
Madsa...........	18	247	$\frac{12-16}{16}$	253·01	$\frac{30-34}{42}$ A	254·75	$\frac{50-55}{65}$ A	Felt 'sleepy' at end of third sitting.
Tapan	20-25	240	$\frac{16-20}{50}$ A	...	...	...	...	
Dubwai	20-25	237	$\frac{6-10}{37}$ A	...	...	...	...	Very slow at learning what was required.
Meiti	25-30	242	$\frac{44-48}{48}$	...	...	...	...	
Dick Tui	30-35	249	$\frac{27-31}{38}$	247	$\frac{29-33}{51}$	249	$\frac{6-10}{73}$ A	Tired at end of third sitting.
Jimmy Rice ...	30-35	240	$\frac{29-33}{54}$	...	...	...	...	
Mabo	30-35	244 247 A	$\frac{45-49}{53}$ A	249	$\frac{31-35}{59}$ A	...	...	
Charlie Boro ...	30-35	240	$\frac{17-21}{56}$ A	242	$\frac{36-40}{64}$ A	...	...	Slow at learning what was required.
Oroto	35-40	237	$\frac{11-15}{35}$ A	...	...	...	...	
Billy Gasu	35-40	237	$\frac{11-15}{41}$ A	...	...	...	...	
Pasi..............	40-45	237	$\frac{12-16}{25}$ A	224	$\frac{28-32}{41}$ A	247 250 A	$\frac{60-64}{64}$ A	Possibly a little tired before second sitting.
Capsize	40-45	242	$\frac{26-30}{55}$ A	...	...	...	...	Learnt unusually quickly.
Wasadgi	40-45	240	$\frac{14-18}{36}$ A	240	$\frac{16-20}{30}$	...	...	
Smoke...........	45-50	?	...	...	...	...	...	See p. 159.
Tibi..............	45-50	240	$\frac{51-55}{64}$ A	...	...	...	...	Slow at learning what was required.
Alo	45-50	240	$\frac{21-25}{51}$ A	...	...	...	...	
Kriba	50-55	240	$\frac{18-22}{43}$ A	...	...	...	...	
Komaberi	50-55	242	$\frac{21-25}{50}$ A	...	...	...	...	
Azò	55-60	240	$\frac{16-20}{30}$ A	...	...	...	...	
Ulai..............	55-60	240 242 A	$\frac{34-38}{58}$ A	242	$\frac{31-35}{59}$ A	...	...	
Harry [Mamus]	over 60	?	...	...	...	...	...	See p. 159.

TABLE XXVIII. *Aberdeenshire Adults.*

	Identification-letter, Sex and Age	L_1'	N_1'	L_2'	N_2'	L_3'	N_3'	Remarks
I. Unmusical	A. ♀ 16	244	16—20 / 45 A	...	...	...	...	
	B. ♀ 24	237	21—25 / 45 A	...	...	...	...	
	C. ♀ 25	253·01	21—25 / 33 A	...	...	...	...	
	D. ♂ 30	252	50—54 / 61 A	...	...	...	...	
	E. ♂ 33	249	18—22 / 30 A	...	...	...	...	
	F. ♂ 35	249 250 A	31—35 / 41 A	...	...	...	...	
	G. ♂ 35	237	26—30 / 35	...	...	...	...	
	H. ♂ 37	237 240 A	26—30 / 35 A	237	16—20 / 34 A	244 249 A	52—57 / 61	What was required had to be re-explained at each sitting.
	J. ♂ 43	240	21—25 / 43	...	...	...	...	
	K. ♂ 43	240	16—20 / 29 A	...	...	...	...	
	L. ♂ 43	253·01 254·75 A	56—60 / 68 A	...	...	...	...	
	M. ♂ 45	254	36—40 / 55 A	250	16—20 / 30 A	...	...	
II. Doubtfully musical	N. ♀ 35	250 253·01 A	25—29 / 33 A	...	...	...	...	
	O. ♂ 45	249	38—42 / 45	252	16—20 / 35 A	...	...	
	P. ♂ 50	254	21—25 / 49 A	255·67	19—23 / 63	255·20 255·86 A	49—53 / 57 A	
III. Musical	Q. ♀ 27	254	41—45 / 50 A	...	...	...	...	
	R. ♂ 28	252	42—46 / 67	...	...	...	...	
	S. ♂ 33	252	36—40 / 45 A	250 252 A	19—23 / 33 A	253·01	16—20 / 30 A	
	T. ♂ 33	249	11—15 / 38 A	...	...	...	...	
	V. ♂ 34	254 254·75 A	26—30 / 37 A	...	...	...	...	
	W. ♂ 47	250 252 A	36—40 / 45 A	...	...	...	...	

by the higher fork. The columns N_1, N_2, N_1', N_2', etc., contain fractions, the denominator of which expresses the number of times the two forks were presented at the sitting, the numerator showing where in the series the five judgments of the least perceptible tone-difference occurred. L and N apply to the Murray Islanders, L', N' to the Aberdeenshire folk. L_1, L_2', N_3', etc. show whether it is the first, second, third, etc. sitting of the subject. Where the letter A occurs in the N or N' columns, it implies that towards the close of that sitting the subject has been each time told whether his judgment is right or wrong. Where the letter A occurs in the L or L' columns, it follows a figure which gives the alteration in threshold occasioned by this procedure. The figure in the same square immediately above, unaccompanied by the letter A, shows the threshold determined at that sitting before the procedure of confirming or correcting the judgments was begun. Where A occurs in the N columns, and not in the L columns, it signifies that the threshold was not altered. Thus $L_1' = \frac{249}{252}$ A, $N_1' = \frac{66\text{—}70}{75}$ A, means that an Aberdeenshire subject at his first sitting was presented with the two forks on seventy-five occasions, that he was able to appreciate a difference of $(256 - 249 =)$ seven vibrations per second, that after being told that his judgments were right or wrong, he could detect a still smaller difference of $(256 - 252 =)$ four vibrations per second, and that the (at least four) correct judgments of the latter pitch-difference were given between the sixty-sixth and seventieth presentation of the pairs of forks.

The Order of Presentation of the Tones.

Here, as in nearly all our experimental work among the Murray Islanders, it was impossible to obtain introspective information of any value. But an objective examination of the five thousand judgments of tone-differences, which I obtained in the Torres Straits and in Scotland, undoubtedly shows that by some (whom I will call Class I) a greater number of correct answers was given when the fixed fork was presented first, by others (Class II) a greater number of correct answers was given when the variable fork was presented first, while many subjects (Class III) appeared wholly uninfluenced by the order in which the forks were sounded.

I find that of thirty-one Murray Island adults and children, twelve belonged to Class I, seven to Class II, and twelve to Class III. In Scotland the proportions were very similar. Of thirty-four, fourteen belonged to Class I, six to Class II, and fourteen to Class III.

I give two examples of Class I and of Class II from Aberdeenshire and Murray Island. As before, R indicates a right, W a wrong answer, S a judgment of equality. The fixed fork vibrated 256 times per second. The frequency of the variable fork is given each time it was changed. The letters *hl*, *lh*, indicate the order of presentation of the forks, the higher preceding or following the deeper fork.

CLASS I.

Aberdeenshire.

S. 253·01, *lh* s, *hl* R, *lh* s, *hl* s; 252, *lh* s, *lh* R, *hl* R, *lh* R, *lh* s; 250, *lh* R, *lh* s, *hl* R, *hl* R, *lh* R, *lh* R, *lh* R; 252, *lh* s, *lh* s, *hl* R, *hl* R, *hl* R, *hl* R, *lh* s; *lh* R, *hl* R, *hl* R, *hl* R, *lh* R; 253·01, *lh* R, *hl* R, *hl* s, *hl* R, *lh* s.

Murray Island.

Abau. 240, *lh* w, *lh* R, *hl* s, *lh* R, *hl* R; 237, *lh* w, *hl* R, *lh* s, *lh* R, *hl* R; 234, *lh* R, *hl* R, *lh* R, *lh* R, *hl* R; 237, *lh* w, *hl* R, *hl* R, *lh* R, *lh* R; 240, *lh* w, *hl* R, *lh* w, *hl* R, *lh* R; 240, *lh* w, *lh* w, *hl* R, *lh* w, *hl* w.

CLASS II.

Aberdeenshire.

P. 255·86, *lh* R, *hl* s, *hl* w; 255·67, *lh* w, *hl* w; 255·20, *lh* R, *hl* R, *hl* R, *lh* s, *lh* R; 254·75, *lh* R, *lh* R, *hl* s, *hl* w, *hl* w; 254·00, *lh* R, *hl* R, *hl* R, *hl* R, *lh* R; 254·75, *hl* R, *hl* s, *lh* R, *lh* R, *hl* s?; 255·20, *lh* R, *hl* R, *hl* s, *lh* R, *hl* R; 255·67, *lh* R, *hl* w, *hl* R, *lh* R, *hl* R?; *hl* s, *lh* R, *lh* w, *hl* R, *hl* w; *hl* w, *lh* R, *hl* R, *hl* w, *lh* R, *hl* w; 255·86, *lh* R, *hl* R, *hl* w, *lh* R, *lh* R, *lh* R; 255·9 ??, *lh* s, *hl* w, *lh* R, *lh* w.

Murray Island.

Jimmy Rice, jun.

244, *lh* w, *lh* w; 242, *lh* w, *hl* w, *hl* w, *lh* R, *lh* R, *lh* R, *lh* R, *hl* w; 240, *lh* R, *hl* w, *hl* R; 237, *lh* R, *lh* R, *hl* R, *hl* R, *lh* R, *hl* R; 242, *lh* R, *hl* w, *hl* w; 240, *hl* w, *hl* R, *hl* R, *lh* R, *lh* R; 242, *lh* R, *hl* R, *hl* R, *lh* w, *hl* w, *hl* w.

It will be seen that of the answers given by the two subjects in Class I, 87 °/。 and 83 °/。 were correct when the fixed fork was presented first, while only 50 °/。 in each were correct when the variable fork was presented first; and that of the answers given by the two subjects in Class II, 81 °/。 and 75 °/。 were correct when the variable fork was presented first, while only 43 °/。 and 47 °/。 were correct when the fixed fork was presented first.

The influence of the order of presentation of the two forks is seldom noticeable at the first sitting. It does not usually appear until the subject has had some practice in determining small differences of pitch. Possibly I have somewhat over-estimated the number of persons whose judgments were found to be affected by the order of presentation. But before deciding on each case, I went carefully through the results of every sitting, and ruled out several apparent instances, which were really due to an accidentally preponderating number of one particular order of presentation in the neighbourhood of the smallest perceptible tone-difference.

To what these differences of behaviour are due, whether some subjects form an absolute pitch-impression, whether others retain or recall an auditory image of the first tone for comparison beside the second tone or whether their judgment is based on differences of more or less sub-conscious adaptation, I cannot as yet decide. In Scotland one of my adult subjects, M, informed me that the discrimination appeared easier if the fixed fork were sounded first: he returned nearly 67 °/₀ correct answers under these conditions, but only 25 °/₀ when the variable fork was sounded first. He thought that practice had enabled him to recognize the fixed fork as soon as he heard it, and that it was easier to judge between this and the variable fork, if the recognition of the former had preceded the hearing of the latter. However, when I sounded one of the forks singly and asked him if he could say whether it was the fixed or the variable fork, he seldom returned a correct answer. On the other hand, the Aberdeenshire adult P, whose answers I have recorded above, thought it far easier to detect a pitch-difference if the variable fork were sounded first; two others were unable to discover that their decisions were in any way influenced by the order of presentation of the forks.

Unfortunately the two forks which I used were so arranged, that the fixed fork gave always the higher, the variable fork always the lower tone. It would be interesting to observe the effect of reversing these conditions; indeed it would be imperative to do so, before one could attempt to interpret the significance of the influence of order on the judgments of comparison of two nearly identical tones. It may be, as Schischmánnow[1] has suggested, that a rise of pitch can be recognized more easily than a fall. It may be that this is complicated by the factor that more correct judgments are given when the variable follows the standard than *vice versa*, or again wide individual differences of type may exist, as Martin and Müller[2] have observed in their experiments upon the comparison of weights. But a further discussion of the meaning of these results is impossible until a more extended series of experiments has been made. All I would here point out is that the Murray Islanders and the Aberdeenshire people show no apparent differences in the way they are affected by the order of presentation of the tuning-forks.

Conclusions.

Two important considerations must not be forgotten, in concluding from Tables XXV—XXVIII that the adults, and to a less extent the children, of Aberdeenshire surpass the people of Murray Island in their power of distinguishing two tones of nearly identical pitch.

In the first place, as I have before pointed out, the results given by the children of the two districts are more comparable with one another than are those given by the adults.

Secondly, owing to their greater inattention and for other reasons, a smaller number of experiments was made on certain islanders, especially upon the children, at their first sitting than on the Aberdeenshire folk.

It becomes difficult, therefore, from the above data to deduce a numerical measure

[1] *loc. cit.* S. 598. However, L. W. Stern (*Ztsch. f. Psych.* Bd. xxi. 1899, S. 376) on inadequate grounds concludes that a fall of pitch is more easily recognized than a rise, so long as the pitch-change is discontinuous.

[2] *Zur Analyse der Unterschiedsempfindlichkeit*, Leipzig, 1899, § 6, S. 29 ff.

of relative pitch-discriminability in the primitive and civilized races. Some idea, however, of the existing differences may be gained, if we dismiss from consideration (i) the results given by those subjects, on whom the number of observations made at their first sitting did not exceed thirty, and (ii) the improved results, gained by telling the subject if his judgments were right or wrong. After these eliminations, we find that the average difference of vibration-frequency ($=\Delta$) just distinguished by the adults of Murray Island and of Aberdeenshire at their first sitting is 15·4 and 7·6 vibrations per second respectively, and that the average difference just distinguished by the children of Murray Island and of Aberdeenshire at their second sitting is 12·5 and 4·7 vibrations per second respectively,—*i.e.*, in each case a difference of nearly 8 vibrations per second between the Papuan and the Aberdeenshire peoples for the tone c'. Accordingly the absolute discriminative sensibility $\left(=\frac{1}{\Delta}\right)$ of the Murray Island adults and children is 0·065 and 0·08, that of the Aberdeenshire adults and children is 0·13 and 0·21.

It is noteworthy that, excepting Smoke and Harry, all the 68 subjects readily distinguished an interval less than a tone. Of the six, who in each community failed with an interval just exceeding a semitone, three had only one sitting, two showed subsequent improvement, and one remained stationary.

As would perhaps be expected, the improving effect of practice is greater among the adults of Murray Island than among those of Aberdeenshire. The weak discriminative sensibility of the former is probably due to their lack of familiarity with European musical notes, precise intervals and instruments. But they show themselves capable of becoming quickly adapted to their new experiences[1]. On the other hand, the effect of practice among the island children is rather less evident and less continuous than in Aberdeenshire.

The influence of the order of the presented tones hardly needs reconsideration here. Both in Murray Island and in Aberdeenshire preference was more often shown for hearing the fixed fork before the variable than for the reverse sequence. The subject requires fuller investigation before it can be discussed further.

Finally, the general results of these experiments are not without interest from the standpoint of comparative music. For if it be supposed that smaller intervals are employed by primitive than by civilized communities—if, for instance, third- and quarter-tone music be at all widely spread among savage peoples—we should expect them to show evidence of extremely high sensibility to minute differences of pitch. That this is not the case, so far as the Murray Islanders are concerned, is shown by the experiments described in this section. Nor could it be expected, since the intonation of native songs by the older men was often so variable and so inaccurate, that the intended intervals were only evident when several islanders sang them together[2].

[1] It is noteworthy that both Preyer (*loc. cit.* S. 37) and Wolfe (*loc. cit.* S. 569) found that the improving effect of practice in discriminating minute intervals did not simultaneously facilitate the discrimination-power for larger intervals.

[2] A description of their music will follow in volume IV.

III. SMELL.

By CHARLES S. MYERS.

1. OLFACTORY ACUITY AND DISCRIMINATION OF ODOUR-STRENGTHS.

It is certain that most travellers have been struck with the acute sense of smell possessed by the barbaric hunters with whom they may have associated. Paulitschke[1], for example, reports of the Somalis that their keenness of smell "equals that of the best sporting dogs. With dilated nostrils they scent the game..." And many instances of like observations could be quoted. Some affect to attribute the cause of this olfactory hyperacuity to the wideness and flatness of the nostrils in the lower races. A different explanation is offered by Althaus[2], "Doubtless the olfactory nerve is as highly useful to man in his natural condition as to beasts, and the peculiar pigment, which surrounds the endings of this nerve and appears to assist in an easier resorption of odorous substances, is even now better developed in the coloured and savage races than in the Caucasian, among whom the nerve itself appears attenuated." Ribot accepts the prevailing view: "in the human species savage races have a characteristic fineness of smell in which they approach the animal world[3]."

On the other hand, Hyades[4] declares that among the Fuegians the sense of smell is little developed. Lombroso and Carrara[5], the only observers that have hitherto attempted to estimate the acuity of smell in a primitive people, write of the Sudanese Dinkas,—"Contrary to what is believed to hold among savages, their smell was obtuse; nearly all failed to recognize an odour until the fourth solution (1 : 2000) of the essence of cloves had been reached, while three of them could not recognize any odour in the entire series; but," as they rightly remark, "imperfections of language may be partly responsible for such difficulties." Although, of course, it is possible that considerable differences in olfactory acuity exist among the primitive races of mankind, there are,

[1] *Ethnographie Nordost-afrikas*, Berlin, 1896, Bd. II. S. 2, 3.

[2] *Arch. f. Psychiatrie*, Bd. XII. 1882, S. 124.

[3] *L'Hérédité Psychologique*, Paris, 1882, p. 14.

[4] *Mission Scientifique du Cap Horn*, Tome VII. Paris, 1891, p. 207.

[5] *Contributo all' Antropologia dei Dinka. Estr. dagli Atti della Soc. Rom. di Antrop.*, Vol. IV. Fasc. ii. 1897, p. 19.

as we shall later see, other reasons which will satisfactorily account for this diversity of opinion on the subject.

The experimental data, of which this section is the outcome, were obtained almost exclusively in Murray Island. The mode of life of the islanders, and their lack of animal food, made it *a priori* improbable that use would have developed their sense of smell to any high degree, a prediction which is borne out in the following experiments.

Experimental Methods.

So little work has been done in olfactometry generally, and its inherent difficulties are so great, that my investigations among the Murray Islanders were primarily directed rather to the discovery of suitable methods for future experiments than towards an estimation of the acuity of their smell-power.

I had hoped to be able to use Zwaardemaker's olfactometer[1]. This instrument consists essentially of a glass tube bent at right angles near one end which is inserted into the nostril. Over the longer horizontal part of the glass tube slides an equally long, closely fitting, hollow cylinder of odorous material, which can be adjusted so that any length of the cylinder projects beyond the further end of the glass tube. When the cylinder is pushed 'home' upon the tube, the subject breathes in odourless air (a wooden screen preventing the odour of the cylinder from directly reaching the nose). When the cylinder is pulled out, a certain amount of odoriferous air reaches the nostrils, the strength of the odour depending on the length of cylinder exposed. The cylinder may be of a certain caoutchouc or gutta-percha composition which has nearly uniform odour-strength; or it may be made of pure kaolin-porcelain, which before use requires to be steeped in any desired fluid of known concentration. With this instrument Zwaardemaker and other workers have made important contributions to the physiology of smell. It is, however, very unsuitable for work of the kind upon which I was engaged, where the attention of the subjects immediately flagged as soon as they disliked or lost interest in the experiment to which they were submitted, and where their visits to us, as has been already pointed out in the introductory chapter to this volume, were so irregular. The Murray Islanders entertained a great objection to inserting the glass tube of the olfactometer within their nostrils. The odour of the caoutchouc and gutta-percha cylinders was far too strong to determine their olfactory acuity. The porcelain tubes demanded the frequent preparation of dilute odorous solutions. The glass tubes required careful cleaning after each experiment. Altogether it was impossible to use the olfactometer in Murray Island, and recourse was necessary to some other form of experiment which could be more quickly made ready and be more easily used even at the sacrifice of greater accuracy.

After this it need hardly be pointed out that the dilution of known volumes of odorous gases or vapours with air, as practised by Valentin[2], Passy[3], and others, were

[1] H. Zwaardemaker, *Die Physiologie des Geruchs*, Leipzig, 1895, S. 85 ff.
[2] *Grundriss der Physiologie*, Brunswick, 1850, S. 515.
[3] *L'Année psychologique*, Paris, 1896, p. 378.

methods likewise impracticable under the conditions in which we were working. The one method of sufficient simplicity and promise that remained lay in the preparation of variously diluted solutions of a given odorous substance, by smelling which the olfactory acuity could be roughly measured. In such forms of experiment, it is true, one cannot hope to maintain a constant odour-strength in the solutions employed. A certain loss is inevitable whenever the vessels are unstoppered for the subjects to smell them. One cannot guarantee that the solutions shall have precisely the same strength as had those of former series, when they have to be prepared afresh. For their preparation involves a variable (and important although infinitesimal) amount of adhesion of the more concentrated solutions to the walls of the vessels in which the latter are diluted. In such forms of experiment, too, it is impossible to arrange that the several subjects who are to smell the solutions shall regulate their breathing in exactly the same way so as to be equally affected by the odour. Moreover, as will be shown later (pp. 178, 179), the passage of the individual from smelling one odorous solution to smelling another solution weaker or stronger than the former involves difficulties which are not to be overlooked. Finally we are wholly uncertain of the relation between the concentration and the odour-strength of solutions of odoriferous substances. It would be altogether wrong to suppose that the intensity of the olfactory stimulus is directly proportional to the strength of the solution employed. As yet we are without objective test of the strength of a given volume of odour-laden air. We only judge of its strength subjectively by the sensation which it produces, and in smell, perhaps more markedly than in most of the senses, increase in strength of stimulus produces a change not only in intensity but also in quality of sensation[1]. A colour-stimulus if sufficiently intense appears white. Such changes in quality were observed by me in the valerianic acid experiments described below, and very probably by one of the Australians (p. 184) to whom a weaker and a stronger solution of camphor suggested two different odours with which he was familiar.

In my first experiments with odorous solutions (Series A and B), I made use of valerianic acid, a substance which had been previously employed in olfactometrical experiments. Owing, however, to the extreme lack of permanence of the odour, the results proved to be very unreliable unless solutions were freshly prepared for every few sets of observations. Finally, my choice rested on Japanese camphor (Series C, D, E), a comparatively stable smell, which was quite familiar to the islanders, many of them having in their possession camphor-wood chests[2].

My initial difficulties in finding an odourless water were best met by the use of rain-water. The distilled water, which I had brought out from England, and the water from the wells of the island proved as useless as might be expected. Owing to its rubber fittings I could never distil a water free of smell from a metal condenser which I had brought with me. Even rain-water soon acquired some smell in Murray Island. As it was not always possible to get sufficiently fresh rain-water, some

[1] Cf. J. Passy, *C. R. de la Soc. de Biol.* 9me Sér. Tome IV. 1892, p. 854.

[2] Camphor has since been likewise recommended by Toulouse (*C. R. de la Soc. de Biol.*, 11me Sér. Tome I. 1899, p. 379 *et passim*), who uses aqueous solutions of known strengths. He believes that his solutions (the weakest being 1 : 10,000,000,000,000) can be kept for weeks without sensibly losing strength. This is not my experience. My solutions were freshly prepared every two or three days.

allowance must be made for the greater difficulties under which the Murray Islanders worked.

I used to keep a saturated solution of camphor in rain-water within a closely stoppered, wide-mouthed quart bottle. Several small pieces of camphor-block were always floating on the surface of the liquid, which was shaken from time to time. When a little of the solution was run off and filtered for use, more water and camphor were put into the bottle. By this means I maintained a stock solution, which, when filtered, had a sufficiently constant (*i.e.* its maximum) strength of smell. The proof of its uniformity is best illustrated by the fact that both in Murray Island and in Scotland I experimented on the same individuals on two or three occasions with solutions prepared at different times, and I found the results to be surprisingly constant. The method, of course, makes no pretence to extreme accuracy, no allowance, for instance, for changes of external temperature, and like disturbing factors.

It might be thought desirable to have substituted an alcoholic camphor solution of known strength in place of the above-mentioned aqueous solution. But it seemed likely that such a stock-solution would vary from time to time in smell-strength, partly owing to alcoholic evaporation while the stock-solution was standing on the shelf, partly owing to the escape of odoriferous particles whenever the bottle was unstoppered for purposes of decantation. Moreover, an aqueous solution of an odorous substance is always preferable to its alcoholic solution.

Detailed methods of experiment are given in the next section. The cylindrical glass tubes which I used were such as are familiar to collectors of natural history specimens, having a capacity of one ounce, measuring 7·5 cms. in height and 2·5 cms. in diameter. The tubes of the various series were identified by number-labels adherent to their bases. They were quite indistinguishable from one another to the subject who was under investigation.

So far as possible, those islanders were selected who had not very recently been smoking and were not suffering from colds.

In every series and at nearly every sitting, control-experiments were made on one or more members of the expedition.

Beside the experimental data, obtained from Murray Island, in Series D and E, I have grouped the results of investigations made by me later, under conditions as precisely similar as possible, upon an equal number of adults and children in Scotland.

Experimental Data.

Series A. 14 boys of Murray Island.

20 minims of a freshly made mixture of 5 minims of valerianic acid in 15 ounces of water were diluted with water to 4 ounces. Of this diluted solution, half a dram was transferred to tube v_4, 1 dram to tube v_3, 2 drams to tube v_2, 4 drams to tube v_1. Tubes v_4, v_3, and v_2 were further diluted with water so as to contain 4 drams of solution. Four tubes, w_4, w_3, w_2, w_1, each contained 4 drams of well-water.

The tubes were presented in the following order:—w_4, v_4, w_3, v_3, v_2, w_2, v_1, w_1.

The boys were asked if they smelled water or something else in each tube. The water was not quite free from smell. Consequently, in some instances (enclosed in brackets in the table below) it was impossible to decide whether or not the valerianic acid had been really detected.

TABLE XXIX.

Name	Age	v_4	v_3	v_2	v_1
Apori	14	R	R	R	R
Poï (Pasi)	13	R	R	R	R
James	13	R	R	R	R
Jimmy Rice ...	12½	R	R	R	R
Biskak...........	11	R	R	R	R
Abau	11	R	(R)	R	R
Loko	9	R	R	R	R
Jimmy Dauar..	10	W	R	R	R
Charlie Ako ...	11½	W	(R)	R	R
Tom (Maboali).	11½	W	(R)	R	R
Johnson	12	(R)	(R)	R	R
Babelu...........	10	(W)	(W)	R	R
Depoma	10	W	W	R	R
George (Pasi)...	11	W	W	(R)	R

On a subsequent occasion three of the above boys were again tested, and along with them an adult islander and a European (J. B.).

TABLE XXX.

Name	Age	v_4	v_3	v_2	v_1
George (Pasi)...	11	W	(R)	R	R
Poï (Pasi)	13	R	R	R	R
Jimmy Dauar..	10	W	R	R	R
Jimmy Dei......	45-50	(W)	(W)	R	R
J. B.	40	W	R	R	R

Series B.

Four tubes containing valerianic acid solution and four containing water were prepared as in series A. They were presented in the reverse order, the stronger before the weaker solutions. The resulting judgments, however, were not sufficiently numerous to indicate more than an approximate equality in the results given by the island adults and children.

Series C. 9 men and 8 children of Murray Island.

The experiments described in this and the following series gave far greater promise of definite results than the preceding.

They were conducted with four cylindrical glass tubes of which two were filled with camphor solution and two with rain-water. The four tubes were placed in a row, each a foot's distance apart from its neighbour. About thirty seconds before the subject was asked to smell the tubes, a solution of camphor was put before him, so that he might afterwards recognize its odour. He was told that of the four tubes one or perhaps more than one tube had a camphor-like odour and that the others contained merely water. Four times the order of the tubes presented was changed, while the subject's back was turned. In this way, each individual smelled the series of four tubes five times. About five seconds were allowed to elapse between the presentation of successive tubes, in order to prevent the onset of fatigue. The tubes were placed on a table, before which the subject sat. He was allowed to smell them in the way which seemed best to him, but was told not to touch them with his hands.

In series C, two of the four tubes contained 4 drams of water, the third contained 30 minims, the fourth 15 minims of the filtered saturated aqueous solution of camphor. The experiments were not repeated in Scotland.

Series D. 16 men of Murray Island, 16 men of Aberdeenshire. Table XXXI.

Four tubes as in series C, the first two containing 4 drams of rain-water, the third and fourth respectively containing $7\frac{1}{2}$ and $3\frac{3}{4}$ minims of the stock camphor solution[1] in 4 drams of water.

Series E. 6 men and 12 children of Murray Island, 6 men and women, 12 children of Aberdeenshire. Table XXXII.

Six tubes were used, α, β, γ, δ, ϵ and ζ, containing camphor solutions of the following strengths. Tube α contained 4 drams, β 2 drams, γ 1 dram, δ 30 minims, ϵ 15 minims, ζ $7\frac{1}{2}$ minims of the filtered saturated aqueous solution. The last five tubes were diluted to 4 drams with water[2].

Tubes α and β were first presented, and the subject was asked to indicate the stronger-smelling solution. The subject then turned his back for a moment, while the

[1] These solutions were prepared by filtering fifteen minims of the stock solution into four drams of water. The mixture was well stirred. Two drams were then removed to a glass tube containing two drams of water. The remaining two drams were then diluted with an equal quantity of water. After stirring, two drams of this latter mixture were removed to the fourth glass tube containing two drams of water.

[2] It seems that a similar series of solutious had been already used by Nichols and Bailey (*Nature*, Vol. xxxv. 1886–7, p. 74), but the details of their results have not been published.

tube, which he had judged to contain the weaker solution, was presented along with tube γ. Next he considered the relative strengths of these two solutions; the weaker was then given with δ, the adjudged weaker of these with ϵ, and the adjudged weaker of these with ζ. Whenever the subject had any hesitation in forming an

TABLE XXXI.

Adult Murray Islanders		Number of right answers		Aberdeenshire Adults	Number of right answers	
Name	Age	Stronger solution	Weaker solution	Age	Stronger solution	Weaker solution
Joe Brown ...	55–60	5	5	53	5	4
Lui	55–60	5	5	40	5	4
Enoka	55–60	5	3	40	4	2
Alo	50	4	2	40	5	1
Smoke.........	45	4	3	35	5	5
Capsize	40–45	5	3	35	5	5
Maboali	40	5	4	34	5	4
Oroto	35	5	3	33	5	5
Babelu.........	30–35	4	4	27	5	4
Dick Tui......	30	4	3	25	5	5
Loko	25	5	5	25	5	4
Pai	25	5	5	25	5	5
Geaz	25	5	3	23	5	1
Poï	25	5	2	20	1	0
Dubwai	20–25	4	3	20	5	4
Dawita	19	5	1	18	5	4
Average of 16 Adult Islanders		4·7	3·4	Av. of 16 Aberdeenshire Adults ...	4·7	3·6

opinion, he was allowed to pass two or three times to and fro from one to the other of each pair of the presented solutions. Where the final decision was obviously uncertain, the same pair was presented three times and the balance of the three judgments was taken. The interval between the withdrawal of one pair of tubes and the presentation of the next pair was about ten seconds.

In this way five different pairs were presented to each subject. The right or wrong answers given (judgments of equality being grouped with wrong judgments), are shown in the five consecutive columns of the following table. If a wrong answer be entered in one column, the individual has a far greater chance of answering rightly in the next. For if δ were wrongly adjudged weaker than ϵ, δ would be given next accompanied by ζ.

TABLE XXXII.

Murray Island.							*Aberdeenshire.*					
Name	Age	I.	II.	III.	IV.	V.	Letter, Sex and Age	I.	II.	III.	IV.	V.
Ulai	55–60	R	W	R	R	R	A. ♂ 45	R	R	R	R	R
Kriba	50	W	R	R	R	R	B. ♂ 34	R	W	R	R	R
Jimmy Dei	45–50	R	R	R	W	R	C. ♂ 25	R	R	R	R	R
Capsize	40–45	R	R	R	R	R	D. ♀ 20	R	R	R	R	W
Charlie Boro	35	R	W	R	R	R	E. ♀ 19	R	R	R	R	R
Dick Tui	30	R	R	R	W	R	F. ♀ 18	R	R	R	R	R
Mary	14	W	R	W	R	W	G. ♂ 14½	R	W	W	W	W
Maletta	13½	R	R	W	R	R	H. ♂ 12¾	R	R	R	R	W
Godaia	13	R	R	R	R	R	I. ♀ 12	R	R	R	R	R
James	13	R	R	R	W	R	K. ♀ 12	R	R	W	R	R
Jimmy Rice	12½	R	R	R	R	R	L. ♀ 11¾	R	R	R	R	R
Tom (Tanu)	11½	R	R	R	W	R	M. ♀ 11¾	R	R	R	R	R
Captain	11½	R	R	R	R	R	N. ♀ 10¾	W	R	W	W	R
George (Pasi)	11	R	R	R	W	R	O. ♂ 10¼	R	R	R	W	R
Abau	11	R	R	R	R	R	P. ♀ 10	R	R	R	R	R
Harry	10½	R	W	R	R	R	Q. ♀ 10	W	R	R	R	R
Jimmy Dauar	10	R	R	R	R	R	R. ♂ 9½	R	R	R	W	W
Depoma	10	R	R	R	R	R	S. ♂ 8¾	R	R	R	R	R
Number of wrong answers:	Adults	1	2	0	2	0	....	0	1	0	0	1
	Boys	0	1	0	3	0	....	0	1	1	3	3
	Girls	1	0	2	0	1	....	2	0	2	1	0
Total		2	3	2	5	1	....	2	2	3	4	4

Conclusions.

For two reasons the interpretation of these data is exceedingly difficult. In the first place, no series contains a sufficient number of examined individuals. For, although at different times I obtained about sixty sets of observations, for the most part from different islanders, these sets are distributed over the five series in no two of which are the experimental conditions the same. Secondly, in spite of these frequent modifications of experiment, I reached the close of my stay in Murray Island, as it will be seen, without having made use of a wholly satisfactory method.

There are, however, few experiments of which it can be said that they teach nothing. In the preceding and in the following pages I have pointed out the drawbacks and imperfections of each method of investigation. It remains to present the few general conclusions, which can be legitimately drawn concerning the comparative acuity of smell among Murray Islanders and among Europeans.

The disadvantages attending the use of valerianic acid in series A and B have been already alluded to (p. 171). The solutions of these two series were made up with well-water, rain being very infrequent in Murray Island at this time. The well-water had a smell which was no doubt very familiar to the island children. With a few exceptions they quickly recognized the smell of the valerianic acid solutions. With v_3 before them, they would often say that it had a smell like v_4, identifying also v_2 with v_3 or v_1 with v_2. Series A was devised to determine the approximate threshold at which the dilute acid could be detected from water. The table shows considerable individual variations in smell-acuity, nearly half the boys failing with the weakest solution, a much smaller proportion with the next stronger solution, while all succeeded with the two strongest solutions. Of the three boys on whom this series of experiments was repeated, two gave the same and the third gave somewhat improved results. Series B was planned with a view to determining the differences brought about, when decreasing instead of increasing strengths of the valerianic acid solutions were successively presented; but owing to the evident superiority of camphor solutions, I passed on to the later series before sufficient data had been collected. It appeared to me impossible to repeat experiments in Europe which would be fairly comparable with these two series, because at this period of our stay in Murray Island there was no sufficiently odourless water at hand.

Series C showed similar individual variations. Of nine adult islanders two had distinctly subnormal acuity, four were worse than, three were equal to two members of the expedition (W. H. R. R. and A. C. H.), whose acuity was investigated at the same time. Of eight island children, one had distinctly subnormal acuity, five were worse than, two were better than, the same two Europeans. The children gave results perhaps slightly better than those of the adult islanders. Neither children nor adults showed so high a degree of anosmia as a third member of the expedition.

At first sight the general averages of the results in series D appear to be not very different in Murray Island and in Scotland. But I must emphasize once again the difficulty I had of procuring a sufficiently odourless water in the Torres Straits, even where as in series C and D rain-water was used. In Murray Island everything seemed to have a smell. I am convinced that the test in series C and D consequently fell more heavily there than in Aberdeenshire. This is confirmed by some investigations on a member of the expedition (W. H. R. R.), who in Murray Island gave an average of 4·5 and 3·5 right answers respectively for the stronger and weaker solutions of series D, but in Aberdeenshire gave all ten answers invariably correct on three different occasions. If now, using this observer as our standard, we compare the 16 Murray Islanders in series D with him, we find that the olfactory acuity of three is decidedly defective, of seven is slightly worse than, and of six is *better than* his. Comparing the 16 Aberdeenshire adults in the same series with the same standard observer, we find that the olfactory acuity of four is decidedly defective, of seven is slightly worse than, and of five is *equal to or better than* his[1].

As has been mentioned, the order of the four tubes in series C and D was changed for each of the five sets of judgments. It happened almost invariably that in one set the weaker of the two solutions of camphor followed immediately upon the stronger. In series D this occurred 14 times to Murray Island adults and 20 times to Aberdeenshire adults. On 8 of these occasions both peoples failed to detect the weaker solution, a possible indication that the Murray Islanders found greater difficulty than the Aberdeenshire adults in perceiving a faint after a strong smell.

In series E an attempt was made to test the discrimination of odour-strengths in Murray Island and in Scotland. At first sight it would appear that, if the intensity of stimuli varied with the concentration of the solutions, each individual should have been as successful finally with the tubes ϵ and ζ as he had been at the beginning with the tubes α and β. For, however much the olfactory organs were fatigued by the time the last two tubes were reached, the difference of sensation by which the two solutions are discriminated should remain approximately constant. In point of fact more complex influences are at work. It has been already pointed out that we have no proof that intensity of stimulus and concentration of solution are proportional to one another. Moreover, owing to the subject's subnormal acuity, natural or induced by fatigue during the experiment, the odour of the two weakest solutions may fall below the threshold; finally his attention and judgment may have become worse, or practice may have made his answers more reliable than they were at the beginning.

An inspection of the table in series E shows that three or more wrong answers were returned only by one Murray Island child, Mary, and by two Aberdeenshire children, G. and N. The Murray Island children made fewer erroneous judgments than the Aberdeenshire children. On the other hand, the Aberdeenshire adults were more successful than the Murray Island adults. Unfortunately, the series is too small and the differences in odour-strength are too great for the data to bear further interpretation. But so far as they go, the results show no very remarkable differences in the behaviour of the two communities to the same experiment.

In Aberdeenshire I tried a few experiments on the same individuals on various occasions, using in one series 15 and 7½ minims, in another 7½ and 3¾ minims (diluted as usual to 4 drams with water) and in both series two other tubes of plain water.

[1] It is of course possible that the larger number of wrong answers given by this observer in the Torres Straits resulted partly from impaired health, but I have no doubt that it was chiefly due to the lack of odourless water above mentioned.

The results showed that the 7½ minims-solution was identified far more frequently, if presented in company with the weaker, than when accompanied by the stronger solution. This dependence of the successful detection of an odoriferous solution upon the relative intensity of odoriferous solutions presented in the same series with it was also indicated in Murray Island. Its importance in olfactometric experiments can scarcely be overrated. For this reason the majority of the determinations made by Mr Seligmann in Mabuiag are incomparable with my own, as he generally used three instead of two different strengths of camphor-solution in one and the same series. He did, however, investigate six individuals of Mabuiag and Badu according to the method of series D, and he obtained an average of 4·8 and 4·2 right answers for the stronger and weaker solutions respectively. So far as they go, these results are better than those given by the Murray Island and Aberdeenshire people. He also obtained 5 and 4, 4 and 1, 5 and 1, 5 and 4 right answers from four Australians of the Seven Rivers district, Queensland, using the same method.

We may on the whole conclude, I think, that the average olfactory acuity is slightly higher in Murray Island and in the Torres Straits generally than in Aberdeenshire, a smaller proportion of the islanders having obtuse and a greater number having hyperacute smell-power. The average acuity of the children of both communities seems slightly higher than that of the adults.

But I would not lay too much stress in this section upon results, so far as comparative olfactory acuity is concerned. I have rather tried to show the drawbacks of each of the methods I took up, and to indicate the errors which future workers in this field may avoid. The sense of smell is the most difficult of all the senses to investigate, and I returned from the Torres Straits, as I went to them, without having a wholly satisfactory method at my command. But my several attempts to find one point in the same direction. I have no doubt that I should have obtained far more definite results had I introduced the various strengths of camphor solution (as Dr Rivers has since done with success elsewhere) singly, instead of two together, into every set of the four tubes employed in series C and D. The time taken up in the investigation of the islanders would have been much prolonged and the difficulty of finding them sufficiently at my disposal would have been somewhat greater. But, compared with previous methods, this procedure bids fair to yield the best results in olfactometrical experiments on primitive peoples.

2. MEMORY AND DISCRIMINATION OF ODOURS.

In a paper, which was published during the year of our expedition, upon the people of the Mekeo district, British New Guinea, the following observation appears[1], "As the islands of the Torres Straits are also in the vicinity of New Guinea, I may say that the natives of these islands, like the Australian Kanakas[2], have an exquisitely delicate sense of smell. Because of this faculty, it seems that they make excellent policemen or detectives....To track a man down, some object belonging to him, preferably his garment, is procured if possible. They smell at it and then start off in pursuit of the individual, whom they will readily recognize among several others because of his odour." During our stay in the Torres Straits none of us heard of this practice. Possibly it existed in the larger islands, but in Murray Island, at least, in which most of the following investigations were made, serious crime was exceedingly rare, the usual business of the court-house consisting of disputes about land and of charges of trivial assault.

I asked Pasi, the younger Mamus [chief] of Murray Island, if he could distinguish islanders from one another in the dark by the smell of their person. He said that he could not. I questioned also some other natives and obtained the same reply. Several men told me of their own accord, "White man got one kind smell, Murray Island man another kind," and once I heard added, "Mainland (Australian) woman got another kind."

Feats, like those already alluded to in Father Guis' paper, were long ago recorded of the maroon negroes of the Antilles[3], who are said to distinguish their own tracks from those of a Frenchman by their odour, also of the South American Indians[4], who, it is claimed, pursue their enemies by the same means. The American Indians, however, "possess an infinite number of divers drugs with which they cover themselves....These ointments, remaining for some time on the skin, become rancid....This odour is sometimes so penetrating that it leaves a train and a trail wherever a man thus besmeared has recently passed. Seeing that by the sole means of smell Americans can rediscover the path taken by their fellow-countrymen through the forests, the Spaniards have attributed this professed cleverness (sagacité prétendue) to a fineness of sense; but I am finally convinced that Europeans would soon acquire this power of discrimination if they lived long among savage people, and that there is nothing strange in the matter at all[5]."

The Murray Islanders as a rule used no such perfumes except on occasions of native dancing, when they anointed themselves with coconut oil freely. Now and again cheap European perfumes were introduced from Thursday Island. The peculiar,

[1] Le R. P. Guis, "Les Canaques," *Les Missions Catholiques*, Lyon, 1898, Tome xxx. p. 178.

[2] The word *Canaques* is very loosely used by this writer.

[3] Le Cat, *Traité des Sens*, Rouen, 1740, p. 256.

[4] Von Reek, *Reise der Salzburg*, Bd. I. S. 862, reference in Haller's *Elementa Physiologiae Corporis Humani*, Lausanne, 1763, Vol. v. p. 179.

[5] De P***, *Recherches philosophiques sur les Américains*, Berlin, 1777, Tome I. p. 171.

but not unpleasant, odours of the Murray Islanders, although occasionally the result of dirty garments, appeared to me very like (and were possibly due to) the odour of coconut oil, as a rule. Father Guis[1] remarks that the smell of an abundantly sweating New Guinea native is in no wise different from that of a French regiment after a five or six hours' march. V. d. Hörck[2] failed to find any special skin-odour among the Lapps. According to Hyades[3], the Fuegians cannot recognize by their smell either Europeans or natives of an opposite sex to themselves. There can be little doubt, however, that most coloured people, especially when unclean, emit a skin-odour which is sufficiently distinct from that of Europeans to be generally recognizable[4].

This faculty of discriminating between and of remembering closely similar odours appears to be well developed among several non-European peoples. Our Malay boy in Sarawak was one day seen smelling the clean linen returned by our washerman, sorting it out according to the skin-odour of the wearer; and I am told that Chinese servants do the same. According to Sir Edwin Arnold[5], the most refined classes of Japan amuse themselves by competing in a game, wherein they have to identify certain scents emitted from a series of small packets which are burnt in succession. Perhaps ten such packets will be burnt; but three different scents are first presented to the company, and it is explained that these scents are equally distributed among the ten packets, so that three of the packets will emit one scent, three another, and three a third, while one of the ten packets will have an unknown odour, which must be identified.

To what extremes practice can develop in ourselves the association of odours with strange ideas is well shown in some interesting experiments made a few years ago by Francis Galton[6]. "I taught myself to associate two whiffs of peppermint with one whiff of camphor, three of peppermint with one of carbolic acid, and so on. Next I practised at small sums in addition; at first with the scents themselves, and afterwards altogether with the imagination of them....In this way...I convinced myself of the possibility of doing sums in simple addition with considerable speed and accuracy by means of imaginary scents."

Probably the mode of life led by primitive peoples and their general mental status combine to make them more aware of and attentive to the majority of external stimuli than we ourselves are. The intimacy of their acquaintance with the common, and especially the more useful, objects of their surroundings is often little short of marvellous. And, *inter alia*, their memory for odours and their power of discriminating between them become developed to a very high degree. The refinement of such faculties, to which attention has been already drawn, must in many instances be really responsible for the apparently exceptional olfactory acuity with which primitive folk have often been credited. A faint odour may be simultaneously perceptible to the civilized and to the uncivilized individual. To the latter it will be full of meaning and so will at once engage his attention; for the opposite reason it is apt to escape the notice of the

[1] *loc. cit.*

[2] *Verhdl. d. Berlin. Gesell. f. Anth., Ztschr. f. Ethn.*, 1876, Bd. VIII. S. 51.

[3] *loc. cit.*, p. 210.

[4] Cf. Léon Moncelon, *Bull. de la Soc. d'Anth. de Paris*, Sér. 3, Tome IX., 1886, p. 318; Mgr. le Roy, *Les Missions Catholiques*, Lyon, 1897, Tome XXIX. p. 90.

[5] *East and West*, London, 1896, pp. 365—373.

[6] *Psychol. Review*, Vol. I. 1894, pp. 61, 62.

former. A boat carrying a European is being paddled down a river of Sarawak by an Iban (Sea-Dayak) crew. Suddenly the natives stop and exclaim, "We can smell the durian fruit." But the European has ignored the odour until it is pointed out to him; even then he is doubtful if so faint a smell is really that of the durian. As the boat approaches the river-bank, the odour waxes until no doubt rests in the mind of any one who has ever smelled the fruit that it is growing in the immediate neighbourhood. Such an example (which actually occurred) affords proof not so much of the high olfactory acuity of primitive people, but rather of the manner in which their faintest olfactory sensations are fraught with meaning and are at once seized and acted upon.

Odour-Vocabulary.

The number of words which we use to denote varieties of olfactory sensations is strikingly small, and is an expression of the scant value and utility of these varieties. It might be suspected that primitive peoples would have a better developed odour-vocabulary. The Maories, for instance, appear to have eight different synonyms for the phrase 'to smell unpleasantly[1].' There are, of course, obvious difficulties in arriving at the meaning of native words which have no exact counterpart in European languages. The only opportunities which I had for studying the subject were in the course of certain experiments described below upon Murray Islanders, wherein various substances, chiefly scents of European manufacture, were presented to the islanders. Never once did an islander give a generic name: with one doubtful exception the odours were always likened to some special familiar odour. It is true that as the replies were partly expressed in English, one cannot be certain that generic odour-names do not abound in the Murray Island language. But had they been in common use, I should now and again surely have heard them[2].

Comparisons of Scents and other Substances.

Observations on the Murray Islanders.

In these experiments various scents and odorous substances, much diluted or mixed with water, were successively presented. Twelve men and one woman (named Sisi) were separately examined in Murray Island. After smelling each and before proceeding to the next, each islander recorded his opinion as to the nature of the odour, and expressed his like or dislike of it. In a few instances they attempted to range the solutions in order of preference. The series of scents was supplied to the expedition in solid form by Messrs Piesse and Lubin of New Bond Street, London. About six of them were presented in disregarded order to each individual. A sufficient time elapsed between the presentation of successive bottles to prevent serious disturbance from odour-contrast and the like.

It was obvious that all the islanders took a very great interest in the proceeding,

[1] Bishop William Williams, *A Dictionary of the New Zealand Language*, Auckland, 1892.

[2] Mr Ray, however, tells me that *semelag* and *gemelag* (*sem*=an unknown tree, *gem*=body, *lag*=smell or taste) are respectively used for 'stink' and 'perfume.'

giving their answers with the utmost care and deliberation. With one doubtful exception they replied to my question, "What smell you call that?" by describing it in terms of some odour with which they were familiar. In many instances a satisfactory comparison naturally presented considerable difficulty. The individual would often run through various more or less likely odours aloud or in an undertone, until finally he fixed on one which seemed most closely to resemble that of the bottle before him. In many cases I have been unable to identify the plant or tree in the replies given below. In others I could obtain no answer save that it was a good smell or a bad smell.

The islanders examined were (i) Komaberi, (ii) Komaberi jun., (iii) Barsa, (iv) Jimmy Wailu, (v) Smoke, (vi) Jimmy Dei, (vii) Damper, (viii) Billy Kuris, (ix) Wasalgi, (x) Kriba, (xi) Pasi, (xii) Charlie, (xiii) Sisi. In the following paragraphs the answers are grouped together according to the scent presented, and each is preceded by a figure, so that by reference to the above list the individual who returned it may be at once identified.

Camphor. (iv) Pain-killer = "medicine belong headache[1]." (iv) "China-box[2]." (v) Urine. (vii, viii) *Pas*[3]. (x) Water in which a tree has rotted. (xi) *Arzer*.

Valerianic Acid. (i) Dead snake. (v) *Saret* = "banana kept long time." (vii) "Coconut stink" (= bad coconut). (viii) *Biri* (from New Guinea). (x) *Obar* fruit[4]. (xi) *Ager kup* (*Ager* is an aroid with acrid juice).

Thyme. (ii) *Paiwa*[5]. (iv) "Close up (= very like) china-box[2]." (vi) "Belong big tree, New Guinea, yellow flower." (? = frangipanni.)

Sandal. (i, iii, vii, viii, ix) Sandal-wood (usually pronounced *sanot*). (iv) "Tree belong Fly River." (v, viii) *Abal* (= pandanus) fruit. (v) *Kira-kira* (? = *gir-gir*, meaning pleasant), *waiwi* fruit (= Mangifera indica L.), *sarik pas* (= Andropogon Nardus L.). (x) *Paiwa*[5].

Benzaldehyde. (vii) *Tibi pas* (= Ocimum canum, Sims). (xi) *Obag-obag*.

Jasmine. (i) *Mar*, a New Guinea plant. (xi) *Abal*. (xii) "Scents[6]."

Violet. (ii, v) *Mam-mam-mam-pas*. (iv) Chemist's shop. (i) *Kusibager* (= a zingiberaceous plant, ?sp.). (ii) "Make him scents" (= material for scents).

Verbena. (ix) *Kira-kira* (? = *gir-gir*, meaning pleasant). (xii) *Sarik pas* (= Andropogon Nardus L.).

Heliotrope. (v) *Lever pas* (= Ocimum basilicum L.). (vii, xi) *Kozo*. (viii) *Kusibager* (= a zingiberaceous plant). (x) Crushed mosquito.

Vanilla. (ix) *Kaïï* fruit.

Musk. (xiii) *Kaba sus* (= banana juice).

Asafœtida. (ii, iii) Bad coconut milk. (iv) The smell of a man's sores. (v) "Old coconut kept long time." (vii) Dead snake. (viii, x) Bad young coconut. (ix) "Fruit in *Erub* (Darnley Island) belong you fellow" (= onion).

[1] A popular patent medicine in the Torres Straits which is said to smell of camphor.
[2] The chests imported by the Chinese into Thursday Island are made of camphor-wood.
[3] Some kind of Ocimum is probably here meant. Jukes (*Narrative of the Surveying Voyage of H.M.S. Fly*, London, 1847, Vol. II. p. 288), however, translates *Pas* as peppermint-tree.
[4] I cannot identify this tree but can testify to the aptness of the comparison.
[5] 'Paiwa' was applied to the Chili plant of Murray Island, but also (and here) to the Sandal-wood tree growing in the Fly River of New Guinea.
[6] Occasionally the Murray Islanders bought bottles of perfumes at Thursday Island.

Caproic Acid. (vi) Putrid king fish.

Civet. (i) Putrid pigeon[1]. (v, xii) Fæces. (vii) Dead man, dead pigeon. (viii, xi) *Arger* (= Callicarpa, ? longifolia). (ix, xi) Infant's fæces. (xii) *Kuper-sor* (= shell of whelk).

Observations on the Western Islanders, Torres Straits.

Fourteen men of Purim, Badu and Mabuiag (two of whom had South-Sea fathers) and one from Boigu, an island south of New Guinea, were examined in a similar but less extensive manner by Mr C. G. Seligmann in Mabuiag. The figures indicate the number of individuals who gave identical replies.

Camphor. (2) pain-killer, (1) grass in swamp, (1) "medicine belong white man." (1) fæcal smell. Not recognized by 8 men.

Ocimum sanctum (*Tokar*). Recognized by 6 men, not recognized by 1 man.

Linimentum terebinthæ aceticum. (2) ants. (1) *wiba* (? = honey).

Phenol. (1) "stuff Chinamen smoke" (? = burning opium). Not recognized by 2 men.

Observations on Australians.

Mr Seligmann also obtained for me answers from several men of the Seven Rivers district, Queensland. Even making allowance for their scant knowledge of English, he thought that they took far less interest in the experiment, and showed much less intelligence than the Mabuiag islanders.

Camphor. (3) pain-killer, (2) swampy smell, (2) fruit (name unknown), (1) "scent belong oil," (1) urine, (1) horse's urine.

Linimentum terebinthæ aceticum. (2) ants.

Ammonia. (1) urine, (2) woman's urine.

General Results.

In Murray Island, the examination of the thirteen individuals was spread over a period of four or five weeks. Here, at least, there can be no doubt that the individuals, who had already been examined, spoke freely meanwhile to those who had not about the various scents which they had smelled. Nevertheless, in spite of the preconceived opinions which may have thus been formed, those who were examined later showed just as much independence of judgment as those who had been examined before them. Indeed in these, as in many other of our experiments, the decisions of the islanders were remarkably unbiassed by suggestions from outside, and by any leading questions that might be asked at the experiment. For example, Billy Kuris, after some hesitation, compared heliotrope to *kusibager*. I hinted to Pasi, who was examined next, that perhaps he thought heliotrope smelled like *kusibager*. No, he replied, it smells more like *kozo*. Komaberi, who came after Pasi, denied that either *kusibager* or *kozo* smelled like heliotrope. Considering how easily our judgments of odours are modifiable by suggestion, this behaviour is certainly noteworthy.

The Murray Islanders gave their replies with surprising readiness and assurance. My impression was that the old associations and new thoughts which the above odours

[1] All birds and insects were called 'pigeon' by the Murray Islanders.

awakened were more numerous and more vivid and were more rapidly evoked than they would have been in the case of Europeans tested under similar circumstances. If this be so, it is yet another expression of the high degree to which the sensory side of mental life is elaborated among primitive peoples (cf. pp. 44, 45, 181).

Attention may be specially drawn to the apt comparison of the acetic turpentine liniment with ants, of ammonia with urine, of civet with fæces, of asafœtida with the onion, and of musk with banana juice. The comparison of sandal-wood with Andropogon Nardus is of special interest, since the latter yields citronella oil, from which is obtained the aldehyde, citronellon ($C_{10}H_{18}O$). According to Zwaardemaker[1] the odour of citronellon closely resembles that of citral ($C_{10}H_{16}O$) contained in citron oil, and obtained as an oxidation-product of geraniol. The odour of sandal-wood is also allied to that of citral. Hence in this author's classification of odours[2], the fourth sub-class of the second or aromatic class is made up of two groups, (i) geraniol, and (ii) citral, the latter of which includes citronellon and sandal-wood.

The comparison of an ocimum with camphor and of Ocimum basilicum with heliotrope appears to be equally appropriate, for the plant is said to have a strong aromatic flavour, like that of cloves, and to yield a yellowish green volatile oil, which on being kept solidifies into a crystalline camphor, isomeric with turpentine camphor[3].

The fruit of Mangifera indica, compared by one observer to sandal-wood, is said to exude, just before ripening, a resinous substance with the odour and consistence of turpentine[4]. Sandal-wood and turpentine, according to Zwaardemaker, belong to different sub-classes of the same class of odours.

Phenol is placed by him in the second sub-class of the sixth or empyreumatic class. Its odour was hence aptly compared with that of burning matter.

Camphor was likened to decaying vegetation both by a Murray and a Mabuiag Islander, and by the Australians. By a Murray Islander and Australian it was also compared to urine.

The only odours, which the Murray Islanders styled "bad smells" (*adud lag-lag*), were those of asafœtida, valerianic acid and civet. The smell of these substances generally produced grimaces and often expectoration. Civet was undoubtedly the most repulsive of all. We had other evidence during our visit of the intense disgust of the Murray Islanders for fæcal odours. However, valerianic acid was liked by Barsa and Smoke, while asafœtida was not much disliked by Billy Kuris, was at first pronounced a "good smell" (*debe lag-lag*) by Sisi and Dick Tui, and was persistently liked by Wasalgi and Smoke. Clearly, violet, musk and thyme were the favourite odours. Jimmy Dei begged for a present of some musk. Violet was preferred more frequently than any other substance, but there appeared to be no odour in Murray Island comparable with it.

Among the Mabuiag and neighbouring Islanders and among the Australians, the odour of camphor and of the acetic liniment of turpentine was much more generally liked than disliked.

So far, then, as these experiments go, they show that the people of the Torres Straits have much the same liking and disliking for various odours as obtains among ourselves.

[1] *Die Physiologie des Geruchs*, S. 219. [2] *Ibid.* S. 234.

[3] George Watt, *A Dictionary of the Economic Products of India*, Calcutta, 1889—96, Vol. v. pp. 441, 442.

[4] *Ibid.* Vol. v. p. 153. I am indebted to Mr R. H. Yapp of Gonville and Caius College, Cambridge, for these two references.

IV. TASTE.

By CHARLES S. MYERS.

Taste-names in Murray Island.

SEVEN adults, Berò, Dauai, Wanu, Lui, Jimmy Dei, Wasalgi, and Jimmy Rice were separately examined. I tested them with dilute solutions of sugar, salt, acetic acid, and quinine, applying the solutions usually in the order named. The tongue was first dried, and was then wiped with a piece of cotton-wool moistened with the solution. The individual closed his mouth and reported on the nature of the taste he experienced.

I asked four islanders to range the solutions in their order of pleasantness. They all placed the sweet solution first and the bitter last. Two preferred the salt to the acid, one the acid to the salt solution, the fourth could not form a decided opinion. The distaste for the bitter solution was most obvious. Generally I used it last, as several of the islanders insisted on leaving the room in order to expectorate.

The following is the list of taste-words obtained.

Sweet. All gave the name *debe lag-lag* (= good taste[1]). Lui also suggested *au geb-geb* (= big, *i.e.* fully, ripe).

Salt. All gave the name *kurab-kurab*, save Wanu, who described it as *makakalam gur* (= like sea-water). Jimmy Dei, Dauai and Wasalgi observed that it was "all same salt." Jimmy Rice used also the word *zirab-zirab*.

Acid. *Zirab-zirab*[2] was given by Berò, Jimmy Dei, and by Jimmy Rice, who explained that unripe fruit tasted *zirab-zirab*. Wanu described the solution as *sus-sus* (literally = juicy: *sus* = any juice, *e.g.* milk: probably the word is applied here to the juice of sour fruit) and as *kurab-kurab*. Lui gave *kebe geb-geb* (= little ripe), *urweri* (= hot, *ur* = fire) and *kap-kap* (apparently = biting,—Jimmy Dei explained that a chili tasted *kap-kap*). Both Wasalgi and Dauai called acid *kap-kap*. Dauai suggested also *kurab-kurab*. Lui, Wasalgi and Dauai all agreed that the taste was *zirab-zirab* when I suggested the word.

Bitter. Berò likened it to *sus-sus* (which he explained as the taste of juice obtained by squeezing the broken stem of certain plants). Wanu suggested *makakalam* (= like) *kurab-kurab*. Lui called it *kap-kap*, and finally *kurab-kurab*, which was also given by Jimmy Dei. Wasalgi called it *kegar* (? meaning).

It mattered not in what order the four solutions were presented: all five individuals showed great difficulty in making up their minds about a name for the bitter

[1] According to Mr Ray, the root-meaning of *lag* (which is used for smell as well as for taste, cf. footnote, p. 182) is 'that which is wanted.' *Kaka lag-lag* = I desire or am willing.

[2] Mr Ray writes it *zurab-zurab*. *Z* in Murray Island was almost sounded as *ds*.

taste. On the other hand, the sweet taste has a most definite taste-name, *debe lag-lag*. *Kurab-kurab* appears to be the usual word for salt, *zirab-zirab* for acid: but the two tend to be confused.

Taste-names in Mabuiag.

Mr Seligmann has obtained for me the following taste-words:

Sweet. Five men called the solution of sugar *kapu mital*, *kapu nguki* or *kapu mital nguki* (*kapu* = good, *mita* = taste, *mital* = tasty. *mitalnga* = something with a taste, *nguki* = water). One man called it *mina mitalnga* (*mina* = real, 'proper'), another *wam mitalnga* (*wam* = honey-comb), a third called it *urabau nguki mitalnga* (*urab* = coconut).

Salt. Seven men gave the name *adabad* or *adabad mitalnga* (*adabad* = salt water). One man styled it merely *kapunga* (= good thing).

Acid. Four names were given, each by different men. *Sasa teralnga* (√*sasa* = to pinch, *tera* = strong taste, *teralnga* = thing with strong taste). *Seberarnga*. *Walipusi* (meaning unknown). *Pidi mitalnga* (? *pid* = black-bee)[1].

Bitter. Four men called it *il mitalnga* or *ild mitalnguki* (*il* = bile, *ild* = bile-like). Two called it *adabad mitalnga* (= salt), one *teralnga* (= thing with strong taste), and one *katam mitalnga* (*katam* = banana, ? here banana-skin).

It will be observed that the Mabuiag people show the same peculiarities in their taste-vocabulary as in their colour-vocabulary (pp. 63, 64). They tend far more than the Murray Islanders to liken a given taste to that of some special substance with which they are familiar. The Murray Islanders usually choose a general name, implying ripeness, warmth, etc., while the former prefer (often, no doubt, on the spur of the moment) to name some particular object, *e.g.* honey, coconut-milk, or bile. Save for this, the two vocabularies are very similar. Sweetness has the best defined taste-word, saltness comes next. Acidity appears to have even a less definite name in Mabuiag than in Murray Island.

General Conclusions.

The results of this inquiry led me to study the taste-vocabularies of other peoples, a fairly extensive series of which I have by now collected, thanks to the ready help of known and unknown friends abroad. I hope to discuss the subject in detail elsewhere, but there are one or two points of immediate interest to which I will refer here.

The word for 'sweet' both in the eastern and in the western islands of the Torres Straits literally means 'tasting good.' It has this meaning in many different countries. In Europe the relation of ἡδύς to ἥδομαι, of *suavis* to *suadeo* and the manner of use of 'sweet' in early English seem to indicate that the original meaning of these words was 'giving a pleasant taste.' It is certain that the allied Sanskrit √*svad* primarily signified 'giving a nice or savoury taste,' and only later came to mean 'sweet[2].'

[1] Mr Ray suggests that *walipusi* should read *wati-puzi* (*wati* = bad, *puzi* = to go down) and that *pidi* should read *ipidad* (= bad).

[2] I owe to Mr H. M. Chadwick of Clare College, Cambridge, an interesting suggestion that the Indo-Germanic *svādus* may have been related to *su* (= good) and *ed* (= to eat).

One of the Torres Straits Islanders called also salt a 'good' taste. In the Soudan, in Upper Guinea, in the South Victoria Nyanza, in Dakota, in the New Hebrides and elsewhere there are languages which similarly employ a common word (equivalent, perhaps, to 'tasty') for sweet and salt. Salt is so highly valued by primitive people that this need cause little surprise. The Baganda, according to the Rev. J. Roscoe, apply the words *kuwoma* and *kawa* to sweet, salt, acid, and bitter substances, according as they like or dislike them. Thus sugar, salted meat, and certain sour fruits which they eat with relish, are called *kuwoma*. Brackish water and quinine are called *kawa*. In Sanskrit, Persian and Arabic, the same word is used not only for the taste of salt, but also to denote lustre, grace or beauty. Coming still nearer home we have in Lithuanian *saldus*, in old Slavonic *sladuku*, in Russian *sladkij*, all of which mean 'sweet.'

The word for saltness is usually derived from the sea or from whatever be the source of the salt obtained. I do not know the derivation of the Murray Island word *kurab*. The Mabuiag *adabad* is probably derived from sea-water. In Murray Island there was some confusion between salt and sour or acid: both in Mabuiag and Murray Island there was confusion between bitter and salt. This is doubtless due to the fact that certain common tactile sensations may accompany each of these three tastes, varying from mere astringency to acridity and actual pain[1]. The same confusion of taste-words appears even in Europe. Thus, the peasants of Marchfeld, according to Mach[2], call salt 'sour,' "because the expression *salty* is not familiar to them." So, too, in Lithuania *suras* (= Anglo-Saxon *sur*, sour) means 'salt.'

The absence of a distinctive word for bitter appears to be very common. The Dinkas of the Soudan frequently described the bitter solution used in Lombroso and Carrara's experiments as 'salty'[3]. The same want of differentiation is to be met with in Maori and in one of the dialects in the Solomon Islands. Indeed 'bitter' in England, like πικρός in ancient Greece, was formerly used to denote 'biting,' pungent, sharp, saline, as well as truly bitter tastes. We still speak of the bitter brine and the Bitter Lakes. I am confident that many Europeans have a very indefinite notion of what bitterness really is. Several Aberdeenshire adults whom I tested had precisely the same difficulty as the Murray Islanders in giving a name to the taste of the bitter solution. Two of them could only describe it as a variety of acid taste. In colour-nomenclature the word 'grey' is often used in an equally loose fashion. It is, however, remarkable that there should often be no distinctive word for bitterness, the sensation of which is now regarded with such unanimity by physiologists as *sui generis*, differing from other taste-sensations as widely as the sensation of blue differs from that of red. A similar state of things has been already met with in the colour-vocabularies of primitive folk (page 53 ff.), where of two fundamentally different sensations, red and blue, each of which is keenly appreciated, one receives, the other usually lacks a definite name.

[1] Oehrwall, *Skandinav. Arch. f. Physiol.*, 1894, Bd. II. S. 9; Kiesow, *Beitr. zur physiolog. Psychologie des Geschmackssinnes*, Leipzig, 1894, S. 8.

[2] *Contributions to the Analysis of the Sensations* (Eng. Trans.), Chicago, 1897, p. 42, footnote.

[3] *Contributo all' Antropologia dei Dinka, Estr. dagli Atti della Soc. Rom. di Antrop.* Vol. IV. Fasc. ii. 1897, p. 19.

V. CUTANEOUS SENSATIONS.

By W. McDOUGALL.

1. THE DELICACY OF TACTILE DISCRIMINATION[1].

In devising the most suitable method for the investigation of the delicacy of discrimination of two points of the skin simultaneously touched, I was led by the following considerations.

(1) The method should leave as little as possible to the subject, *i.e.* it should demand one or other of two simple replies only, and the accuracy of its results should be as far as possible independent of the impartiality and straightforwardness of the subject.

(2) The procedure should be, as far as practicable, without knowledge on the part of the subject.

(3) It should not attempt extreme accuracy, but should arrive as rapidly as possible at a rough measure of the threshold of discrimination; for the process possessed little intrinsic attraction for the subjects and they soon wearied of it.

(4) It should be calculated to keep the attention and interest of the subject as nearly as possible at a maximum.

(5) It was desirable to operate on skin-areas that are not liable to special education of tactile discrimination through employments; for it was a principal object of our work to discover, if possible, racial characteristics; and, since it has been shewn that tactile discrimination of the finger-tips is much improved by practice, especially such as results from certain employments[2], any racial differences in this respect would be liable to be obscured by differences in habits of life in the case of the skin of the hands and fingers.

[1] My work as described in the following pages was carried out under the general direction of Dr Rivers, and I take this opportunity to express my hearty thanks to him for sympathetic stimulus and constant helpfulness.

[2] A. Stern, *Zur ethnographischen Untersuchung des Tastsinnes der Münchener Stadtbevölkerung*, München, 1895.

Procedure.

With these considerations in view I adopted after some preliminary trials the following procedure. I used a small pair of carpenter's dividers with blunt metal points, the intervals between the points being measured on a millimetre scale. These two points were applied to the skin simultaneously with light pressure lasting about one second. The subject was told to keep his eyes shut, and the area of skin operated on was further guarded from his view; it was necessary also to guard against hints that might be given by friendly by-standers, for the subjects tended naturally, and were encouraged, to submit to the process in the spirit of competition. He was told to say 'one' or 'two,' according as he judged that one or both points touched his skin. Everyone who has made this sort of experiment is aware that there is a certain narrow range of interval, in which the two points give a sensation that is different from the sensation of one point and yet is not the sensation of two points. The threshold that I sought was therefore, not that distance at which two points can be distinctly felt, but a slightly lower one, that distance at which they yield a sensation perceptibly different from that yielded by a single point.

One point was applied in every experiment about as frequently as the two points, for I found that in the absence of this precaution most subjects quickly began to answer 'two' at every application or at least in an undue proportion of cases. It is usually considered sufficient in the case of educated subjects to introduce only occasional 'Vexir-Versuche' in experiments of this kind, but my own experience leads me to believe that even the best trained subjects are liable to be biassed in favour of the more frequently repeated stimulus, and in the case of these savage subjects there could be no doubt about it.

I always began a series of observations with the two points at such a distance apart as was considerably greater than the threshold distance, and the interval was diminished by successive steps, the diminution at each step being 25 °/° or 30 °/° of the interval of the preceding step. At each step of this descending series the application of the points was repeated until five answers to the double point were obtained. If there was no error in these five answers I proceeded to the next step; if there was an error I went on to five more double touches, and if then there were two errors in the ten cases, this distance of the two points was accepted as the measure of the threshold of discrimination. That is, I chose arbitrarily two wrong answers in ten (or 20 °/° of wrong and 80 °/° of right answers) as indicating the threshold of discrimination. The interval between the two points thus determined would of course be rather larger than that representing the theoretical threshold, but for comparative purposes this is no drawback. If in the series of ten double touches only one wrong answer was given I went on to the next step and usually found then a large proportion of wrong answers. The mean between the distances of the last two steps was then accepted as representing the threshold. The answers to the single touches were recorded, but the errors among them were used only as a rough guide and as confirmation of the conclusion drawn from the answers to the double touches. In almost every case there occurred several wrong answers to the single touch at the stage immediately preceding that at which wrong answers to the double touches first appeared. The record was kept in this form.

Distance between 2 points...	30 mm.	20 mm.	15 mm.	10 mm.	7 mm.
Single touches..................	— = —	= =	— × — —	— × = × — =	= = × — ×
Double touches	— =	— ≡ —	— — —	— — × — = —	= × — = × ≡

The simple stroke denotes a right answer, the cross a wrong answer. The order of succession is from above downwards in each vertical column. In order to keep the interest and attention of the subject as keen as possible, I found it necessary to tell him after each answer whether he was right or wrong, for in default of this precaution many of the subjects soon contented themselves with random answers.

It will be seen that this procedure is a combination of the method of minimal changes with the method of right and wrong answers. It is I think the best that can be devised for the purpose of obtaining a general view of the delicacy of tactile discrimination in a group or class of people.

In the earlier cases I investigated by this method the tactile discrimination of the skin of the forearm, of the nape of the neck, of the palmar surface of the terminal phalanx of the thumb, and of the inner surface of the pulp of the second toe. But I soon found that the length of the procedure caused too great a strain on the patience of my subjects. I found too that it was undesirable to extend the observations on any subject over two or more sittings, because in any sitting subsequent to the first the interest of the subject was so far diminished as to make the results unreliable. I therefore confined my observations to the skin of the forearm and the nape of the neck. On the forearm the points were applied to the middle third of the anterior surface about its middle line. The line joining the two points was always parallel to the long axis of the forearm. On the nape of the neck the points were applied across the middle line about midway between the *vertebra prominens* and the roots of the hair.

Results.

The average thresholds for Murray Island men and boys (ages 10—14) determined in this way were as follows[1]:

Forearm.

Average of 50 men = 19·8 mm. (median = 20 mm., extremes 40 mm. and 2 mm.).
„ 25 boys = 14 mm. (median = 15 mm., extremes 25 mm. and 2 mm.).

Nape of neck.

Average of 21 men = 11·6 mm. (median = 10 mm., extremes 25 mm. and 2 mm.).
„ 18 boys = 9·8 mm. (median = 10 mm., extremes 20 mm. and 2 mm.)[2].

[1] The values for individual Murray Islanders determined in this and in the following investigations are appended in tabular form, see pp. 203, 201.

[2] With the instrument used it was not possible satisfactorily to apply the two points at an interval less than 2 mm., and in a very few cases the threshold was possibly less than 2 mm.

In order to have exactly comparable measurements in the case of Englishmen I made a similar series of determinations of this threshold by the same method on a number of Englishmen, mostly of the working classes[1], and found on the same area of the right forearm,

Average of 23 men = 44·6 mm. (median = 40 mm., extremes 90 mm. and 10 mm.),

and on the nape of the neck,

Average of 19 men = 20·8 mm. (median = 20 mm., extremes 35 mm. and 10 mm.).

Weber[2] gives 40·6 mm. as the average threshold of tactile discrimination on the forearms of European men and 54·1 mm. on the back of the neck. Landois[3] gives 45·1 mm. for the forearm and 54·1 mm. for the back of the neck of the adult European, and 33·8 mm. and 36·1 mm. as the thresholds on the same skin areas of European boys of twelve years of age. I have discovered only one other record of observations of this kind on a number of individuals of the coloured races[4], on negro children namely, but unfortunately there are given no such details of the method employed and of the skin areas tested as would make these available for comparison with my results.

Conclusions.

These figures indicate that in the skin areas tested the Murray Islanders have a threshold of tactile discrimination of which the value, in terms of distance of two points touched, is just about one-half that of Englishmen, or we may say in other words, that their power of tactile discrimination is about double that of Englishmen. And since the values of the thresholds found for four different skin areas in 12 persons and in two different areas in 58 persons are in a fairly constant proportion to one another, we may assume that this result is true for all or most parts of the skin. It is noteworthy that, while among 23 Englishmen only three gave thresholds for the skin of the forearm of less than 30 mm. (namely 25, 15, and 10 mm. respectively), among 50 Murray men 7 gave thresholds of less than 10 mm. (namely in 2 cases 7 mm., in 2 cases 4 mm., in 1 case 3 mm., and in 2 cases 2 mm.). It is perhaps well to add that the two Murray men who gave the extraordinarily low threshold of 2 mm. on the forearm, were tested with especial care and neither of them returned a single wrong answer in a series of 10 touches with two points at distance 2 mm. and with corresponding number of single touches, so that in both cases the threshold was really less than 2 mm. Two boys who gave the same low threshold of 2 mm. on the forearm were also tested with especial care.

[1] Among the Englishmen were five of the educated class, and these gave a rather higher average threshold than the rest, who were all of the lower class. The latter were all inmates of the Cheadle convalescent home, and since I chose for my experiments only those who had as nearly as possible regained their normal health and had been surgical patients they may be regarded as fairly representative of the uneducated class of Englishmen. I am much indebted to Dr Compton, who was resident medical officer of the home at the time my observations were made and who most courteously and willingly gave me every kind of assistance that was necessary.

[2] Wagner's *Handwörterbuch*. Braunschweig, Bd. III. S. 540.

[3] Landois and Stirling. *Textbook of Physiology*, 4th Ed., p. 1020.

[4] A. MacDonald, *Journ. Amer. Med. Assoc.*, Chicago, 1899.

It should be noted that the skin of these islanders is of very fine glossy texture save in the case of those afflicted with *Tinea imbricata*, a kind of ringworm that is very common in the islands.

The conclusion that this delicacy of tactile discrimination constitutes a racial characteristic receives some support from the results of similar measurements made upon the same skin area of the right forearms of 10 Sea-Dayaks or Ibans of Sarawak[1]. In them the average threshold of tactile discrimination was 35 mm. and the individual thresholds ranged from 20 mm. to 50 mm. Although the number of these cases is so small, the difference between these Dayaks and the Murray Islanders in this respect is too marked to be due to chance, for even if we take the 10 Murray men of highest threshold, their average is yet lower than that of the 10 Dayaks. These few cases will therefore suffice to allay any suspicion that the difference between the Murray men and Englishmen might be due to the more habitual covering of the skin among the latter.

2. LOCALIZATION OF POINT OF SKIN TOUCHED.

In 20 individuals I investigated the power of localization of a point on the skin lightly and momentarily touched. The subject sat holding in his right hand a light pointed rod about the size of a lead pencil, and while his right hand rested on his right knee and his eyes were closed I lightly touched with a similar bluntly pointed rod the skin of the front of his left forearm resting with palmar surface upwards on his left knee. The subject was instructed to open his eyes after feeling the touch and to put his pointer as nearly as possible upon the point of skin touched. The two points were marked down on a rough sketch of the forearm and joined by a line. This was repeated thirty times, in some cases oftener. In this way I obtained a chart of the errors of localization on the forearm of each subject. The results present no points of especial interest and do not readily lend themselves to tabular statement. There was in nearly all cases a very marked tendency for the errors to fall into groups of similar direction of error. But these groups and the directions of errors were very varied and I fail to discover any common tendency in the different cases, save that in all the errors were preponderantly in the direction of the long axis of the arm, either upward or downward, and in most the accuracy was greatest in the region just above the wrist. There was no certainly recognizable correlation between the accuracy of tactile localization and the delicacy of tactile discrimination, such as I had expected to find.

[1] Owing to the difficulties of the language and a variety of other adverse circumstances it was found impossible to make any large series of measurements of this kind on the natives of Sarawak, where, after leaving Torres Straits, several members of our expedition visited Dr Hose, the Resident of the Baram district of Sarawak. I therefore include in this report the few results of this kind obtained.

3. TEMPERATURE SPOTS.

It was a matter of the greatest difficulty to secure an accurate chart of temperature spots in the skin, because any marks that I could make on the skin without injury to it were apt to be washed away by frequent sea-bathing before the individual could be secured again for another working-over of the same skin-area. I managed to map out satisfactorily the cold spots in four individuals over an area of four square centimetres. Their distribution and their mode of response presented no peculiar features, and the spots seemed entirely similar in every way to those of English subjects.

4. SENSIBILITY TO PAIN.

In view of the oft-repeated statement that savages in general are less susceptible to pain than white men, it seemed a matter of some interest to obtain a measure of the threshold of sensibility to pain. I used for the purpose the instrument devised by Prof. Cattell, and known as the algometer. It consists of an ebonite rod 9 mm. in diameter, with smooth, somewhat flattened, hemispherical head, which slides within a large ebonite rod against the resistance of a spiral spring. The larger rod is grasped by the operator, and the end of the smaller rod applied perpendicularly to the skin and a steadily increasing pressure made until the subject cries "Stop." A brass pin, projecting from the smaller rod, pushes an index up a scale which is attached to the larger rod and graduated in kilograms. The degree of pressure exerted can then be read from the index after removing the instrument from the skin. I instructed my subjects to cry "Stop" at the moment that they began to feel any pain, but I found that in nearly all cases it was possible to detect the moment of onset of pain by observing the slight flinching which it commonly causes in the expectant subject. The onset is a perfectly sharp and definite change in the sensation.

In choosing areas for application of the algometer it seemed desirable to avoid those in which trunks and branches of nerves traverse the tissues underlying the skin, as the presence of these might irregularly affect the results. It was also clearly necessary to avoid repeating the pressure upon one spot, because a single application of the algometer suffices to lower the threshold for pain at the spot, probably through the marked hyperæmia of the tissues which it induces. I therefore made a single application to the nail of either thumb, of either forefinger, and of either great-toe, and to the skin of the small hollow just above the patella of either knee (the leg being at right angles to the thigh), and two applications to the forehead on adjoining spots in the middle line just above the glabella and two to the sternum in the middle line. It soon appeared that there was a fairly close correspondence between the degrees of sensitivity of these different areas in each individual, and the application was therefore confined in the later cases to the nails of the thumbs and forefingers and to the forehead. The figures found for either of the symmetrical areas and for the two applications to the forehead were in nearly all cases approximately equal, and this equality afforded a guarantee of the accuracy of the procedure. When the two figures were unequal their mean was taken to represent the value of the threshold.

The average of the results in terms of kilograms of pressure are:

for 47 Murray men,

thumb-nails 6·7 kilo. (median 6·2)
forefinger-nail 5·5 kilo. (median 5·5)
forehead, (23 cases) 6·2 kilo. (median 5·5);

for 18 Murray boys (ages 10 to 14 years),

thumb-nails 3·8 kilo.
forefinger-nails 3·3 kilo.

I put here for comparison with these figures the corresponding figures found by exactly similar procedure in the same English subjects as were mentioned in the preceding section on æsthesimetry.

Average of thresholds of 23 Englishmen,

thumb-nails 3·8 kilo.
forefinger-nails 3·6 kilo.
forehead 3·8 kilo.;

and of 5 English boys (ages 13—14),

thumb-nails 2·9 kilo.
forefinger-nails 2·4 kilo.

I add the average of similar measurements on five Dayaks,

thumb-nail 4·5 kilo.
forefinger-nail 3·9 kilo.

It is interesting to note that in this respect the Dayaks stand between the Murray Islanders and the Englishmen, and nearer to the latter, just as they do in respect of the delicacy of tactile discrimination.

Comparing Murray men with Englishmen, we see that, while their average threshold of tactile discrimination is only about half as high, their average threshold for skin-pain (produced by pressure) is nearly double that of the Englishmen; or expressing the difference in other words and more loosely, we may say of these Murray men that their sense of touch is twice as delicate as that of Englishmen, while their susceptibility to pain is hardly half as great.

VI. MUSCULAR SENSE.

By W. McDOUGALL.

1. THE DISCRIMINATION OF SMALL DIFFERENCES OF WEIGHT.

To determine the threshold for discrimination of weights it was again necessary to devise a method which, proceeding as completely as possible without knowledge on the part of the subject, should lead as rapidly as possible to a rough estimate of the value of the threshold. After some trials I adopted a procedure, closely resembling that followed in the determination of the threshold of tactile discrimination, and constituting a combination of the method of minimal changes with that of right and wrong cases. The weights used were eleven cylindrical tins, each 7 cms. in diameter and 11 cms. in height. They were nearly filled with dry sand, and then by adding shot they were graduated to form a series of weights ranging from 800 grams to 900 grams by steps of 10 grams. The subject sat comfortably in a chair, and the weights were placed on a box at his right side at such a height and distance that they were a little in front of his right hand when the right arm was allowed to hang at its natural angle of rest. The tins were presented in pairs, side by side, upon the box, and the subject was told to lift both in turn to a height of about 6 inches, and to say which was the heavier He was allowed to lift the two tins in either order, either heavier or lighter first, because when he was made to lift them always in the same order he soon discovered the fact and his judgment was then biassed, or at least an undesirable complication of his mental process was introduced. Any constant errors due to disposition in time and place were thus not eliminated, as that seemed impossible without making a longer series of experiments than the subject's limited stock of patience and interest would permit. A few trials shewed that it was impossible to make a subject give more than about thirty judgments without disturbance of the results through fatigue and loss of interest.

If the subject could express no judgment of the relative weights after once lifting both tins he was asked to lift them both once more. Pairs of such a difference as was easily discriminated were first presented several times, generally pairs differing by 60 grams. Then pairs of less and less difference successively. At each step in this series of diminishing difference, pairs of weights of the same difference were presented until three right answers had been returned without error. Here again it was necessary to choose some proportion of right to wrong answers as indicating the threshold of discrimination. But it would have been unwise to fix this proportion rigidly. To choose that difference which evokes a series of right answers with no error would be to make too high an estimate of the threshold in many cases, to choose that difference which evokes as many wrong as right answers would be to estimate it too low.

I therefore, after some experience, worked according to this arbitrary scale. A difference evoking five right and one wrong answer was held to be a difference above the threshold, *i.e.* greater than the least perceptible difference, and I proceeded to present pairs of weights of one degree less difference. Five right and two wrong answers were held to indicate the threshold, and if the proportion of wrong answers was larger than this, this difference was held to be below the threshold, and the mean of this difference and that of the preceding step was chosen to represent the value of the threshold. The cases in which the subject judged the weights to be equal or gave the answer 'uncertain' or 'don't know' were very few, and were reckoned as wrong answers. The answer generally took the form 'This one heavy,' the subject pointing to one of the two tins. The number of right and wrong answers at any one step was of course too few to give a reliable indication, but in conjunction with the answers at the preceding steps they admit, I think, of a rough but reliable estimation of the least perceptible difference. Some guidance as to the reliability of the result was obtained by carefully watching the behaviour of the subject. Thus, if at any time he was obviously careless, or if his attention was for the moment distracted in any degree, the result of that observation was recorded but was not allowed full weight, and the series was prolonged.

I transcribe the record of one subject to illustrate the mode of procedure.

difference = 60 grms.	900 – 840 *r*
	860 – 800 *r*
	880 – 820 *r*
difference = 50 grms.	890 – 840 *r*
	870 – 820 *r*
	880 – 830 *r*
difference = 40 grms.	860 – 820 *r*
	880 – 840 *r*
	840 – 800 ×
	890 – 850 *r*
	880 – 840 *r*
	900 – 860 *r*
difference = 30 grms.	830 – 800 *r*
	870 – 840 ×
	900 – 870 *r*
	860 – 830 *r*
	830 – 800 *r*
	880 – 850 *r*

difference = 20 grms.	870 – 850 ×
	850 – 830 *r*
	830 – 810 *r*
	820 – 800 ×
	860 – 840 *r*
	880 – 860 *r*
	900 – 880 *r*

difference = 10 grms.	880 – 890 ×
	880 – 870 *r*
	850 – 860 *r*
	850 – 840 ×
	830 – 820 *r*
	870 – 860 ×

In this case 20 grms. was taken as the measure of the least perceptible difference.

Of 19 boys and 45 men the average least perceptible difference was almost exactly the same in the two groups. I therefore put them together and give the average least perceptible difference of 64 Murray Islanders, namely 27·2 grms. (median 25 grms., extremes 10 and 55 grms.). If then we take 850 grms. as the mean value of the weights compared, the average least perceptible difference equals 3·2 °/₀ of the total weight.

For comparison with this result I give the corresponding average least perceptible difference of 30 Englishmen, namely 33·3 grms. (median 35 grms., extremes 10 and 50 grms.) which is 3·9 °/₀ of the total weight. The power of discrimination of small differences of weight appears therefore to be rather more delicate in the Murray Islanders than in Englishmen, and this may seem a somewhat surprising result in face of the fact that the Murray men were asked to make a judgment of a kind with which they are totally unfamiliar, so much so that they lack any word to express the abstract idea of weight. In spite of this they all seemed to grasp very readily the nature of the task that was set them and, with few exceptions, to make the comparisons attentively and with confident judgment.

2. THE DEGREE OF THE 'SIZE-WEIGHT ILLUSION.'

To obtain an estimate of the degree of the 'size-weight illusion' producible in these people I took a set of cylindrical tins 7 cms. in diameter and 11 cms. in height. These were partially filled with sand to form a series of weights ranging from 32 ozs. downwards by steps of 2 ozs. A larger cylindrical tin 10 cms. in diameter and 16 cms. in height was partially filled with sand until its weight equalled 32 ozs. The large tin of 32 ozs. and the small tin of the same weight were then presented to the subject as in the preceding series of experiments on weight discrimination. The subject was instructed to grasp either tin in turn so that the cylindrical surface rested against the palm of his hand, and to raise it about six inches, and then to say which was the heavier. Every subject pointed to the smaller tin as the heavier without hesitation. The large tin and the small tin of 30 ozs. were then presented in similar fashion; and so the large tin was presented successively with each of the smaller tins in the descending order of weight of the latter, until the subject ceased to call the smaller one the heavier, *i.e.* either judged them to be equal or the smaller to be lighter, or was undecided. When the subject pronounced the smaller tin to be equal to the larger or was undecided, the difference of weight between the large tin and that smaller one was taken as measure of the extent of the illusion produced in him. When the subject pronounced one small tin to be heavier than the large tin and the small tin next in descending order to be lighter, the mean of the weights of these two small tins was subtracted from that of the large tin and the difference was taken as the measure of the extent of illusion. The subject was not made aware of his error or of the tendency to overestimate the smaller tin, and was at once put through a series of tests entirely similar to the last, save that he was required to lift the tins in all cases by means of a loop of string passed over the palmar surface of the joint of the forefinger between the second and third phalanges. A second measure of the degree of illusion was thus obtained under conditions which allowed the subject to appreciate the difference of size of the tins through the eye only, whereas in the previous series he was made aware of the difference of size both through the kinæsthetic and the visual senses. The results of the two series corresponded closely in nearly all cases, but in just half the cases the illusion was rather greater when the size was appreciated both by sight and by grasp than when by sight alone, which tendency appears clearly in the average of the results of 36 Murray men:—

The larger tin of 32 ozs. was judged on the average of these 36 cases to be equal in weight to a smaller tin of 23·5 ozs., when lifted by grasping, and to be equal to a tin of 24·4 ozs. when both were lifted by string only.

The measure of the illusion in the former case is then 8·5 ozs. (median 8 ozs., extremes 15 ozs. and 1 oz.) which equals 26·5 % of the weight of the larger tin, and in the latter case 7·6 ozs. (median 7 ozs., extremes 15 ozs. and 1 oz.) which equals 23·7 % of weight of the larger tin.

24 Murray boys tested in the same way shewed an average illusion of 27 % and 23·1 % in lifting by grasp and by string respectively.

It was of some interest to compare the behaviour of women in this respect with that of the men and I therefore managed to test 13 Murray women and girls in this way and found the average degree of illusion to be 32·2 % and 28 % by the two methods respectively.

Of 20 English men tested under similar conditions by the grasp-method alone the average illusion was 15 %. The illusion affected the judgment of weight of the Murray men almost twice the amount that it affected that of the English men, and the Murray women shewed themselves still more markedly subject to it.

I made this series of observations on the degree of the 'size-weight illusion' in the belief that the degree of the illusion produced might be regarded as in some sense a measure of the degree to which the individuals tested are subject to the influence of suggestion. But, since becoming familiar with the Müller-Schumann theory[1] of the process of discrimination of differences of weight, I have realised that the size-weight illusion effect is more complex than I had supposed. If we accept, as we must, this theory, we have to believe that, in comparing, by successively lifting, two objects, that appear of equal size and weight to the eye, equally strong impulses are given to the muscles concerned in the two efforts, without deliberate adjustment but by a reflex or automatic process; and that when we perceive by any means inequality in the mechanical effects[2] produced in the two objects, we infer inequality of their weights, that object being judged the lighter in which the greatest mechanical effects are produced. When, then, one of two equal weights appears the larger to the eye and to the grasp, it determines, without the subject being conscious of the fact, a stronger motor impulse to the muscles concerned; and the mechanical effects produced upon the larger object are therefore greater and the subject judges it to be the lighter weight. We must assume then that with a given difference in size of the two objects a certain degree of illusion as to their relative weights is normal, and the greater degree of the weight-illusion might be held to imply merely a larger estimate of the difference in size of the two objects. But I think we must believe that there is at work also a suggestibility of a more complex kind corresponding to the general suggestibility of the subject, for without this assumption it seems impossible to account for the marked differences in the degree of illusion in the three classes of subjects, English men, Murray men, and Murray women; for the Murray men, although they exhibit a greater nicety in the discrimination of small differences of weight, are yet subject to the size-weight illusion to a very much greater degree than the English men.

[1] G. E. Müller u. Fr. Schumann, "Ueber die psychologischen Grundlagen der Vergleichung gehobener Gewichte." *Pflüger's Arch.* Bd. XLV. 1889.

[2] Differences of rate or height of movement, or of the duration of the period of latency before actual movement follows the beginning of the effort, seem to be the principal differences of the mechanical effects on which the judgment of difference of weight is commonly based.

VII. VARIATIONS OF BLOOD-PRESSURE.

By W. McDOUGALL.

I EXAMINED in a number of natives the state of the arterial blood-pressure during rest and during physical and mental exertion and in a few cases during a slightly painful sensory stimulation. My leading idea was to discover, if possible, some correlation between the activity of mental processes and the response of the blood-pressure. For, since the effective working of the brain is so intimately dependent on a rapid circulation of the blood through it, and since that circulation is so largely determined by the state of the arterial pressure throughout the body, the power of mental activity to raise the general blood-pressure must be of great importance in promoting the vigour and effectiveness of mental processes. And it may be that this power is an element of fundamental importance in determining the superiority of the higher races. It has been frequently asserted that the inferiority of the black races is due to the cessation of the growth of the brain at an earlier age than in the white races, and it may be that this is in part, or wholly, due to a less active response of the blood-pressure to mental activity. I may say at once that I did not succeed in discovering any evidence to this effect. Nevertheless it may be worth while to make a brief report of my observations.

I used the Hill-Barnard sphygmometer, applying the pressure-band to the left upper-arm of the men and to the left thigh of the boys. The principle of the instrument is as follows:—A rubber bag is placed round the limb and lightly compressed by a broad leather band buckled over it. A rubber tube leads from the bag to a manometer, and when air is pumped into the system the pressure within it is indicated by a needle travelling over the face of the dial of the manometer. When the air-pressure within the system is approximately equal to the blood-pressure within the main artery of the limb the needle oscillates with each pulse-beat, and the oscillations are largest when the pressures in the two systems are equal. It is not easy to make an exact determination at any given moment and it is therefore necessary to repeat the readings as often as possible under any given set of conditions and to take the mean of them.

The subject sat at a table with his left arm resting on the table and his right arm free to execute any given task. After adjusting the instrument I engaged the subject in conversation for some minutes in order to allow any exciting effect of the application of the band to his arm to subside. A series of some five to ten readings was then taken of the blood-pressure during rest. The subject was then told to squeeze with his right hand a dynamometer up to a point equal to about 50 % of his maximal squeeze, previously determined, and to maintain the squeeze until told to let go. The reading was taken between 15 and 20 seconds after the beginning of the squeeze, and this was repeated as often as seemed necessary to obtain a satisfactory mean record, generally four or five times. Then, while the subject rested, another series of about five readings was taken, during which time the blood-pressure returned to normal. He was then made to do some mental work. For this purpose various expedients were tried, but I found that the most satisfactory was to set the subject to find his way into the centre of a maze drawn on a card, by tracing the open paths with a pencil in his right hand. Most of the subjects became very keen on accomplishing this feat and continued to apply themselves steadily to it for a period which often exceeded ten minutes or a quarter of an hour. While this was in progress a series of readings of the blood-pressure was made at intervals of one minute, or rather oftener, and was continued for some minutes after the subject desisted from his attempts. In some cases the algometer was then applied to the hypothenar eminence with sufficient pressure to be slightly painful, and readings were taken as nearly as possible 15 seconds after the beginning of each application of the algometer. During the squeeze and during the application of the algometer the blood-pressure begins at once, and continues, to rise markedly while they are continued. The mean of the records, taken as nearly as possible 15 seconds after the beginning of the squeeze or the pressure, was therefore taken to represent the rise of blood-pressure due to physical exertion and painful impression respectively. During mental work the blood-pressure rose only slowly and usually did not reach its highest point until after from 5 to 10 minutes of work. But as the work was not continued in all cases for so many minutes, the mean of readings taken after the first 2 minutes of work was taken to represent the rise due to mental work.

In 26 Murray men I found in this way an average rise of blood-pressure in the brachial artery equal to 16·5 mm. of mercury during muscular work, 6·6 mm. of mercury during mental work (24 cases), 11 mm. of mercury during slightly painful stimulation (14 cases). In 11 Murray boys the corresponding averages were 23 mm. and 11 mm. of rise of blood-pressure in the femoral artery during muscular and mental work respectively[1]. In 16 English men the corresponding averages were 25 mm. and 13 mm. of rise of blood-pressure during muscular and mental work respectively[2].

I would attach no certain significance to this difference between the English men and Murray men in this respect. The difference is too small, the numbers of individuals too few and the difficulty of the observations too great to allow us to regard the figures as more than a suggestion of a possible difference as regards this very important physiological reaction in the two classes.

In view of possible correlations that may be drawn between the various functions of individuals I append in tabular form the names of the Murray men and boys, with the figure found for each individual by the procedures described above under the headings touch and weight discrimination, sensitivity to pain, size-weight illusion and blood-pressure.

In the 1st and 2nd columns of the table the figures indicate the threshold of discrimination of two points touched on the skin in terms of the number of millimetres separating the two points. In the 3rd, 4th and 5th columns the figures indicate the values of the threshold for pain in terms of kilograms of pressure exerted through the algometer. In the 6th column the figures denote the least perceptible difference of weight in grams between weights of approximately 850 grms. In the 7th and 8th columns the figures denote the number of ounces that the larger weight of 32 ozs. was underestimated in comparison of it with weights of smaller volume. In the 9th, 10th and 11th columns the figures denote the mean blood-pressure and the mean rise of blood-pressure in terms of millimetres of mercury in the brachial artery of the men and the femoral artery of the boys.

[1] In the brachial artery of the Murray men the average blood-pressure during rest was equal to 98 mm. of mercury (extremes 85 mm. and 122 mm.); in the femoral artery of the boys it was equal to 138 mm. (extremes 120 mm. and 165 mm.).

[2] Similar observations made on 14 Sea-Dayak men of Sarawak gave an average blood-pressure in the brachial artery during rest equal to 102 mm. and an average rise during muscular and mental work of 17 mm. and 7 mm. respectively.

Adults	Æsthesiometer: Forearm	Æsthesiometer: Nape	Algometer: Forehead	Algometer: Thumb-nail	Algometer: Finger-nail	Weight: Discrimination	Weight: Illusion: Grasp	Weight: Illusion: String	Blood-pressure: Rest	Blood-pressure: Muscular work	Blood-pressure: Mental work
Alo	35	...	...	5·5	4·6	15	...	...	107	14	2
Barsa	25	...	...	5	5	15	11	10	...	...	...
Babelu	25	...	...	6·6	5·5	15	5	5	...	...	...
Bemop	15	...	...	15	12	50	...	...	...	...	...
Beni	7	...	8·5	11	6	20	1	3	...	...	...
Berò	30	...	8	5·5	4·7	35	12	11	85	12	...
Billy Gasu	25	...	...	4·6	3·9	...	...	...	...	...	...
Billy Kuris	15	8	...	...	...	35	9	7	...	...	...
Boa	30	...	...	4	5·5	20	...	...	...	...	...
Broga [Fly River]	15	7	...	...	...	...	12	8	...	...	...
Canoe	15	...	...	5	3·5	20	...	...	...	...	...
Capsize	25	...	...	10	7	35	11	9	104	29	20
Charlie Boro	20	12	6	7	6·6	15	11	7	100	9	3
Charlie (Pasi)	...	...	...	7·6	7	20	7	5	98	11	6
Damper	15	...	...	10·5	9·8	15	7	7	..	...	...
Dauai	...	...	...	...	...	50	9	9	98	11	...
Dawita (junior)	4	...	...	...	...	15	...	...	...	...	...
Dawita (senior)	...	...	3	4	3·8	35	8	8	85	25	10
Deboro	15	20	6·5	3·5	1·7	...	...	...	...	...	...
Debe Wali	15	3	...	5·5	3·7	20	...	...	80	5	6
Dela	7	20	...	...	...	...	...	...	...	...	...
Dick Tui	...	...	5	5	4·3	...	...	...	100	20	7
Dick (Dauai)	15	17	2·2	5·4	4·5	35	9	7	87	10	3
Dubwai	30	...	...	5	4	25	..	...	...	...	...
Giaz	4	...	7·5	11	7·5	40	...	...	98	9	2
Gizu	30	3	...	...	...	30	6	8	...	...	...
Groggy	25	...	...	4	4·5	35	7	15	...	...	...
Jimmy Dei	20	6	5·5	6·5	6	25	4	6	102	20	18
Jimmy Rice	10	10	...	5·2	4·5	20	7	5	95	1	6
Jimmy Wailu	...	...	9·4	5	4·5	...	6	6	85	25	...
Josiah	20	...	...	10	7·5	...	...	...	...	...	...
Kadub	10	...	3	4	4	35	...	...	97	7	4
Kaige	30	4	12·5	9	6	15	13	7	...	...	...
Kailu	40	20	5·5	4·2	4·2	...	...	...	...	...	...
Komaberi (senior)	...	...	...	...	...	10	...	...	...	...	...
Komaberi (junior)	15	20	3·2	6·5	3	20	9	7	100	14	9
Kaumi [New Guinea]	15	7	5·5	6	6	...	5	5	...	...	...
Kriba	25	...	...	4·5	4·6	25	7	7	...	...	...
Lui	30	...	...	8·4	7	15	7	5	...	...	...
Loko	3	5	3·9	3	3	25	5	1	99	18	4
Mabo	...	...	...	...	...	10	7	5	...	...	...
Madsa	25	10	6	6·2	5·6	40	...	...	76	22	6
Magi	30	25	6	3·8	3	...	10	10	...	...	...
Mamus	...	...	...	...	...	...	13	7	102	12	...
Meiti	2	15	...	...	...	...	8	7	...	...	...

ADULTS	Æsthesiometer		Algometer			Weight			Blood-pressure		
	Forearm	Nape	Forehead	Thumb-nail	Finger-nail	Discrimination	Illusion: Grasp	Illusion: String	Rest	Muscular work	Mental work
Modi	40	...	...	...	...	...	...	...	100	25	20
Oroto	...	...	4·5	8	6·5	30	...	...	122	16	5
Pasi	15	10	4·5	5	4	30	7	9	98	...	2
Poï	20	...	...	5·6	4·7	10	...	...	...	...	...
Sambo	20	...	11·5	6·5	5	35	...	...	...	...	...
Sisa	15	...	4	4·2	4·8	35	9	9	103	17	2
Smoke	15	...	...	7·6	6·6	15	9	7	95	34	4
Tapau	2	2	13	9·2	6·2	10	7	7	95	25	8
Tepem	15	...	...	5	5	25	...	...	...	...	...
Tibi	...	...	...	...	...	40	15	15	...	...	...
Ulai	20	...	...	6·5	4	20	9	8	98	12	3
Wanu	30	...	...	8	6	30	13	12	97	...	7
Wasalgi	10	...	...	12·5	9·5	25	11	11	85	25	2
Zarob	25	...	...	7	5·5	...	...	...	...	...	...
BOYS											
Abau	7	12	3·6	4	3	55	7	9	122	20	5
Apore	20	...	...	7	4·5	35	8	5	165	20	9
Biskak	2	10	...	...	...	30	5	5	...	...	...
Babelu	10	...	...	...	...	...	...	...	...	...	...
Captain	6	5	1·2	3	2	30	9	9	...	...	...
Charlie Ako	12	18	...	...	...	35	7	5	...	...	...
Dela	...	...	...	3·5	2·8	35	...	...	...	...	...
Depoma	15	15	...	...	...	...	13	15	...	...	...
Dick (Toik)	...	...	...	3·2	3	...	...	...	...	...	...
George (Pasi)	7	3	...	...	...	20	9	5	136	27	12
German	20	...	...	...	...	...	...	...	123	15	10
Jacob (Gabi)	15	10	3	4	3	...	11	5	...	...	...
Jacob (Sambo)	15	...	...	...	...	...	...	...	...	...	...
James	25	...	...	3·8	4	40	7	5	162	20	14
Jimmy Dauar	20	10	4·4	3·7	2·2	15	11	9	140	20	20
Jimmy Rice	...	...	...	...	...	10	8	7	115	25	10
Johnson	20	10	...	4·8	4·8	...	7	7	...	..	...
Harry	20	4	2	2·4	2·5	40	...	...	120	30	10
Loko	...	...	...	...	...	45	11	9	...	...	...
Manowar	10	12	...	5	4	15	9	7	...	...	...
Marau	15	7	...	3	3	...	9	9	120	42	3
Nanai	10	...	...	3	3	15	7	5	...	...	...
Poï (Pasi)	20	7	...	4·5	4·5	20	9	5	125	5	14
Sagigi	...	...	...	3·1	2·8	30	13	13	...	...	...
Sailor	8	13	...	...	...	...	7	7	...	...	...
Sam	15	3	...	...	...	...	...	...	...	...	...
Tom (Maboali)	15	...	...	4	4	25	...	...	...	...	...
Tom (Tanu)	15	7	7	4·4	3	30	8	10	124	30	15
William (Tat)	25	20	...	3·2	3·1	15	7	7	...	...	...

VIII. REACTION-TIMES.

By CHARLES S. MYERS.

THREE varieties of reaction-time were investigated in Murray Island; for brevity's sake they will be termed 'auditory,' 'visual,' and 'choice-visual' reaction-times, and the men examined will be termed the 'reagents.' The auditory and the visual were so-called simple reaction-times, measuring the rapidity with which the reagent responded to one given noise or to one given visual stimulus. The choice-visual were compound reaction-times, where one or other of two known colour-stimuli was presented and an appropriate movement had to be made according to the colour which appeared. Fifty-three Murray Islanders were examined[1]. The same set of apparatus was afterwards used in Sarawak and still later in England, in each case on twenty-six individuals. The reaction-times of five members of the expedition were determined in Murray Island and of two Englishmen in Sarawak.

APPARATUS.

The noise-stimulus of the auditory reactions was produced by the impact of a steel hammer against a steel foot, the former being drawn to the latter against the resistance of a spiral spring by means of an electro-magnet and thereby completing a second electric circuit, which was broken when the reagent lifted his finger from a Morse key. In order that it might sound with as nearly uniform intensity as possible throughout the experiments, the hammer was placed at a constant distance, above and behind the reagent, and the current to the electro-magnet was supplied from a minimal number of dry cells. The varying strength of the spiral spring, however, made it impossible to secure really absolute uniformity in the force of the impact.

The apparatus, which released the stimulus for the visual and choice-visual reactions, consisted of a large vertical screen, placed in the open air at a distance of about 35 metres from the subject and provided with a rectangular window, 20 × 5 centimetres. By electro-magnetic means a black board carrying a card, which was white in the case of the simple reaction, was held up from behind the top of the screen. In this position the white surface was just hidden from view and the window appeared to the reagent as black as the rest of the screen. When the board was released, it fell through a certain distance, so that the window was now occupied by a white surface. The reagent lifted his finger from a Morse key as soon as the white card became visible. For the choice-visual reactions, the same falling board was used, now carrying a card

[1] This number includes the two women and three girls, whose reaction-times are given in Table XXXIV, but who are nowhere further considered in this article.

which was covered on one surface with blue, and on the other with red paper. A second Morse key was introduced, working in a circuit alternative to that of the first. One key was depressed by a finger of the reagent's right hand, the other by a finger of his left. He was told to raise his right hand if red appeared in the window and to raise his left hand if blue appeared there. The window was temporarily covered by a piece of cloth, while the board was being replaced in a position ready to fall.

It was considered so improbable that the reaction-times of a primitive people like the Murray Islanders could be profitably investigated, that only the simplest and least costly registering apparatus was included in the psychological outfit of the expedition. Thus, in default of a chronoscope, the reaction-times were recorded by means of a simple time-marker and a Deprez' signal upon the smoked surface of a hand-rotated drum, the frame of which carried a knock-down key. The Deprez' signal was connected with an electrically driven tuning-fork which vibrated fifty times a second. During rotation of the drum the knock-down key led to the production of the appropriate sensory stimulus by breaking a pre-existing current. For the auditory reactions a simple apparatus, devised for us by Captain E. T. Dixon, was introduced, whereby the breaking of the current by the knock-down key served to complete another current which acted on the hammer. The time-marker registered (1) the impact of the hammer, or the release of the board from behind the screen, and (2) the reaction of the subject. In the case of the screen the moment when the board was released did not coincide with the moment when the white card appeared in the window. I found that the average time (latent period) taken for the board to fall completely, so that the whole of the window was occupied by the white card, was 108^{σ}; that the average time (nine trials) for the board to fall, so that half the area of the window was occupied by the white card, was 85^{σ} (m.v. = 3); and that for the lower edge of the card just to appear at the top of the window an average time (eight trials) of 41^{σ} (m.v. = 4) was necessary[1]. I have therefore always deducted 60^{σ} from the actual results, assuming that the card was visible to the reagent before, having completed its fall, it had occupied the whole of the window.

Experimental Methods.

The room in which the Murray Island reagent sat was separated by a small room from that containing the recording apparatus. In practically every set of auditory reactions an observer stood beside him, in order to watch if he were reacting properly and if he gave premature or erroneous reactions. In the visual and choice-reactions this observer stood in the open air behind the screen, in order to replace the card after every fall. From this position he could notice how the individual reacted in the simple visual reactions, and whether or not he reacted appropriately in the choice-visual reactions[2]. In the latter experiments, one had of course to be on one's guard that the subject was not trying to make out if the card was being reversed during replacement. Three individuals, whose behaviour in this respect was suspicious, were re-examined under conditions which made it absolutely impossible for

[1] All measurements in this section are expressed in σ, i.e., thousandths of a second.

[2] I am much indebted to Dr Rivers for his unfailing help in this direction.

them to detect the movements of the assistant at the screen, but the results of the second series were in every way consistent with their previous reactions. There can, indeed, be no doubt that in these, as in our other experiments, the islanders, as a rule, made no attempt to go beyond what they were told to do. They settled down at once to record their reaction-times in a straightforward manner.

I found no difficulty in explaining to the Murray Islanders the general bearing of reaction-time experiments. I pointed out that individuals must vary in the time taken to shoot at a suddenly appearing object after they had first observed it, and they seemed clearly to understand that I was somehow able to find out whether they were likely to be good or bad marksmen by studying the rapidity of their reactions. At the close of the experiment they would view the tracings with evident interest, and ask whether they had been quick or slow, occasionally enquiring how they compared with some other Murray Islander. There is, therefore, every reason to believe that the reagents, as a whole, were doing their best to produce their quickest reactions. Perhaps the least interest was shown by those who through slightly defective vision or hearing imagined that they would prove bad subjects for the experiment. But their results were apparently as reliable as those of the others.

Each individual was allowed to react in the way which seemed best to him. There was no attempt to turn his attention in the direction either of the stimulus or of the movement. The only care taken was that he did not press so heavily on the Morse key as thereby to retard his reaction-time materially. The key was placed on a low table before which the reagent sat. One finger, usually the index finger of the right hand, was placed comfortably on the key. A warning "Now!" from the room containing the registering apparatus prepared the subject for the reaction. After an interval, varying as nearly as possible between one and two seconds, the drum was rotated and the reaction-time recorded. The observer, who watched the movements of the reagent, was careful to notify anything abnormal in the reaction: this he communicated to me, who had charge of the registering apparatus. After every choice-reaction the observer, who now stood beside the screen, cried out, "right, blue," "wrong, red," thus naming the colour exposed and informing me whether the subject had reacted with the appropriate hand.

Every individual was allowed a few preliminary trial-reactions, the number of which depended on the speed with which he settled down to his task of giving a succession of seemingly reliable reactions. On an average, perhaps, six such reactions were given in each series. Even in the difficult choice-visual series they rarely, if ever, exceeded ten. All subsequent reactions, premature, normal and prolonged, were recorded, so far as was possible. Unfortunately, however, with such imperfect, clumsy apparatus as I had to work with, occasional breaks in the records were inevitable. Sometimes the markers had not been accurately brought to bear on the travelling surface, sometimes the tuning-fork was not vibrating as it should, or owing to inadequate magnetization the screen fell before the warning had been given. These and other mishaps made it impossible always to secure a really accurate, uninterrupted record of reactions. But throughout, the reactions that were not registered are so few that the omission can make no appreciable difference in the results.

The rapidity with which the reactions followed on one another at any one sitting varied with the kind of reaction. The auditory reactions could be repeated most quickly, about eight per minute. The visual reactions recurred rather more slowly, as the fallen card had each time to be carefully replaced. The interval between successive choice-visual reactions was so long (averaging nearly half a minute) that possibly the reagent formed some opinion meanwhile as to which of the two colours would next appear in the window.

These and other defects, however, operated to an equal extent in Sarawak and in England among the individuals there examined, with whom the Murray Islanders are to be compared.

Each sitting usually lasted between twenty and thirty minutes. Two kinds of reaction (the auditory and visual or the visual and choice-visual) were generally tried at one sitting. An interval of a few minutes was allowed, during which the necessary alterations in apparatus were made, and the reagent could rest himself before beginning a new kind of reaction. Most subjects made their first start with the auditory reactions. In the case of a few islanders experiments were limited to this mode of reaction. But in by far the majority the visual reaction-time was also determined, and this series of experiments followed on the auditory time-experiments. Some days or weeks later a second sitting was obtained, at which the choice-visual method was usually employed, followed often by a few simple visual reaction-times. Two or three series of auditory or visual reaction-times were obtained on different days from a few islanders. But only the first series of reaction-times are taken into account in the following pages, save where the influence of practice and fatigue is being considered.

Arrangement of the Data.

The task of presenting the experimental results of reaction-times concisely and at the same time satisfactorily is indeed a difficult one. Nearly every worker at the subject has elaborated his own method, so that his data, while comparable *inter se*, are incomparable with those obtained by other workers.

The chief difficulty lies in the fact that, when observations are made on imperfectly trained individuals, they are sure to contain a few values which in one or other direction differ very widely from the mean. Such values, if very low, may be premature reactions, or they may be false reactions where the individual reacts to a stimulus which he has mistaken for the proper stimulus. The very high values are usually due to lapses of attention; but, in my Torres Straits experiments, at least, they arose occasionally from undetected premature reactions, after which the individual had so little time to readjust his finger before the proper stimulus was presented that his reaction to the latter was delayed.

It is needless to point out that these well-known aberrant values affect the mean reaction-time very considerably. We may escape easily enough from the difficulty of dealing with them, if we accept the view that sporadic experiments, made upon this or that person, who is devoid of experimental training and unlearned in methodical introspection, are valueless. But one of the aims of this section is to prove that such experiments are very far from being unprofitable. We note that some workers[1], by bringing the reagent's introspective observations into relation with his time-records, have attempted to solve the difficulty in this way. But introspection is all but impossible in the case of a primitive people. Others, after having taken the average, have excluded that value which deviated most from that average and, after taking a fresh average, have in similar fashion ruled out the next most aberrant value, the process being repeated several times[2]. Most workers, however, pass over their method of treating the aberrant reactions of the insufficiently practised in silence.

There are two reasons, at least, which make it difficult or inadvisable to separate aberrant reactions from the rest. In the first place, it is impossible to fix any but the widest limits, applicable to all individuals, of which it can be said that only those reactions are to be accepted as true which fall within them. Secondly, the elimination of aberrant reactions is (or, at least, always has been) tantamount to their neglect. Now these fluctuations are one of the most interesting features of reaction-times. *A priori*, it is highly improbable that the average minimal (*quasi*-automatic) reaction-time, if only the reagent be adequately practised, differs widely in different communities. On the other hand, in a comparative psychological study of peoples or of individuals, the extent and meaning of the variations from the average are obviously well worth an attempted investigation.

Accordingly in Table XXXIV. *no recorded reaction-time has been omitted*, the aberrant reactions being invariably included with the rest. But some idea of their frequency may be gained by an inspection of the columns headed *Abn*. The unduly shortened reactions are denoted by the letter α, the unduly prolonged by β: the figure following α or β gives the number of such reactions. I have already alluded to the impossibility of having fixed values for α and β, unless the value of α be so low, and that of β be so high, that they are likely to suit the needs of practically every individual. I have therefore arbitrarily fixed the limits of α and β respectively at 70^σ and 300^σ for auditory, at 120^σ and 350^σ for visual, and at 250^σ and 850^σ for choice-visual reactions. In many individuals, of course, an auditory reaction-time of 90^σ may really be premature, or a visual reaction-time of 280^σ may be unduly prolonged. Nevertheless the number of α and β reactions will afford a fair guide to the frequency of aberrant reactions.

In the same tables two sets of figures will be found for every reaction. In the auditory and visual reactions the first set contains the *average* of the first ten reaction-times, the second set contains the *median* of all the reaction-times obtained at one sitting[3]. The figures in the column next to that marked *median* indicate the *number* of such reactions from which the median was obtained.

It seemed worth while to record the average of the first ten observations because several previous workers have adopted this procedure. Nevertheless, it must be remembered that such an average reaction-time is in reality a very poor indication of the true

[1] Cf. S. Exner, *Arch. f. d. ges. Physiol.* 1873, Bd. VII. S. 644 ff.; G. Martius, *Phil. Stud.*, Leipzig, 1891, Bd. VI. S. 199; G. Dwelshauvers, *ibid.* S. 222.

[2] J. McK. Cattell, *Phil. Stud.* 1886, Bd. III. S. 317, 318; L. Witmer (*Proc. Amer. Psychol. Ass.*, 1893, p. 7) adopts a similar plan.

[3] In a few cases, where less than ten reactions were obtained at one sitting, the average of the total is substituted for that of the first ten.

TABLE XXXIV.

Name	Age	Auditory									Visual									Choice-visual							
		Series	Av. of 10	m. v.	v. c.	Abn.	Median	of	m. v. q.	Abn.	Series	Av. of 10	m. v.	v. c.	Abn.	Median	of	m. v. q.	Abn.	Series	Av. of 10	m. v.	v. c.	Abn.	Median	of	Abn.
MEN																											
Mamus	60	1, i.	147·0	7·0	5	...	145·0	17	7·5	...	1, ii.	271·0	26·4	10	β_1	255·0	17	35·0	β_1	...	...	...	...	...	...	...	...
,, ...	,,	...	...	...	...	...	...	...	...	...	2, ii.	280·5	77·3	28	β_1	235·0	9	51·25	β_1	2, i.	466·5	67·8	15	...	455·0	31	...
Azò	55–60	1, i.	196·0	28·0	14	...	200·0	15	17·5	...	1, ii.	204·0	28·8	14	...	195·0	16	27·5	β_1	...	...	...	...	...	...	...	...
Dauai	,,	1	316·0	39·2	12	β	300·0	16	43·75	β_9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Lui...........	,,	1	467·0	97·6	21	β_9	470·0	21	93·75	β_{18}	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Ulai	,,	1, i.	140·5	28·3	20	α_1	152·5	15	13·75	α_1	1, ii.	290·5	44·6	15	β_1	260·0	15	32·5	β_1	...	...	...	...	...	...	...	...
,, ...	,,	2, ii.	162·5	16·0	10	...	160·0	11	12·5	...	2, i.	257·5	18·0	7	...	252·5	18	20·0	β_1	...	...	...	...	...	...	...	...
,, ...	,,	...	...	...	...	...	...	...	...	...	3, ii.	280·0	25·0	9	...	275·0	4	25·0	...	3, i.	491·0	79·2	16	...	490·0	37	β_1
Wanu	,,	1	182·0	29·2	16	...	160·0	30	15·0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, ...	,,	2, ii.	143·0	17·6	12	...	135·0	5	20·0	...	2, i.	200·0	14·0	7	...	200·0	16	16·75	...	...	...	...	...	...	...	...	...
,, ...	,,	...	...	...	...	...	...	...	...	...	3, ii.	287·5	37·6	13	β_1	280·0	6	32·5	β_1	3, i.	565·0	127·0	22	β_1	610·0	15	$\alpha_1\beta_2$
Alo	50	1	141·0	19·2	14	...	142·5	32	17·75	α_1	2, ii.	315·0	37·8	12	β_1	300·0	9	12·5	β_1	2, i.	572·2	57·5	10	...	550·0	23	β_3
Canoe	45–50	1	130·5	24·5	19	...	130·0	10	22·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, ...	,,	2, ii.	100·5	54·3	54	α_3	115·0	12	35·5	α_3	2, i.	161·5	88·4	55	α_2	185·0	25	17·5	α_2	3	?	?	?	?	?	?	?
Jimmy Dei	,,	1	129·0	22·0	18	...	132·5	30	20·0	...	2	216·0	11·0	5	...	220·0	14	15·0	...	...	...	...	...	...	...	...	...
,, ...	,,	...	...	...	...	...	...	...	...	...	3, ii.	310·0	18·75	6	...	312·0	8	16·25	...	3, i.	548·0	118·0	21	β_1	545·0	24	β_2
Sisa	45	1, ii.	82·5	73·6	90	α_5	115·0	16	52·5	α_7	1, i.	562·0	135·2	24	β_8	585·0	18	190·0	$\alpha_1\beta_{10}$	...	...	...	...	...	...	...	...
Wasalgi...........	,,	2	107·5	24·5	23	α_1	120·0	27	12·5	α_3	1, i.	197·5	15·5	8	...	195·0	21	16·25	...	...	...	...	...	...	...	...	...
Baton	40–45	1	146·0	22·0	15	...	135·0	27	17·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Capsize...........	,,	1, i.	245·5	31·6	13	β_1	250·0	14	27·5	β_2	1, ii.	211·0	35·7	17	...	195·0	9	38·75	...	...	...	...	...	...	...	...	...
,, ...	,,	2, i.	183·0	81·6	45	$\alpha_2\beta_2$	225·0	19	52·5	$\alpha_2\beta_4$	2, ii.	377·0	73·6	20	β_3	380·0	5	91·25	β_3	3	620·0	60·0	10	...	630·0	26	...
Pasi	,,	1	109·5	12·5	11	...	105·0	23	12·5	α_1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, ...	,,	2, ii.	108·5	12·8	12	...	110·0	10	7·5	...	2, i.	214·5	21·4	10	...	217·0	16	18·75	...	...	...	...	...	...	...	...	...
,, ...	,,	...	...	...	...	...	...	...	...	...	3, ii.	233·5	26·2	11	...	220·0	11	17·5	...	3, i.	416·3	34·7	8	...	432·5	24	...
Magi	40	1, ii.	113·5	45·4	40	α_2	115·0	16	33·75	α_4	1, i.	224·0	13·2	6	...	227·5	10	17·5	...	...	...	...	...	...	...	...	...
,, ...	,,	...	...	...	...	...	...	...	...	...	2, ii.	284·0	45·2	16	β_1	287·5	10	50·0	β_1	2, i.	431·5	47·8	11	...	422·5	24	...
Maboali	,,	1	105·0	28·0	27	α_1	97·5	30	17·5	α_5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Papi	,,	1	311·5	66·1	21	β_5	305 0	16	30·0	β_{11}	2, ii.	345·7	33·5	10	...	350·0	7	35·5	...	2, i.	432·5	46·5	11	...	430·0	19	...
Debe Wali	35–40	1	98·5	37·8	38	α_3	145·0	36	33·75	α_4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Kadub	,,	1, ii.	121·5	20·5	17	α_1	127·5	14	20·0	α_1	1, i.	288·0	51·6	18	β_1	260·0	15	40·0	β_1	...	...	...	...	...	...	...	...
,, ...	,,	...	...	...	...	...	...	...	...	...	2, ii.	255·0	22·0	9	...	260·0	8	28·75	...	2, i.	553·5	40·5	7	...	560·0	18	β_1
Barsa...........	35	1, i.	123·5	31·5	26	α_1	120·0	13	25·0	α_1	1, ii.	234·5	18·5	8	...	240·0	15	17·5	...	...	...	...	...	...	...	...	...
Billy Kuris	,,	1	131·0	21·8	17	α_1	137·5	14	15·0	α_1	2, ii.	314·3	68·0	22	β_3	320·0	7	62·5	β_3	2, i.	493·0	(?)58·7	12	...	450·0	21	...
Charlie Boro......	,,	1, ii.	116·0	11·2	10	...	115·0	11	7·5	...	1, i.	217·5	51·0	23	$\alpha_1\beta_1$	205·0	13	32·5	$\alpha_1\beta_2$	2	513·5	74·5	15	...	500·0	31	...

Groggy	35	1	140·5	8·7	6	...	135·0	13	11·25	...	2, ii.	267·0	29·8	11	...	247·0	10	17·5	β_1	2, i.	564·0	47·0	8	...	565·0	20	β_1
Babelu	30–35	1	139·5	12·6	9	...	115·0	18	7·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mabo	,,	1	104·5	4·5	4	...	105·0	25	10·0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Dick Tui	30	1, i.	136·5	14·5	11	...	140·0	19	15·0	...	1, ii.	250·5	17·6	7	...	250·0	12	15·0	...	...	...	...	...	...	...	...	...
,, ...	,,	...	...	...	...	...	...	...	...	...	2, ii.	276·1	31·0	11	...	290·0	9	32·5	...	2, i.	398·0	58·0	15	...	395·0	18	...
Beni	25–30	1	167·5	32·0	19	...	155·0	15	22·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Jimmy Wailu....	25	...	...	...	...	...	...	...	...	...	1	240·5	26·6	11	...	255·0	28	22·5	β_1	...	...	...	...	...	...	...	...
Loko	,,	1	155·0	26·0	17	...	150·0	15	17·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Poï............	,,	1, ii.	86·5	28·9	33	a_2	100·0	11	25·0	a_2	1, i.	225·0	24·0	11	...	220·0	13	32·5	...	...	...	...	...	...	...	...	...
,, ...	,,	2	166·5	7·8	5	...	165·0	16	7·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Dubwai............	20–25	1, ii.	130 0	38·0	30	a_1	125·0	12	26·25	a_2	1, i.	282·5	25·0	9	...	300·0	17	23·75	...	...	...	...	...	...	...	...	...
Tapau	21	1	166·0	25·4	15	...	157·5	14	20·0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Deboro	19	1	188·5	12·5	7	...	187·5	10	12·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Dick (Dauai) ...	18	1	192·0	11·4	6	...	190·0	11	12·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, ...	,,	2, ii.	122·0	15·6	13	...	125·0	5	18·75	...	2, i.	224·0	12·8	6	...	220·0	24	12·5	...	...	...	...	...	...	...	...	...
Madsa	,,	1, ii.	132·0	13·4	10	...	125·0	11	15·0	...	1, i.	207·0	17·4	8	...	205·0	20	12·5	β_1	...	...	...	...	...	...	...	...
Berò	17	1	121·0	7·2	6	...	120·0	32	7·5	...	...	...	...	...	...	...	...	...	...	2	500·5	81·7	16	...	485·0	14	...
,, ...	,,	...	...	...	...	...	...	...	...	...	3, i.	217·0	18·4	8	...	220·0	19	20·0	...	3, ii.	409·0	32·6	8	...	397·5	12	...
Kaniu	,,	1	107·5	24·5	23	...	100·0	26	12·5	a_3	...	...	...	...	...	...	...	...	...	2	?	?	?	?	?	?	?
WOMEN																											
Biged............	40–45	1	150·5	97·1	65	$a_3\beta_1$	177·5	18	105·0	$a_5\beta_2$	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Banuga	19	1	268·0	30·0	11	β_1	260·0	16	26·25	β_2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
BOYS																											
Apori............	14	1, i.	147·5	19·0	13	...	140·0	12	17·5	...	1, ii.	279·5	18·9	7	...	270·0	11	10·0	...	...	...	...	...	...	...	...	...
,, ...	,,	...	...	...	...	...	...	...	...	...	2, ii.	328·0	20·0	6	β_1	325·0	10	10·0	β_2	2, i.	514·5	73·4	14	...	550·0	23	β_1
James	13	1, ii.	117·0	4·7	4	...	120·0	5	6·25	...	1, i.	228·0	18·6	8	...	240·0	15	20·0	...	...	...	...	...	...	...	...	...
,, ...	,,	2, ii.	122·1	3·4	3	...	120·0	7	2·5	...	2, i.	244·5	26·4	11	...	232·5	14	17·5	...	...	...	...	...	...	...	...	...
,, ...	,,	...	...	...	...	...	...	...	...	...	3, ii.	244·5	23·3	10	...	240·0	12	22·5	...	3, i.	548·0	61·6	11	...	575·0	22	β_1
Jimmy Rice, jun.	12½	1	140·0	16·0	11	...	140·0	18	10·0	...	2, ii.	288·5	48·8	17	β_1	260·0	12	12·5	β_1	2, i.	535·5	(9)70·0	13	...	530·0	24	a_1
Captain............	11½	1	227·0	37·0	16	...	200·0	15	40·0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Charlie Ako......	,,	1	203·5	21·5	11	...	215·0	15	27·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Sailor	,,	1	175·5	35·2	20	a_1	185·0	19	20·0	a_1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Tom (Tanu)......	,,	1, ii.	205·0	24·7	12	β_1	197·5	10	15·0	β_1	1, i.	249·0	62·6	25	a_1	280·0	22	17·5	$a_1\beta_1$	...	...	...	...	...	...	...	...
Biskak	11	1	207·0	41·6	20	...	205·0	15	45·0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Tom (Maboali)...	,,	1	207·0	14·6	7	...	210·0	13	17·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Harry	10½	1	165·5	25·5	15	...	160·0	11	25·0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Nanai	10	1	157·5	28·0	18	...	165·0	10	25·0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
GIRLS																											
Mary	14	1	186·5	30·8	17	...	182·5	10	15·0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Azau	11½	1	196·0	28·0	14	...	200·0	15	17·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Dosa	,,	1	219·5	28·5	13	...	210·0	17	25·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

mean[1]. In the first place, its value is very considerably influenced by even a single aberrant reaction. Secondly, while the limiting value of a shortened reaction is zero, that of a prolonged reaction is infinity. Hence the fluctuations on one side of the average are liable to be very much greater than on its other side[2]. The median, on the other hand (that value which stands midway when the data are arranged in order of magnitude), is considerably less affected by these factors. Aberrant reactions affect its value only to the same extent as do normal reactions. Consequently the median, especially when derived from a fairly large series, may be held to indicate a truer mean than the average.

Following the auditory and visual reaction-averages and medians, are two pairs of columns respectively marked *m. v.* and *m. v. q.* The columns of *mean variations* (*m. v.*) express the average deviation of the ten reaction-times from their average. The columns of *mean variations of quartiles* (*m. v. q.*) give the figures obtained by finding the median of each half of the series when arranged in order of magnitude of data, and by then taking half the sum of the difference of each of these two medians (quartiles) from the median of the entire series.

The visual choice-reactions have been arranged somewhat differently. The columns headed *median* and *of* give respectively the median of, and the total number in the series. Few series were without one, two, or even more erroneous reactions in which the individual reacted with both hands or with the wrong hand. Their number will be discussed later. The column headed *av. of* 10 gives the average of those ten consecutive right reactions in the series which agreed best with the median. As a rule, there was hardly any choice as to which group of ten should be selected. Where a choice was possible the result usually varied little, from whatever group the average was taken[3].

The columns headed *v. c.* contain a quantity which has so far received no name in psychological statistics. The *variation-coefficient*[4] expresses the ratio between the mean variation and the average. It is obtained by the formula $v.\ c. = \frac{m.\ v. \times 100}{av.}$. Its importance lies in the fact that the mean-variation depends not merely on the fluctuations of individual data from their average, but also on the actual magnitude of that average, varying directly with its value. Thus if a reagent, whose average reaction-time to an auditory stimulus is 120^{σ}, shew a mean variation of 10^{σ}, and if, reacting to a visual stimulus his average reaction-time be 180^{σ} and his mean variation be 15^{σ}, he is reacting with an equal degree of constancy in each case, although the absolute values of the mean variation are not the same.

The Arabic and Roman numerals in the columns headed *series* are easily explained by an example. For instance, 3 ii implies that the reactions in question were performed at the reagent's third sitting, and that at that sitting they had been preceded by some other kind of reaction (viz., by 3 i).

[1] I have used the word 'mean' throughout this section in the sense of the ideal average.

[2] Cf. E. Kräpelin, *Ueber d. Beeinflussung einfacher psychischer Vorgänge durch einige Arzneimittel*, Jena, 1892, S. 23.

[3] In two instances it was impossible to obtain more than nine consecutive correct reactions. The averages appear in Table XXXIV, but are preceded by the figure (9).

[4] The term has been already employed by Professor Karl Pearson in a sense only slightly different from that in which it is used here.

Interpretation of Results.

1. *Simple reactions*, (i) *Age and reaction-time.*

The following table shows that the children and older adults of Murray Island reacted more slowly than the young adults. The columns headed *Av. of med.* give the average of the figures in the 'median' columns of Table XXXIV, those headed M.V. show the mean variation of those figures from their average.

Table XXXV.[1]

Age	Auditory reactions			Visual reactions		
	No. of reagents	Av. of med.	M. V.	No. of reagents	Av. of med.	M. V.
—15	11	176·1	28·3	4	262·5	12·5
16—35	17	135·7	20·8	11	243·8	27·8
36—	19	176·2	67·8	14	260·3	64·8

This lengthening of the reaction-time in childhood and in old age has been already observed among Europeans[2]. The above table, however, shows that, while the degree of prolongation is approximately the same, the size of the mean variation within the two classes is very different, being enormously greater among the older men than among the children. This can only signify that the same factors are not at work, or at least are not equally active, in each case to produce the same result.

Table XXXVI.

Age	Auditory reactions					Visual reactions				
	α-reactions	β-reactions	α + β	reagents	reactions	α-reactions	β-reactions	α + β	reagents	reactions
—15	1	1	2	11	143	1	2	3	4	60
16—35	9	0	9	17	270	1	8	9	11	178
36—	27	40	67	19	405	3	15	18	14	208

The one factor, which might be expected to contribute most to the delay of the average reaction and to the increase of its irregularity among the older men, was their greater difficulty of self-accommodation to the experiment. They were more clumsy,

[1] In this and subsequent tables only the first series of each individual's reaction-times are considered.

[2] Cf. Gabriele Buccola, *La legge del tempo nei fenomeni del pensiero*, Milano, 1883, p. 152.

less easily adaptable than the younger men or children. They had received no school-training and may (rarely) have been a trifle suspicious of our experiments. Some of them, *e.g.* Papi, persisted in reacting slowly in spite of every apparent endeavour on their part to improve. Others, *e.g.* Sisa and Dauai, gave an abundance of premature (a) and prolonged (β) reaction-times. Indeed, how far more frequent the a- and β-reactions are among the older than among the younger male islanders is well shown in Table XXXVI.

An inspection of the column of variation-coefficients in Table XXXIV. shows that in many cases the length of the older islanders' reaction-times is not due to one or two 'accidentally' delayed reactions. The variation-coefficients of Azò, Dauai, Lui, Capsize and Papi, for instance, are as low as could be expected. In other words, we may say that it was 'natural' for these older men to react slowly, *all* their reaction-times being long, often indeed passing into the region of β-reactions. There are, however, a few older men, *e.g.* Sisa and Magi, whose irregularity of reaction was extremely pronounced, owing to which the average variation-coefficient is unduly high among this section of the Murray Islanders.

The value of the average variation-coefficient of the auditory reactions among the children, younger and older adults is 13·4, 14·6 and 22·8, and of the visual reactions is 14·0, 11·3 and 15·0 respectively. (The value 14·0, however, is based on the coefficients of only four children.) Thus, the older men, both individually and as a class, react less consistently than the younger; but the difference is far better marked in the auditory than in the visual reactions. The children react quite as consistently as the younger adults in the auditory reactions, indeed giving a smaller proportion of aberrant reactions.

(ii) *Comparison with the records of English and of Sarawak reagents.*

We may now consider the Murray Island reactions along with those which I obtained by means of the same apparatus in Sarawak and still later in England. The Sarawak and Murray Island data are comparable in every respect, the individuals of each community being of all ages and the data being dealt with in the same fashion. The Englishmen's figures are less comparable. The majority of them (85 %) were either University students, a very few of whom had done two or three reactions before, or they were young laboratory assistants; the remainder were University graduates of various ages, most of whom had never tried a reaction experiment.

Comparing the young Murray Islanders with the young Englishmen and Sarawak natives, we obtain the following result:

TABLE XXXVII.

Country	Age	Auditory reactions			Visual reactions		
		No. of reagents	Av. of med.	M. V.	No. of reagents	Av. of med.	M. V.
Murray I.	16—35	17	135·7	20·8	11	243·8	27·8
England...	„	24	141·6	19·5	21	222·3	21·2
Sarawak...	„	18	120·7	10·5	9	208·0	8·7

Thus the average auditory reaction of the young Murray Island adult is not appreciably different from that of the Englishman, but his visual reaction appears to be distinctly longer. The Sarawak native reacts more quickly both to auditory and to visual stimuli than the Englishman.

The question, however, arises whether these are real differences in rapidity of reaction, or whether they are the accidental results of 'random sampling,' due, in other words, to the examination of an insufficiently large number of individuals. Between the Sarawak and the English and between the Sarawak and the Murray Island reagents, the differences are unquestionably too great to be accidental. The difference in visual reaction-time between the Murray Islanders and the Englishmen, however, is not quite three times the probable error of the differences[1]. Its significance is consequently a little doubtful, but I am strongly inclined to believe that the difference is real.

This conclusion, however, is dependent on an arbitrary selection of one of many possible ways of arriving at the mean reaction-time from the data which are under consideration. It might be thought that the results would differ, if, instead of the average of the 'median,' either the median of the 'median' columns had been chosen, or the median of the 'average of ten' columns. It might also be deemed desirable to consider separately the individuals whose series contained no α- or β-reactions, so that those who gave irregular reaction-times should no longer weigh upon the general mean. I have made such calculations for all the adult males examined in Murray Island, England and Sarawak.

TABLE XXXVIII.

	Auditory			Visual			Choice-visual	
	Murray I. (36)	England (29)	Sarawak (18)	Murray I. (25)	England (25)	Sarawak (11)	Murray I. (15)	England (18)
Median of av. of 10	134·2	141·0	116·7	225·0	220·5	218·5	500·5	427·1
" " " (series containing α and β omitted)	140·5	144·2	121·5	224·0	219·7	219·0	493·0	427·1
Median of medians	136·2	135·0	120·0	227·5	215·0	215·0	490·0	400·0
" " " (series containing α and β omitted)	142·5	145·0	125·0	220·0	214·2	215·0	450·0	405·0
Average of medians	156·9	140·8	120·7	253·1	218·8	215·2	501·3	411·0
" " " (series containing α and β omitted)	146·0	145·6	126·5	235·0	211·7	217·7	466·7	417·2

These figures, it must be remembered, relate both to the older and to the younger men of the three communities. They are hence generally rather higher than those of the preceding table, but the proportion of elderly people examined in England and Sarawak

[1] Obtained from the expression $0{\cdot}6745\sqrt{\left(\frac{\overline{m.v.}^2}{n}+\frac{\overline{m.'v.'}^2}{n'}\right)}$, where $m.v.$ and $m.'v.'$ are the mean variations, n and n' the number of reagents, in the two series.

was much smaller than that in Murray Island. Moreover, a Murray Islander of thirty-five years of age or upwards is really about ten years older in appearance and vitality than an Englishman of corresponding age. Nevertheless, with a single exception, the same differences in reactions may be here recognized as before. The auditory reaction-time is shortest in Sarawak, and is approximately the same among the Murray Islanders and the English. The visual reaction-time is sensibly longer among the Murray Islanders than among the Sarawak or English reagents. The visual reaction-time of the Sarawak natives, however, is almost identical with that of the English.

2. *Choice-visual reactions.*

The mean values of these reactions, as obtained by various procedures, have been set forth in the preceding table. They are longer by about 60^{σ} among the fifteen adult Murray Islanders than among the eighteen English. Probably 15^{σ} of this time must be attributed to the same causes which produced the more delayed simple visual reaction in the case of the former. But it was clear that the Murray Islanders found relatively greater difficulty than did the English in reacting in the prescribed manner according to the colour presented. Of 345 reactions in Murray Island 45 were wrongly performed. Among the English in 329 reactions only 26 were wrongly performed; here, too, the mean variation of the reagent was less. It must be remembered, however, that most of the English reagents were a well-educated class. There can be little doubt that the Murray Islander would have compared far more favourably with the English villager in choice reaction-time. The number of α- and β-reactions in Murray Island was eleven, in England three; in Murray Island they were all α-reactions, in England ten of them were β-reactions.

The mean variation (M.V.) of the individual medians from the average of the medians is almost the same in the Murray Island and in the English adults, viz. 60·3 and 60·4 respectively. When those medians which contain α- or β-reactions are ruled out, the respective mean variations become 58·9 and 61·3.

The three Murray Island children examined gave an average choice-visual reaction which is about 30^{σ} slower than that of the adults. Their simple visual reaction-time, however, exceeds that of the adults by the same amount.

3. *Practice and Fatigue.*

About thirty successive auditory reactions were obtained at one sitting in the case of nine Murray Island adults. I attempted to find the effects of fatigue or practice by taking the average and mean variation of the first, middle and last ten reaction-times. The results, however, were complicated by premature reactions in the case of four islanders. Wasalgi gave a premature reaction in each set of ten; Kaniu, Alo and Maboali increased their number of, or began to give, premature reactions in their later records; Debe Wali, on the other hand, was able finally to react ten consecutive times without giving a premature reaction. The results of the remaining four, whose long series of reactions were without a single aberrant reaction, are given in Table XXXIX.

The improving effects of practice are well shown in the case of Wanu and Baton. Berò, on the contrary, and perhaps Jimmy Dei, seem to have been fatigued as the sitting became protracted. These differences in behaviour may be interesting when the islanders are later studied from the standpoint of individual peculiarities.

The length of the auditory reaction was not obviously affected by the sequence in which the two simple reaction-times were investigated. On the other hand, as might be expected, a very considerable lengthening of the visual reaction-times occurred, if they had been immediately preceded by a series of choice-visual reactions. Of eleven Murray Islanders the average in eight and the mean variation in ten were greater when the visual followed choice-visual reactions, than when they preceded them or were preceded by auditory reactions[1].

TABLE XXXIX.

Name	First ten		Middle ten		Last ten	
	Average	m. v.	Average	m. v.	Average	m. v.
Jimmy Dei...	129·0	22·0	153·5	27·2	139·5	25·4
Wanu	182·0	29·2	161·0	16·4	146·1	20·2
Baton	146·0	22·4	144·5	18·6	127·0	12·4
Berò............	121·0	7·2	125·5	9·7	129·5	11·6

4. *The Mental Attitude and Degree of Reliability of the Reagents.*

It is now generally admitted that the reaction-time of most practised individuals is longer by about 100^σ, when the attention is directed to the sensory stimulus, than when it is directed towards the reaction-movement; also that in the former or 'sensorial' mode of reaction premature or false reactions are rare or absent and the mean variation is large, while in the latter or 'muscular' mode of reaction the opposite is the case; and that in these respects the natural or 'central' reaction-time, where the attention is left undirected, stands intermediate between the two extreme forms. For auditory reactions the usually accepted sensorial reaction-time lies between 225^σ and 240^σ, the muscular between 120^σ and 130^σ and the central between 140^σ and 180^σ, their mean-variations lying respectively between 20^σ and 30^σ, between 8^σ and 12^σ, and between 12^σ and 20^σ. The subject having been first carefully investigated by L. Lange[2], these phenomena are sometimes collectively known as 'Lange's law.'

[1] The order of J. Allen Gilbert's investigations on the choice and simple reaction-times of children (*Studies from the Yale Psych. Lab.*, New Haven, 1894, Vol. II. pp. 40 ff.) will therefore easily account for the relatively large mean variations obtained by him in the simple reaction-experiments.

[2] *Phil. Stud.*, Leipzig, 1888, Bd. IV. S. 479 ff. But Titchener (*Experimental Psychology*, New York, 1901, Vol. I. Pt. 2, p. 211 footnote) points out that Lange had been anticipated by Orchansky, *Neurol. Cbl.*, 1887, Bd. VI. S. 265 ff.

It seemed worth while to attempt to arrange the auditory reaction-times of the Murray Islanders and of the other two communities under these three heads according to their average value. It will be noted that the mean variation of the above groups never exceeds 14 °/₀ of the average. Hence in the ensuing table only those reagents will be considered whose variation-coefficient is not greater than 14. Reagents whose ten reactions include one or more α- or β-reactions are excluded. The mean-variation is given in brackets. As several of the average reaction-times fall below 120^σ (the accepted 'muscular' reaction), the lower limit of the central reaction has been proportionally increased to 130^σ; in the other direction it has been also extended to 195^σ for the adults and to 210^σ for the children.

TABLE XL.

Average reaction-times	Group	Names of reagents
104^σ—129^σ	Murray Island adults	Pasi (12·5), Charlie Boro (11·2), Mabo (4·5), Berò (7·2).
,,	,, ,, boys...	James (4·7).
,,	English adults	Ed. (7·5), Cl. (10·4), R. (10·2).
,,	Sarawak ,, ...	D. (11·4), J. (8·5), Js. (7·6), Am. (11·2), T. Tg. (10·0), Ng. (8·4).
130^σ—195^σ	Murray Island adults	Mamus (7·0), Groggy (8·7), Babelu (12·6), Dick Tui (14·5), Madsa (13·4), Deboro (12·5), Dick (Dauai) (11·4).
130^σ—210^σ	,, ,, boys...	Apori (19·0), Jimmy Rice (4·7), Tom (Maboali) (14·6), Charlie Ako (21·5).
130^σ—195^σ	English adults	T. (8·5), Wn. (6·0), Ls. (15·6), Ma. (17·0), Wm. (17·5), Ry. (19·2), Jn. (10·5), Gp. (14·0), Jo. (20·8).
,,	Sarawak ,, ...	T. M. (12·5), Jh. (17·9), Jl. (8·9).
196^σ—	Murray I., Sarawak and English adults	None.

All the above are what would be commonly regarded as 'reliable' reaction-times; in other words, all the mean-variations here are very low and the reagents gave no abnormally quick or delayed reactions. They have been obtained, be it observed, from primitive peoples, who had never before been made the subjects of experiment, and from Englishmen who with one exception had had little or no previous experience of such procedure. The averages are derived from the first ten recorded auditory reactions. Of 36 Murray Island adults examined, several of whom appeared to be quite old men, 12 (33·3̇ °/₀) appear in the above table; of 11 boys, 5 (45·4̇5̇ °/₀) appear there. Of 29 English adults examined, none of whom was really old, 12 (41 °/₀) appear. Of 24 Englishmen examined between 16 and 35 years old, 8 (33·3̇ °/₀) appear. Of 17 Murray Islanders similarly aged, 9 (53 °/₀) appear, and of 18 Sarawak adults 9 (50 °/₀). The number of consistently reacting Murray Islanders and Sarawak natives is consequently not less than that observed among the English. A study of the visual reactions leads to similar conclusions, 9 of 11 Murray Island, and 20 of 21 English young adults appearing in a corresponding table.

It will be noted that in the above table of auditory reactions there is not a single reaction-time average which approaches the accepted 'sensorial' value. The nearest of any is that of Capsize (av. = 245·5, m.v. = 31·6); but as his ten reactions include one of 360^σ (*i.e.* a β-reaction), his name is excluded from the table.

It would be tempting to infer that such rapid reactions, attended with such small mean-variations as those of Mabo, Berò and others, are indications that the reagents had fixed their attention on the movement to be made rather than on the sound which they expected. And perhaps such a conclusion is justifiable in the case of extremely rapid reactions. But it is quite possible that there exist wide individual deviations from 'Lange's law,' especially among the imperfectly practised. Otherwise the discrepancies obtained by Cattell[1], Flournoy[2], van Biervliet[3], Dessoir[4], Baldwin[5], Angell and Moore[6], Hill and Watanabe[7] and others, can hardly be accounted for. Probably some individuals are naturally pre-disposed to react more quickly and regularly when their attention is directed to the sensory rather than to the muscular side of the reaction, although one can hardly doubt that after adequate practice the most rapid reactions must be of the muscular type, in which, moreover, the state of the attention must be such as to lead more easily to the occurrence of premature and false reactions.

The very small number of premature, false or prolonged reactions in the visual, as compared with the auditory reactions (cf. Table XXXVI.) makes it therefore probable that the visual-reactions approximated more generally and nearly to the sensory type than was the case in the auditory reactions. The fact that the latter usually preceded the former is insufficient to explain the difference in frequency of aberrant reactions. Moreover the visual reaction-times, obtained even from Englishmen by the apparatus already described, are longer by about 40^σ than the muscular reaction-times usually given. It is possible that the constant 60^σ which I deducted for the latent period of fall of the board (see p. 206) was not sufficiently large. But I think there can be little doubt that when the sensory stimulus takes the form it had in my experiments, viz., of a distant falling board, black in colour and carrying a white card, more attention must then be given to it and less to the reaction-movement, than when, as in the shortest visual reactions, the stimulus is a mere flash of light. Indeed the reaction becomes more nearly a recognition- or discrimination-reaction than a mere simple reaction, and as a fact the values obtained by means of this visual screen (Table XXXVIII.) are closely identical with those obtained in so-called discrimination reaction-time[8], where the stimulus has to be recognized before a reaction is made.

[1] *Phil. Stud.*, Leipzig, 1893, Bd. VIII. S. 403—406.

[2] *Arch. des Sci. phys. et nat.*, Geneva, 1892, 3me Sér. Tome XXVII. pp. 575—577; *ibid.* Tome XXVIII. pp. 319—331.

[3] *Phil. Stud.*, 1894, Bd. X. S. 160 ff.

[4] *Arch. f. Anat. u. Physiol.* [*Physiol. Abth.*] 1892, S. 311.

[5] *Psychol. Rev.*, 1895, Vol. II. p. 259 ff.

[6] *Ibid.* 1896, Vol. III. p. 245 ff.

[7] *Amer. Journ. Psych.*, 1894, Vol. VI. pp. 242—246.

[8] W. Wundt, *Grundzüge d. physiolog. Psychologie*, Leipzig, 1893, Bd. II. S. 369; G. Buccola, *op. cit.* p. 274.

General Conclusions.

It appears, then, that the auditory reaction-times of the young Murray Island adult and of the young English townsman are almost identical, and that the visual and choice-visual reaction-times of the former are respectively 20^{σ} and 60^{σ} longer than those of the latter. This lengthening of the visual and choice-visual reaction-times among the Murray Islanders is probably due to similar causes. The visual reactions were really nearer recognition- than simple-reactions. Owing to the nature of the visual stimulus and the mode of its release, these reactions were clearly more difficult to execute than the simple auditory reactions. Their large average and the few aberrant values also go to indicate that in the visual reactions the attention was more firmly fixed on the expected stimulus than on the prescribed movement. In the visual, then, as in the choice-visual reactions, the attendant psychical conditions were more complex than in the auditory reactions, and in both the former reactions the Murray Islanders proved to be slower than the English. On the other hand, the young Sarawak adults reacted more quickly than the English or the Murray Islanders, the difference in rapidity between them and the English being about 20^{σ}.

The number of Murray Islanders, who gave fairly consistent reaction-times, was not appreciably different from that of the English or of the Sarawak natives. The results of every islander who was examined were capable of being satisfactorily recorded, with the exception of Canoe and Kaniu, who after prolonged trials could not be induced to react correctly in the choice-visual experiments. It is difficult to decide how far these failures were due to lack of ability or to lack of interest. My impression was that Canoe was not doing his best and that Kaniu was considerably less intelligent than most of the islanders.

The young Murray Island adults reacted more quickly than the children. They reacted not only more quickly but more regularly than the older men. Indeed, whether considered as a class or individually, the older islanders reacted far less consistently than the younger. These differences did not appear among the English, where a proportionally smaller number of men over thirty-five years of age was examined, none of whom was really old, while in Murray Island the data include those of some unquestionably aged people.

The small number of abnormally long or short reaction-times occurring among the children is worthy of notice. Their reactions were as reliable as those of the younger adults.

An interesting point, elicited by the carrying out of reaction-times in Murray Island, was the well-marked variety of temperament among the reagents. A dull steady-going islander, having plodded through a series of reactions with moderate speed but with satisfactory regularity, would be followed by a highly strung excitable individual, who was obviously always straining his attention to the utmost and reacted perhaps quickly, but so often prematurely or erroneously that little confidence could be placed in the average of his reaction-times. Between these extreme types there was every gradation.

Other conclusions of a less general nature need not be repeated here.

Comparison with the Results of other Workers.

Before proceeding further, it is worth while considering what is implied when it is said that one people reacts more quickly than another. We must assume that in neither is practice complete. We simply mean, that in a given time one people has adapted itself more readily than another so as to perform a prescribed reaction more rapidly. It by no means follows that the reactions of the perfectly practised individuals in each community are of materially different speed. However improbable, it is conceivable that the duration of identical psychical phenomena may differ in different races. But the reactions derived from imperfectly practised primitive folk cannot provide evidence in proof or disproof of this view. The proportion of slow or irregular reagents (most of whom will react satisfactorily after adequate practice) must vary from community to community. So too will vary the general mental attitude towards the experiment, some individuals naturally turning their attention always in the direction of the stimulus or of the movement[1], some attending now to one, now to the other, others reacting almost automatically, only dimly conscious of the nexus between sensation and muscular action. In this sense, reaction-times may be said to vary inter-racially.

The earliest suggestion with which I have met, that the reaction-time is dependent on the race or country of the reagent, was made in 1879 by A. Herzen[2]. His unpublished experiments led him to believe that Italians react more slowly than Germans. More recently Th. Flournoy[3] has considered the type of reaction to depend on "anthropological or ethnographical characters." He holds 'Lange's law' to be proven for most Germans and Russians, and to be reversed in the case of the South European nations (French, Servians, Roumanians and Greeks).

The reaction-times of some Japanese conjurors were investigated by Herzen more than twenty years ago. I have been unable to find a record of his experiments. He concluded[4] that the Japanese react more slowly than Europeans.

In 1895 a paper, entitled "Reaction-time with reference to Race," was published by R. Meade Bache[5], in which, after giving the results of visual, auditory and tactual reaction-investigations made by L. Witmer upon a few American Indians, Negroes and Caucasians, he concludes that the reaction-time is shortest in the lowest and is longest

[1] Alechsieff, for instance (*Phil. Stud.*, 1900, Bd. XVI. S. 18), states that the sensorial reaction is impossible to some, especially to those who are predisposed to the muscular reaction. Hill and Watanabe (*loc. cit.*) observe that "some never reach the quickness of the muscular reaction, some, while reacting constantly do not conform to the Lange type."

[2] *Archiv. per Antropol. e la Etnolog.*, 1879, Vol. IX. p. 91, footnote.

[3] *Observations sur quelques types de réaction simple*, Geneva, 1896. Ref. in *Ztsch. f. Psych.*, 1897, Bd. XIII. S. 359.

[4] Cf. *Biolog. Cbl.*, 1881–2, Bd. I. S. 730.

[5] *Psychol. Rev.*, 1895, Vol. II. p. 475. A preliminary note appeared in *Proc. Amer. Philosoph. Soc.*, 1895, Vol. XXXIV. p. 337.

in the most advanced races. This opinion is based on the examination of 12 Caucasians, 11 Indians, and 11 Africans who had "a larger intermixture of white blood in their veins than have the Indians on the corresponding list." The average of ten observations and their mean variation are given for each individual. The author, however, does not specify that the ten reaction-times taken were consecutive. It appears to me likely that the ten quickest or most regular of many reactions were chosen, seeing that the variation-coefficients, if calculated in the case of three individuals, fall to 2·6, 2·7, 2·8,—values which are very considerably lower than those obtained by me and others from untrained and even from trained reagents. Among the Indians, moreover, is included a youth whose average auditory reaction-time is only 70^σ. Although his mean-variation is said to be only 6·2, one cannot help wondering what limits, if any, were set from which premature and false reactions were eliminated. Finally, the inequality in age of the individuals within each series makes comparison between the three races very difficult. The Caucasians include four boys below the age of 16 of whom two react more slowly than any of the rest. The Africans include none below the age of 16. If the boys be neglected, the average reaction-times of the Caucasians are almost equal to those of the Africans. The Indians, however, remain with reaction-times by some 15^σ quicker than those of the other two races.

The rapid reactions of the Sarawak natives, as compared with those of the English, have been noticed in these pages already. It is interesting to find that the American Indians, who are near akin, appear to be similarly characterized.

The same, too, has been noted quite recently of the Javanese 'Malays,' who are yet more closely allied to the people of Sarawak. G. Grijns[1] has recently investigated the reaction to electric cutaneous stimuli among some nineteen Javanese students and many Europeans. He concludes that the native reaction-time is decidedly quicker than that of Europeans who have lived for some time in Java, and is (though less markedly) quicker than Europeans who live in Europe.

Lastly, there are a few tactual reaction-times, published in 1901 by L. Lapicque[2], which were made upon eighteen Andamanese, and seven convalescent Hindu criminals, and were compared with those of twenty-eight Europeans. Owing, apparently, to the individual variations among the latter, according as he worked with British officials of the Andaman Islands, with Parisian labourers, students or paupers, the writer concludes that the problem which he set himself, viz., "the determination of the influence of race upon reaction-time, is...illusory." Like so many others, he gives a very imperfect account of his method, but, as far as his few observations go, the reaction-times of the Andamanese, and especially of the Hindus, are distinctly longer than the seventeen European officials, students and labourers, and are slightly longer than the eleven paupers.

In every case one would have preferred a greater body of evidence, and an assurance that the differences are more than chance differences due to insufficient experiments; but it is interesting to note that, while the people of Java, Borneo and North America react more quickly, the African (cross-bred), the Hindu (criminal), the Andamanese and the Papuan appear to react with the same speed as, or more slowly than, the Caucasian.

[1] *Arch. f. Anat. u. Physiol.* [*Physiol. Abth.*], 1902, S. 1—10.

[2] *C. R. de l'Acad. des Sciences*, 1901, Tome cxxxii. pp. 1509—1511.

The early experiments on the Japanese by Herzen, which, if ever published in detail, I have been unable to find, are the only observations I know of which as yet negative this conclusion; we should expect them to fall into the first instead of into the second of the above-mentioned groups.

Such racial differences in reaction-times, if actually established by further research, may turn out to be merely the expression of racial differences in temperament. For it is easily conceivable that a highly strung, nervous people cannot develop the disposition, or assume the attitude, that is favourable to the most rapid and regular reactions with such readiness as can a relatively unemotional people. Moreover, it is at least suggestive that what little evidence we have tends to show that the more excitable Italian and Papuan react less rapidly than the more phlegmatic Teuton and Malay. If, however, we bear in mind how wide are the elementary psychical differences, which in all likelihood underlie seemingly similar temperaments, the unwisdom of venturing on such a general statement is at once obvious.

a