THE DECISION MAKING PROCESS INVOLVED IN FORMULATING THE S-3's FIRE ORDER

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THESIS

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ABSTRACT

The decision making process involved in formulating the S-3's fire order of a direct support artillery battalion was studied using psychometric scaling procedures.

Two missions were considered, an area mission and a precision mission. For each mission a list of factors usually considered when formulating the order was drawn up in questionnaire form. Each list was rated as to the relative importance of factors for being included in the decision making process and for the relative amount of time each demanded in the decision making process. The questionnaires were submitted to 131 subjects that were or had been S-3's and fire direction officers. Forty-five completed questionnaires were returned.

All lists were scaled using the method of successive-categories. As a check, one list was scaled using the method of partial-rank order. The resulting scales provide a means for comparing the importance and time demands of many critical factors according to mission type and according to the amount of formal training received by questionnaire respondents.

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I. INTRODUCTION

This study attempted to scale the factors[1] that a direct support battalion artillery fire direction officer might consider when formulating the S-3's fire order.

The question that immediately arose was what is the utility in doing this type of study? An example of some applications in artillery where different procedures have been used to obtain this type of information will be a start in answering this question. One example was an artillery simulation study done by The Ballistics Reaearch Laboratory [1]. An extended study was conducted using a procedure based upon expert opinion to rank the worth of specific targets. The procedure used gave rankings on a scale of ordinal value [2]. Another study that investigated the S-3's fire order was done by Litton Industries. A procedure using the opinion of a large number of fire direction officers was used to study the factors involved in making the decision of how to attack certain targets. This study was in conjunction with automating the fire direction center for the TAC FIRE systems. It was thought that scaling the factors that are involved in arriving at the S-3's fire order would help give the inexperienced fire direction officer insight into the thought processes of

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[1] "Factor" as used here is not a "factor" in the sense of a factor obtained through factor analysis.

experienced fire direction officers. This thinking was amplified by the findings in an unpublished report [3] concerning counter-battery fire in Vietnam. The report was critical of fire direction officers for two reasons. First, when firing counter-battery fire, an insufficient amount of ammunition was used to obtain a reasonable probability of neutralizing the enemy. Second, the fire direction officers chose an inappropriate fuze to accomplish the neutralization. For a situation that dictates air bursts, in 75.6% of the cases that were studied a point-detonating fuze was fired. It was hypothesized that inexperience was partially accountable for these deficiencies.

The utility of scaling these factors on a scale of at least interval value was deemed important for several reasons. The scales would aid the inexperienced fire direction officer, the interval value might be useful for quantitive research applications, and the entire study could show that it is feasible to use these factors as stimuli in applying psychometric scaling procedures.

II. QUESTIONNAIRE DEVELOPMENT AND ADMINISTRATION

The fire direction officer is primarily concerned with two distinct types of missions (precision and area) when formulating the fire order. The fire direction officer considers the factors differently for each type of mission. Consequently scales were obtained for each type of mission.

Initially a determination had to be made as to what factors the fire direction officer considers. Some of the considerations involved in this determination were what does doctrine specify that the fire direction officer should consider? Are there other factors that the experienced fire direction officer considers that are not included in doctrine? Even though doctrine specifies that certain factors be considered how do experienced fire direction officers look upon these factors? These questions served as guides for the selection of the appropriate factors to be included in the study. The factors that were specified for each type of mission were derived from two sources. The doctrine was obtained from FM-6-40, Field Artillery Cannon Gunnery [4], FM-6-20-2, Field Artillery Techniques [5], and Instructional Note-Operation of the Fire Direction Center [6]. Additional factors were included based upon the writer's experience and a preliminary survey of experienced artillery officers. The factors that were selected are listed in Table I along with a code for each factor and

TABLE I

LIST OF FACTORS SCALED, A CODE, AND THE APPLICABLE MISSION

Factor	Code	Mission Used In: Area	Prec.
Ammunition (amount on hand)	AMOH	X	X
Ammunition (charge)	AMCH	X	X
Ammunition (lot)	AMLT	X	X
Ammunition (supply available)	AMSP	X	X
Conformity to scheme of maneuver of supported units	CONF	X	X
Cover at target or registration point	COVT	X	X
Current instructions from commander and higher headquarters	CINS	X	X
Density of target	DENS	X	
Fuze action	FUZE	X	X
Lateral spread	LASP	X	
Mobility of target	MOBI	X	
Number of rounds	NORD	X	
Offensive capability of target	OFFC	X	X
Permanence of target of registration point	PERM		X
Position of units available to fire	POSN	X	X
Proficiency of units available to fire	PROF	X	X
Projectile type	PROJ	X	X
Proximity of friendly troops to the target	PXFT	X	X
Proximity of no fire areas	PXNF	X	X
Range spread	RGSP	X	
Size of target	SIZE	X	
Size of target or registration point	SIZE		X
Survey control	SURV	X	X
Technique of attack (low angle, high angle)	TECH	X	X
Terrain	TERR	X	X
Time of opening fire	TIME	X	X
Type of target	TYPE	X	
Type of target or registration point	TYPE		X
Validity of current corrections	VALD	X	X
Weather	WEAT	X	X

an indication of the type of mission for which the factor was scaled.

The factors selected certainly are not all inclusive. If, however, these factors were the only ones to be considered, it is believed a mission would be accomplished satisfactorily.

Once the factors were decided upon the next question was in what context should they be scaled? Importance was the overriding consideration and was selected. Time is also an important constraint when the order is being formulated. Therefore it was deemed useful to examine how the experienced fire direction officer allocates his time among these factors when considering them, although the fire direction officer does not consciously make a time allocation when formulating the order.

The next problem was to determine what procedure should be used to obtain judgments and how the necessary data should be gathered.

The judgments could have been obtained by developing an ad hoc procedure. However there are several known and proven procedures (Eckenrode [7]). Three well known and accepted methods [2] are: rank order, pair comparisons, and successive-categories. All of these methods will yield ordering of the factors on at least an interval scale. These methods have been applied to ordering such stimuli as the names of actors or choices of food. It was assumed

that the factors considered in this thesis could be considered as stimuli of this type.

One limitation in the selection of a procedure was that in the case of area missions there were 27 factors to be ordered. In the case of pair comparisons, where n = the number of factors to order, n(n-1)/2 pairs of factors have to be compared. The large number of pairs to be compared did not make this method practical. Full ranking, in the rank order case, is best if limited to 15 or less factors [2]. This directed the choice to the method of successive-categories. One consideration in using this method is that the number of subjects be near 100 or greater. It seemed that it was feasible to obtain this number of subjects.

Another method that appeared to be appropriate was the partial-rank order procedure. In this case, rather than ranking all n factors, only k of them are ranked. This allows more than 15 factors to be considered. It is also an appropriate procedure if the number of subjects is less than 100 [2]. However to obtain scales of interval value each factor must be selected. For comparative purposes it was decided to use both the successive-categories and partial-rank order methods.

With the method determined, the next consideration was the layout of the form for the data collection. For the method of successive-categories a rating scale is required for each factor. Some of the options for this scale were

to use a continuous scale with labeled end points, a discrete scale with labeled end points or a discrete scale with verbal labels for each step. Wells and Smith [8] compare scales using a verbal format, where each category is given a label, and scales where only the end points are labeled. The scale with each category labeled tends to give a distribution where end points are chosen less frequently. Because of the difficulty in obtaining appropriate labels, labeling of each category was discarded. Because of data processing difficulties a continuous scale was discarded. Therefore discrete steps, with labeled end points, were used. The median is used in the computational procedure. To use this statistic, the distribution should cover at least nine steps. To facilitate mathematical computations ten steps were used. The end points were labeled extremely and slightly since the factors that were chosen would not reflect unimportance as a lower limit.

In order to minimize bias reflected by the location of the factors on the form the items were initially listed randomly. After the initial random ordering some of the factors that contained multiple items were broken down to individual factors since they involved independent considerations. These factors were then listed consecutively. As an example ammunition was initially listed as:

Ammunition (amount on hand, supply available, lot, charge)

It was changed to:

Ammunition (amount on hand)
Ammunition (supply available)
Ammunition (lot)
Ammunition (charge)

A questionnaire that consisted of five lists of factors was evolved from the above considerations. Each list of factors was introduced by a paragraph stipulating the mission that should be considered when making the evaluation and instructions explaining how the respondent should mark the scale to indicate his judgment. The first four lists were based upon the method of successive-categories. The fifth list was based upon the method of partial-rank order. The first list was for an area mission situation to be judged with respect to importance. The second list was also for an area mission but it was to be judged with respect to time. The third and fifth lists were for a precision mission situation and were to be judged with respect to importance. The fourth list was also for a precision mission situation but it was to be judged with respect to time. The lists are included in Appendix B.

The final consideration was how to gather the data. There are a large number of officers that could be considered experienced fire direction officers. They are spread over the world with the only significant concentration of them being at the Artillery School at Fort Sill, Oklahoma. Since the local supply of subjects was insufficient, a means of gathering data from a large area was necessary. This was accomplished by placing the form in a self-explanatory

package so that it could be distributed by mail. The package consisted of a cover page outlining the reason for wanting the questionnaire completed, the qualifications that the respondent should possess, and general instructions. The next page was a form, to be completed, to gather the respondent's background data. The questionnaire was the last item in the package. The complete package is included as Appendix B.

It was hoped that this individualistic method would allow the interested respondent to find a time that was convenient for him to make his judgments. This being the case the respondent would then have ample time to consider each factor and situation. Also he would have sufficient desire to do a good job since it was a completely voluntary process.

To accomplish the distribution, forms in stamped self-addressed envelopes were sent to central distribution points at various locations in the continental United States. Although this method did not allow for randomizing the subjects as specified by Bock and Jones [9], it was the only expeditious means available for limited time and resources.

III. SCALING PROCEDURE

The method of successive-categories [2] is based upon the assumption that the distribution of responses to the factors is normal. For this method there are two major scaling principles - that of scaling limits and that of scaling categories. In the interest of computational simplicity the principle of scaling limits was used, even though the two end categories cannot be evaluated.

The first step in the procedure was to compile the frequency data f_{ij} in a matrix.

f_{ij} = number of responses in the cell for the i^{th} factor and the j^{th} category

n = number of factors

N = number of categories

S = number of subjects

$S = \sum_{j=1}^{N} f_{ij}$ except in the case where a subject does not record a response for a factor

In that case: $S > \Sigma f_{ij}$. This does not preclude the use of this method.

From the frequency matrix the cumulative-proportion matrix was computed. To accomplish this $CUM = \frac{D_{ij}}{\Sigma f_{ij}}$ where D_{ij} = the cumulated f_{ij}.

As a check on the procedure 1.0 must appear in the column for the N^{th} category.

The cumulative proportion represents the area under the unit normal distribution curve below the upper limits of the respective category intervals. The linear distances of those limits from the means of the factor are determined by looking up the corresponding deviates in the tables of the normal curve. The deviates pertain to the distribution of a single factor. Each deviate is regarded as the distance of an upper category limit from the mean for that factor. The means for different factors naturally vary. Because of differences in means and in standard deviations, the deviates in any one column are far from equal. There are as many scales as there are factors, each with its own unit and origin.

Next a single set of values, for the upper limits, are determined. Each limit can be evaluated except the upper and lower ones because the corresponding proportions are one and zero, respectively, whose deviates are infinite. If the assumption is made that the dispersions of the factors are equal except for sampling errors it is justifiable to average results from the different distributions. If the matrix of deviates is complete, no cell values indeterminite, the columns are summed and means are found. These means serve as common scale values for upper category limits.

If there are vacancies in the matrix of deviates the means can be determined by subtracting the deviates by

pairs down neighboring pairs of columns. Then divide by the number of pairs that made up the sum.

The means of the columns give the average estimates of category widths. These values are cumulated to provide scale values of the limits of the categories on an interval scale.

The scale values for the factors are determined by interpolating the medians of each factor on the common scale values. Medians are used because the end scales are undetermined and some factors have truncated distribution. Truncation does not preclude the computation of a median unless more than 50 percent of the frequencies fall in an end category.

In the procedure of partial-rank order [2], the first k ranks out of a possible n ranks are ordered by the respondent. An assumption necessary for the application of this method is that the respondent's discriminal dispersions are all equal. If this assumption does not apply the factors with greater dispersions are likely to pile up choices in undue proportion relative to their true scale position.

There are two main approaches to the scaling of stimuli beginning with rank-order data. These are the pair-comparison solution and the composite standard solution. In the interest of computational ease the composite standard solution was used in this study.

The first step in the computation was to construct a rank-frequency matrix. An example of this matrix is included in Table XV, Appendix A.

The factor to be scaled is F_i and receives a number of choices C_i. Each factor in turn is F_m with numbers of choices C_m. At this point a proportion for a pair of factors is estimated using the equation:

$$P_{i>m} = \frac{C_i}{C_i + C_m} \qquad (1)$$

C_i pertains to the comparison between F_i and all others and C_m pertains to the comparison between F_m and all others. There are a total number of choices T to be shared by the n factors so that $\Sigma C_m = T$. There are n equations like (1) for m varying from a to n. In order to find the proportion of the time that F_i is chosen in preference to all factors combined, sum the numerators of those n equations to find the total number of choices for F_i and sum the denominators to find a comparable estimate of the number of comparisons.

$$P_{i \text{ > composite standard}} = \frac{nC_i}{\Sigma(C_i + C_m)}$$

The denominator can be written as $nC_i + \Sigma C_m$, $\Sigma C_m = T$.

Therefore: $P_{i> cs} = \frac{nC_i}{nC_i + T}$

Dividing numerator and denominator by n,

$$P_{i>cs} = \frac{C_i}{C_i + \frac{T}{n}} \qquad (2)$$

The remaining task is to evaluate C_i for each factor. Each time a factor F_i is assigned to a rank value R_j, it is judged definitely greater than R_j-1 other factors and may be said to have received this many choices. If factor F_i is included, as it is in the composite standard, a half of choice must be added. The number of choices then becomes $R_j - .5$ for each placement of F_i. At each rank value the number of choices is $f_{ij}(R_j - 0.5)$. Summing over all m categories:

$$C_i = \sum_{j=m}^{n} [f_{ij}(R_j - 0.5)] = \sum_{j=m}^{n} f_{ij}R_j - 0.5 \sum_{j=m}^{n} f_{ij}$$

from which

$$C_i = \sum_{j=m}^{n} f_{ij}R_j - 0.5N_m$$

where N_m is the sum of all frequencies in the m categories for factor F_i.

Once C_i has been determined the value for equation (1) is easily computed. The normal deviate from the standard normal table is then determined from equation (2) for F_{ij} which is its scaled value. To determine the ranking R_i innumerable constants can be applied to the deviates to locate the 0 for the scale at any desired location. In making the computation it is easier to keep track of the steps by setting up a matrix as displayed in Figure 1.

	F_i	...	F_n	
$\Sigma f_{ij} R_j$				
.5N				
C_i				
$p_{i>cs}$				
$Z_{i>cs}$				
R_i				

Figure 1. Matrix to Aid in Computations for Partial-Ranking Method.

IV. RESULTS

The questionnaires used in the computations were those that were returned within thirty days of their distribution. The data regarding the returns are tabulated in Table II.

TABLE II

NUMBER OF QUESTIONNAIRES RETURNED

	Sent	Returned Completed	Returned Uncompleted	Returned Late	Percentage Returned
Local	21	13	1	1	71%
Fort Sill	80	19	5	-	30%
Camp Pendleton	15	7	-	-	46%
Camp Lejeune	15	6	-	1	46%
TOTAL	131	45	6	2	40%

The background information, for the respondents whose questionnaires were used in the computations, is listed in Table III.

There were several ways to present the results. The method chosen was to display the scales that were computed and to calculate correlation coefficients among the scales. There were many combinations of subsets of the data that could have been computed and displayed for comparison. Some of the subsets that could have been computed were Army, Marines, school trained, basic school only, and more experienced. The subset of "more experienced" would be an

TABLE III

BACKGROUND DATA OF RESPONDENTS

SERVICE: Marine 23, Army 22

RANK: Lt. 9, Capt. 21, Maj. 12, Lt.Col. 2, Col. 1

YEARS IN SERVICE (inclusive):

Years	Number
0 - 3	5
4 - 6	15
7 - 9	11
10 - 12	5
13 - 15	7
16 - 18	2
19 - 30	2

COMBAT EXPERIENCE: Yes 44, No 1

LOCATION OF COMBAT: Vietnam 41, Vietnam and Korea 2, Korea and W.W. II 1

POSITIONS:

	Combat	Other
1. S-3	1	3
2. FDO	3	1
3. AFDO	0	1
Btry.Cmdr.	5	2
FO	0	0
Other	7	2
Multiple among 1,2,3	1	0
Multiple including 1,2,3	22	30
Multiple excluding 1,2,3	5	6

FORMAL SCHOOLING:

Artillery Basic Course	18
Artillery Career Course	2
Both	22
Other	3

important consideration in analyzing the results. In the absence of more complete background data, more experienced were considered to be respondents who had greater than six years service and multiple positions among S-3, FDO, and AFDO. Only nine respondents fell into this subset. Consequently it was not appropriate for analysis.

A subset of school-trained respondents was then determined. A school-trained respondent was one that had completed both the basic and career artillery officers course. Twenty-two respondents fulfilled this requirement and will hereafter be referred to as "trained subjects." Another subset of respondents that had only attended the basic course was also determined. Eighteen respondents fulfilled this requirement. Because of the small number of respondents in each category, however, the scales obtained by the method of successive-categories are probably not as reliable as would be desired. The number of respondents was adequate for the partial-ranking method. The responses of all respondents, trained subjects, and basic school only subjects are summarized for each questionnaire situation in Appendix A.

The scales in Figures 2-7 are obtained by the method of successive-categories. The scales in Figure 8 are obtained by the method of partial-rank order.

Figures 2-4 display the scaled values with respect to importance of the factors and time demand of the factors for an area mission. The scaled values are based on the

responses of all of the subjects in Figure 2, trained subjects in Figure 3, and basic school only subjects in Figure 4.

Figures 5-7 display the scaled values with respect to importance of the factors and time demand of the factors for a precision mission. The scaled values are based on the responses of all the subjects in Figure 5, trained subjects in Figure 6, and basic school only subjects in Figure 7.

Figure 8 displays the scaled values with respect to importance of the factors for a precision mission. The scaled values are based on the responses of all the subjects, trained subjects, and basic school only subjects.

To display the results, all of the scales from the rank-order method were transformed to a common basis. This was accomplished by selecting the minimum computed value from these scales. This value was then transformed to zero to be used as the common zero point. The constant for this transformation was then applied to all of the other scale values. The scales computed by the method of successive-categories had the most important and most demanding factors at the lower end of the scales. Hence increasing importance and demand were indicated by decreasing values. In order to have all of the displayed scales consistent a graphical transformation was made to these scales. The important and demanding factors then appeared at the higher end of the scales and increasing importance and demand were indicated by increasing values.

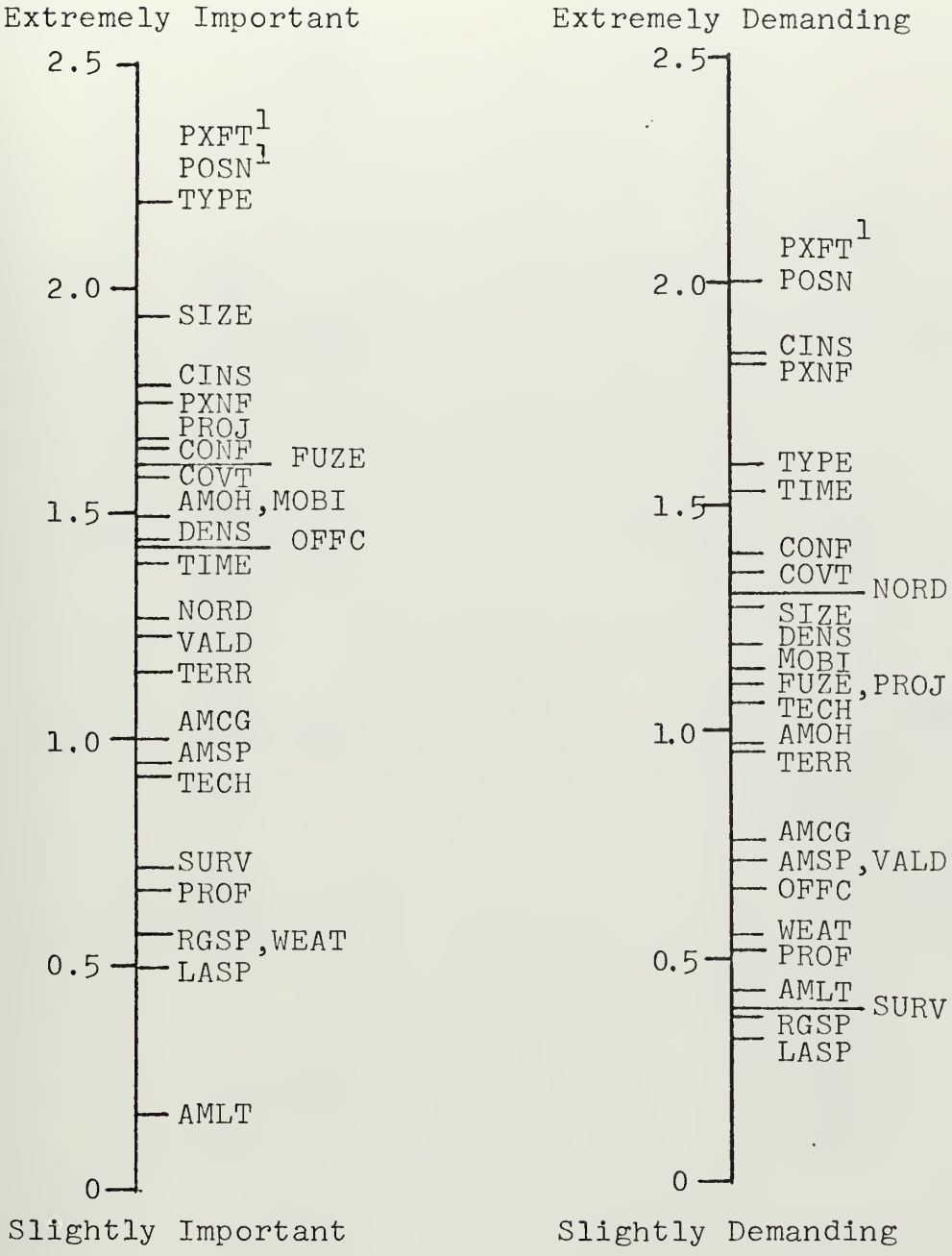

Figure 2. Scales of Factors for All Subjects for Area Missions with Respect to Importance and Time.

[1]This category had over 50% of the responses in an end point therefore its rank is valid but the interval scale is indeterminate.

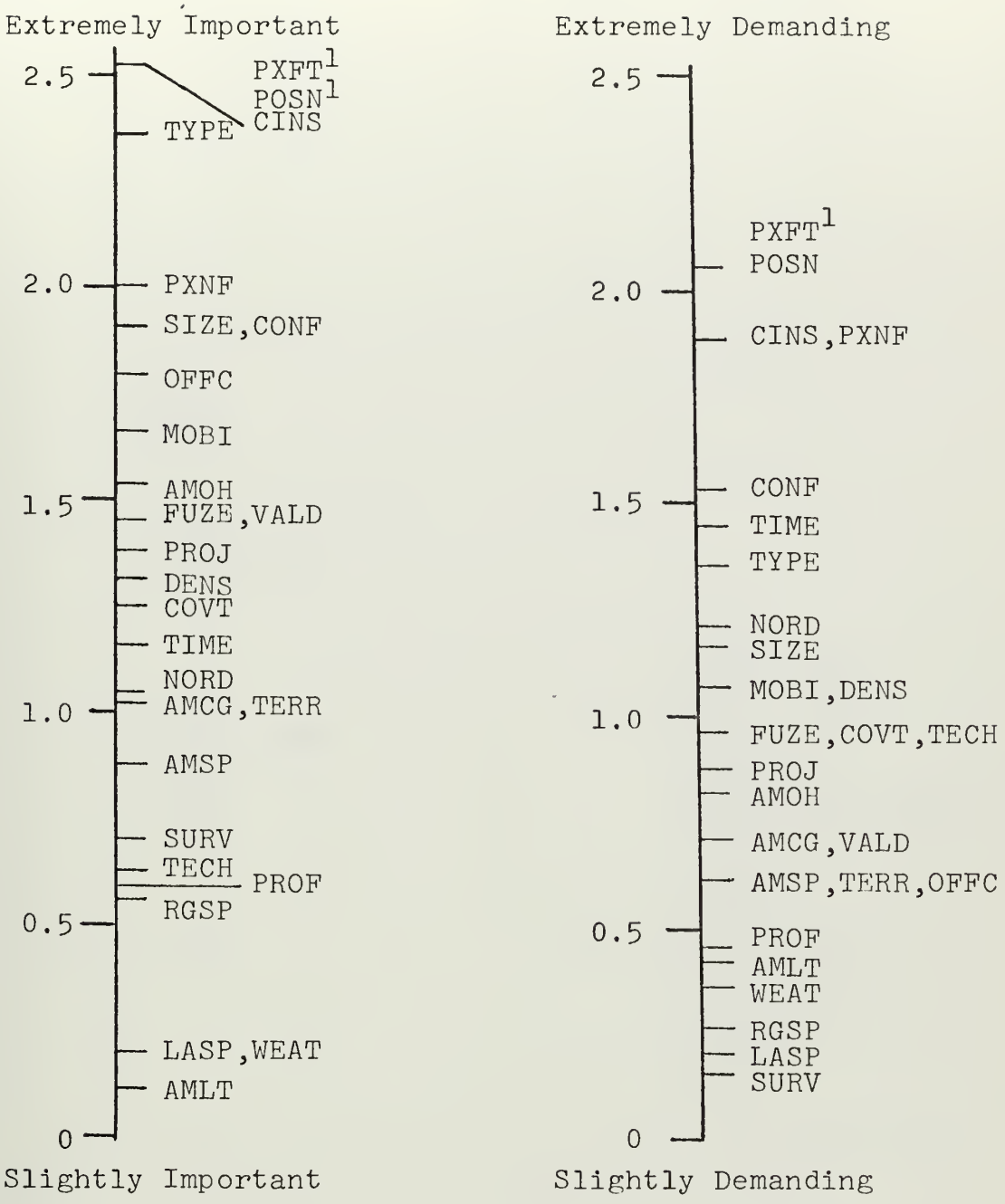

Figure 3. Scales of Factors for Trained Subjects for Area Missions with Respect to Importance and Time.

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[1]This category had over 50% of the responses in an end point therefore the rank is valid but the scale interval is indeterminate.

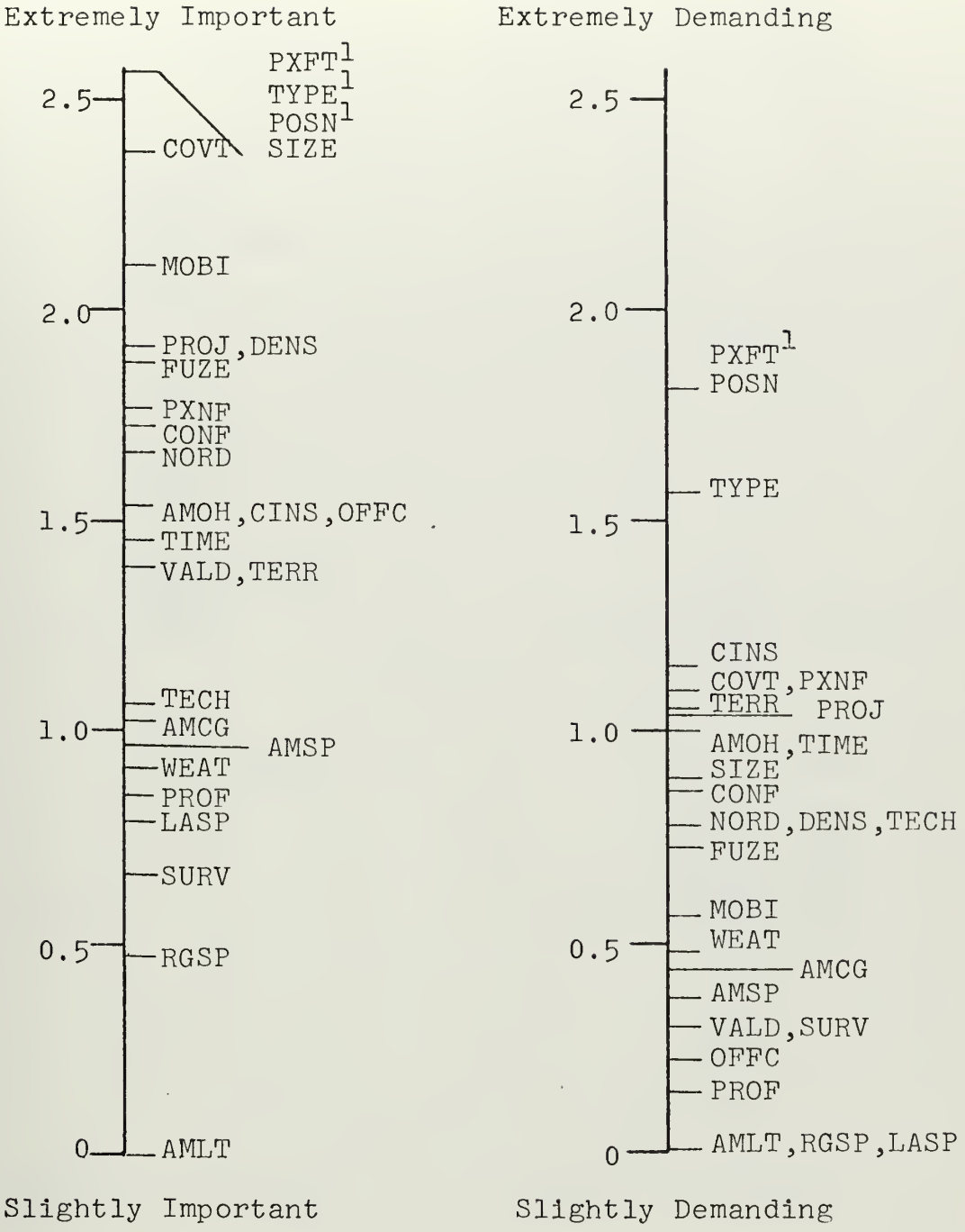

Figure 4. Scales of Factors for Basic School Subjects for Area Missions with Respect to Importance and Time.

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[1]This category had over 50% of the responses in an end point therefore its rank is valid but the interval is indeterminate.

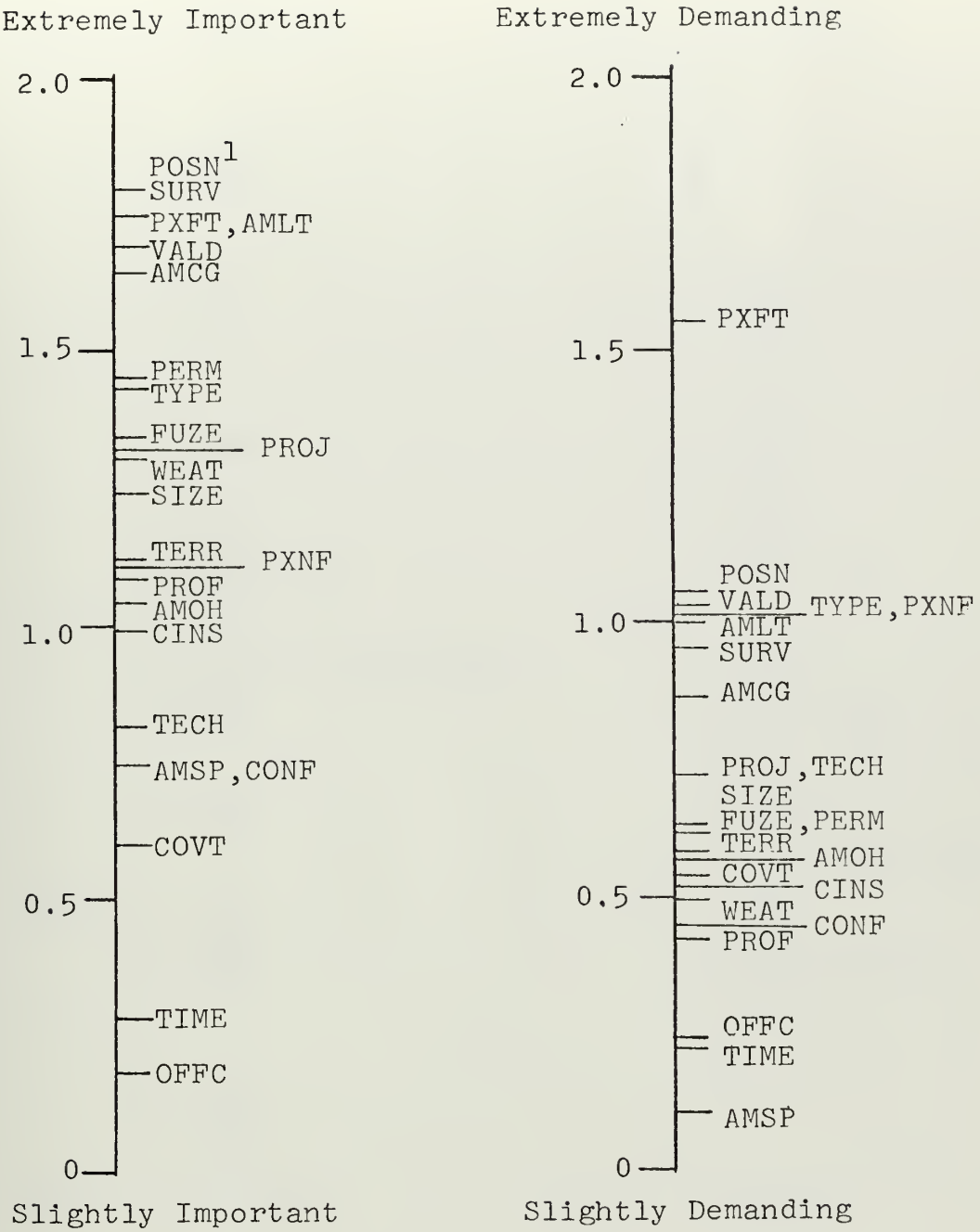

Figure 5. Scales of Factors for all Subjects for Precision Missions with Respect to Importance and Time.

[1]This category had over 50% of the responses in one end point therefore its rank is valid but the interval is indeterminate.

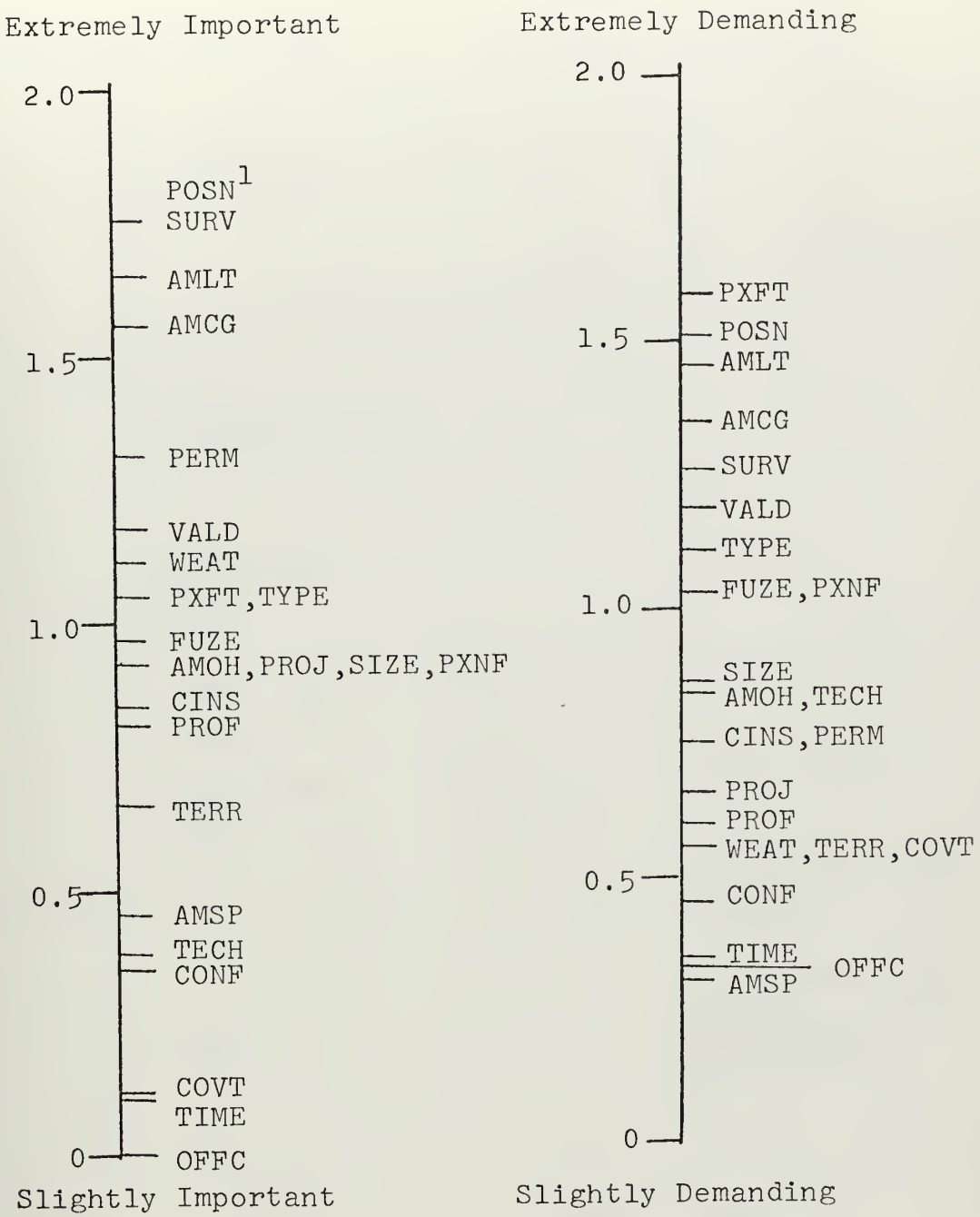

Figure 6. Scales of Factors for Trained Subjects for Precision Missions with Respect to Importance and Time.

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[1]This category had over 50% of the responses in one end point therefore its rank is valid but the interval is indeterminate.

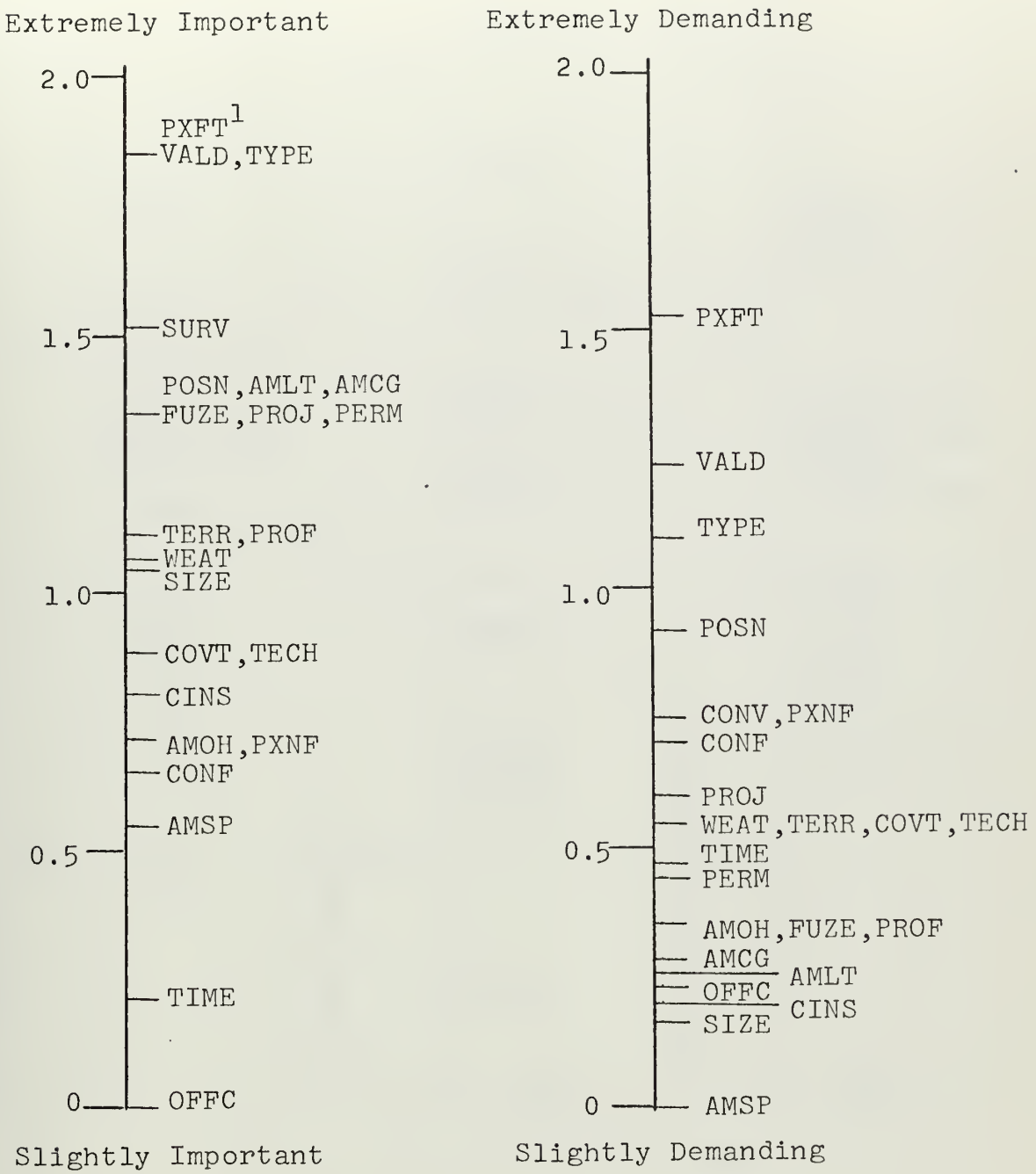

Figure 7. Scales of Factors for Basic School Subjects for Precision Mission with Respect to Importance and Time.

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[1]This category had over 50% of the responses in one end point therefore its rank is valid but the interval is indeterminate.

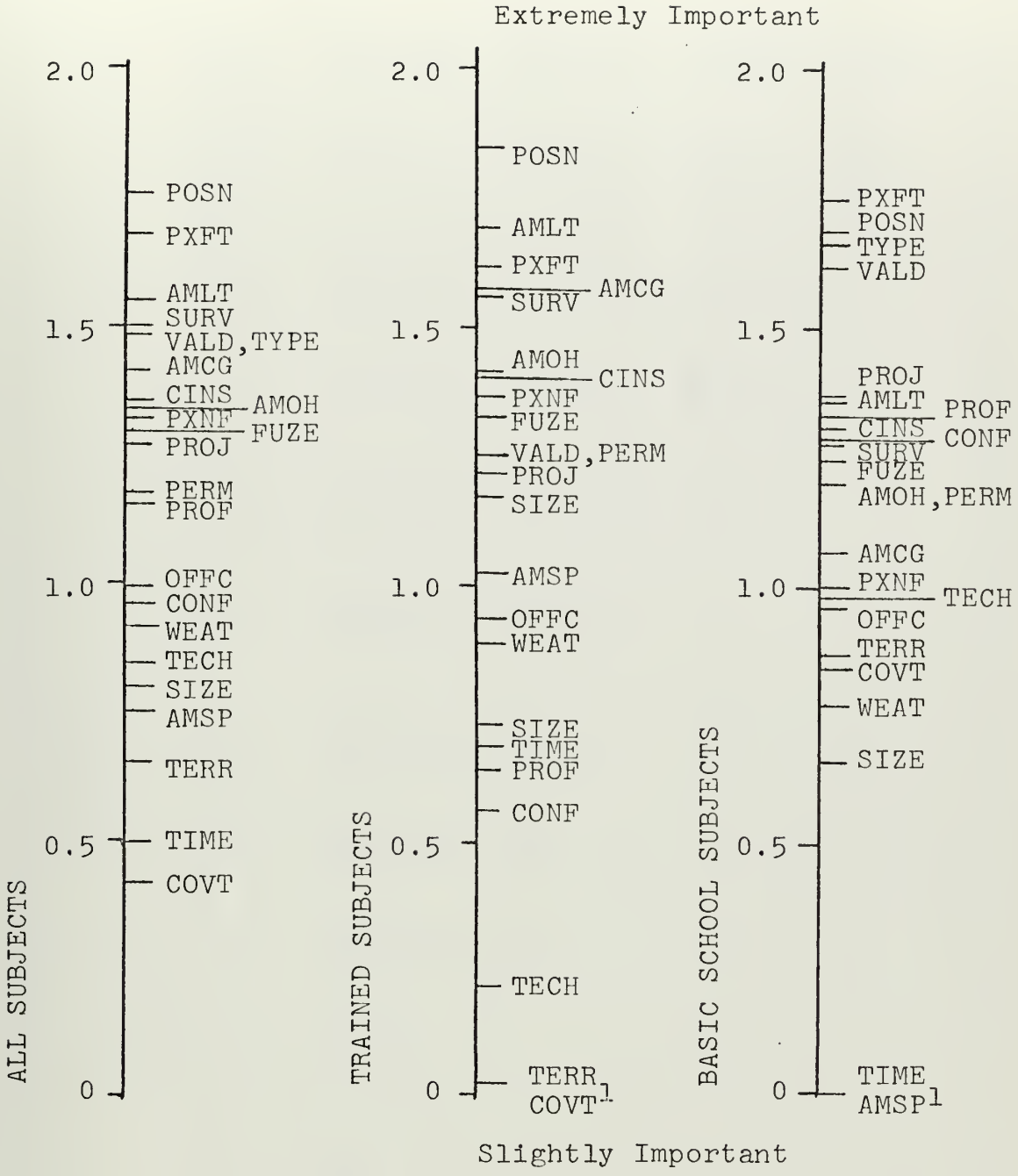


Figure 8. Scales of Factors Computed using the Partial Rank Order Method.

[1]This factor was selected an insufficient number of times to evaluate therefore its rank is valid but the interval is indeterminate.

TABLE IV

CORRELATION COEFFICIENTS FOR EACH SITUATION

Situation	1	2	3	4	5	6	7	8	9	10	11	12
Area Impt.												
1 All	1	.940	.925	.881	.854	.840	.348	.162	.100	.235	.125	.320
2 Trained		1	.840	.813	.819	.729	.149	.028	.044	.334	.248	.319
3 Basic			1	.788	.803	.780	.044	-.062	.121	.325	.237	.360
Area Time												
4 All				1	.978	.898	-.278	-.131	-.030	.266	.161	.341
5 Trained					1	.754	-.051	-.126	-.030	.286	.207	.190
6 Basic						1	.044	-.023	.078	.288	.165	.422
Prec.Impt.												
7 All							1	.952	.898	.811	.853	.423
8 Trained								1	.782	.718	.808	.297
9 Basic									1	.766	.762	.522
Prec.Time												
10 All										1	.913	.616
11 Trained											1	.392
12 Basic												1

The correlation coefficients, where each situation is correlated with the remaining situations, are displayed in Table IV. The correlation coefficients were calculated using the Spearman rank correlation coefficient [10]. The correlations were made based only on the common factors when area and precision scalings were correlated.

The correlation coefficients, determined by correlating the scaling obtained by the method of successive-categories and the scaling obtained by the partial-rank order method, are displayed in Table V. The Spearman rank correlation coefficient was again used.

TABLE V

CORRELATION COEFFICIENTS FOR THE TWO METHODS

		Partial Rank Order		
		All	Trained	Basic
Successive-Categories	All	.786	.707	.636
	Trained	.779	.764	.538
	Basic	.673	.477	.700

V. DISCUSSION OF RESULTS

By looking at the frequency matrices in Appendix A it was obvious that several of the distributions for the factors were not normal. Truncation was also evident, but it was not a problem in the method of successive-categories unless more than 50 per cent of the frequencies fell in an end category [1]. There were some distributions that fell in this category. For those factors a rank could be established but the interval value could not be determined.

Another deviation from normality was the presence of a few bimodal distributions. There were several factors that could lead to this type of distribution. One was the small number of subjects. Another was the background of the subjects. Still another was the general outline that was used to describe each situation. The individual subject had to interpret the situation his own way and did not have recourse to ask any questions for clarification. In addition, most of the subjects had experience in Vietnam where many of the factors that are considered important by doctrine were disregarded in actual practice with satisfactory results being obtained. Consequently there was a conflict in responding between doctrine as taught in school and practice in the field in a specific situation.

It is not known to what degree these deviations from normality may have affected the results, in the absence of discussion as to how robust these procedures are. Other

procedures based on normal distributions are generally robust. Also the procedures gave results that were reasonable.

Another consideration was for programming the procedure for a computer application. Sub-routines, for these procedures, were not found although they may be available. Although a large amount, of the work, was accomplished by a computer, a majority, of the computations, was done manually. Manual computations were required because some of the subjects inadvertently or on purpose left responses for some of the factors blank. Another reason, for the manual computations, was the decision to utilize the normal deviates corresponding to proportion below 0.05 or above 0.95. Finally the blanks that occurred in the computational matrix because of no responses in some particular location caused a problem. This was amplified because of the small number of subjects. These problems could have been overcome by an extensive programming effort.

With respect to the precision mission a few of the subjects indicated that both registration and destruction missions should not have been grouped together in the same situation since some of the considerations for these two types of missions differ. This was an appropriate observation because even though a registration and a destruction mission are both classified as precision missions, the objective that is to be achieved is different. Precision

missions should be divided into two situations - registration and destruction missions.

For the display of the scaled data there are methods by which a meaningful zero could have been obtained. However the desired results were the display of rank order and the relative scale values. The computation of a meaningful zero would not have added any information to these displays.

The Spearman rank correlation coefficient was used to test the null hypothesis that the scales obtained are unrelated. At the level of significance of $\alpha = .01$ the critical values, for rejecting the hypothesis, are 0.508 when an area and a precision mission are being correlated, 0.496 when two precision missions are correlated, and 0.457 when two area missions are correlated. Interesting general trends can be deducted from these figures.

An immediate result from the data in Table IV was the justification for separating the factors into two types of mission since in no case was there significant correlation between the scaling of an area mission and a precision mission.

It was also interesting to note that there was correlation between the scalings for importance and demand for time. The only place that this was not the case was in the correlation relating precision mission time (basic) to precision mission importance (all) and precision mission importance (trained). It is entirely possible that this was an effect of not dividing precision missions into registration and destruction missions.

The correlation between the trained subjects and the basic school subjects was significant except in the precision time situation. The factors that showed a great variation in scaling in this situation, were ammunition (lot) and ammunition (charge). This may have been due to the fact that a trained subject realizes there are fine points to be considered with respect to these factors and thus spends more time on them.

The correlations, that were determined by comparing the scalings obtained by the methods of successive-categories and partial-rank order, were significant. It cannot be stated which of these two methods is more accurate. In the interest of computational ease and a simplified procedure for the subject to indicate his judgment, the method of partial-rank order is recommended.

It is possible to investigate trends or anomalies for specific factors by using the scales displayed in Figures 2-8. One fact that can be determined in this manner is that trained subjects attach more importance to and spend more time considering current instructions from commander and higher headquarters then do the basic-school subjects. Another fact that becomes evident is the justification for breaking ammunition considerations into several categories, since the ranks for these factors cover a large range.

The overall results indicated that many general trends could be detected and specific comparisons could be made by using psychometric scaling procedures in studying artillery procedures.

APPENDIX A

TABULATION OF RESPONSE RESULTS

TABLE VI

FREQUENCY MATRIX FOR ALL SUBJECTS
FOR AREA MISSION IMPORTANCE

Extremely Important							Slightly Important			
24	5	7	0	5	1	2	0	0	0	Position of units available to fire
31	5	3	0	2	2	0	1	1	0	Proximity of friendly troops to the target
4	7	11	6	4	5	4	3	0	1	Ammunition (amount on hand)
2	2	6	7	7	7	2	4	3	5	Ammunition (supply available)
2	1	2	2	6	5	1	8	2	16	Ammunition (lot)
1	5	9	5	3	4	4	4	5	4	Ammunition (charge)
7	4	14	6	2	4	6	1	0	1	Fuze action
14	4	11	5	3	2	0	3	1	2	Current instructions from cmdr. and higher hq.
9	3	14	7	3	1	4	1	1	0	Projectile type
3	3	11	6	5	4	3	5	0	4	Validity of current corrections
0	4	7	3	5	7	5	3	3	8	Survey control
5	10	3	5	8	2	7	2	0	1	Number of rounds
0	3	4	8	1	7	1	4	4	13	Range spread
0	3	5	7	1	6	3	5	2	13	Lateral spread
0	1	2	7	6	7	0	9	3	10	Weather
4	5	8	5	8	3	3	4	3	2	Terrain
18	10	5	6	2	3	0	1	0	0	Type of target
14	8	7	9	4	2	0	1	0	0	Size of target
6	8	6	11	4	5	2	2	0	1	Density of target
10	7	4	8	3	7	2	1	1	1	Mobility of target
12	2	7	4	4	1	6	2	3	3	Offensive capability of target
9	7	7	5	6	3	2	1	2	2	Cover at target
12	6	9	3	1	2	2	4	0	6	Proximity of no fire areas
3	5	3	2	4	9	2	3	5	9	Proficiency of units available to fire
2	3	5	7	6	7	4	5	3	3	Technique of attach (low angle, high angle)
8	10	6	3	4	6	0	2	3	3	Conformity to scheme of maneuver of supported units
10	6	4	7	3	8	1	1	2	3	Time of opening fire

TABLE VII

FREQUENCY MATRIX FOR TRAINED SUBJECTS
FOR AREA MISSION IMPORTANCE

Extremely Important								Slightly Important		
13	3	3	0	2	0	0	0	0	0	Position of units available to fire
15	2	1	0	0	2	0	1	1	0	Proximity of friendly troops to the target
2	2	6	3	4	2	2	1	0	0	Ammunition (amount on hand)
0	2	3	4	2	3	2	2	1	3	Ammunition (supply available)
1	1	1	0	3	3	0	8	0	5	Ammunition (lot)
1	2	5	2	2	2	3	3	2	0	Ammunition (charge)
2	2	4	6	2	2	3	1	0	0	Fuze action
10	3	4	0	2	1	0	2	0	0	Current instructions from cmdr. and higher hq.
3	1	3	5	3	1	3	1	0	0	Projectile type
2	1	6	3	3	1	2	3	0	0	Validity of current corrections
0	1	4	1	3	4	3	0	2	4	Survey control
3	3	0	2	6	1	5	0	0	1	Number of rounds
0	2	0	5	0	5	0	3	1	6	Range spread
0	2	0	4	0	4	1	4	1	6	Lateral spread
0	0	1	2	2	6	0	5	0	6	Weather
1	2	4	2	4	3	1	2	2	1	Terrain
5	8	1	4	2	2	0	0	0	0	Type of target
3	6	3	5	3	1	0	1	0	0	Size of target
2	4	0	7	2	3	2	2	0	0	Density of target
4	3	3	5	0	3	2	0	1		Mobility of target
6	1	4	1	2	0	3	0	2	2	Offensive capability of target
2	1	5	3	2	3	0	1	2	2	Cover at target
8	2	2	2	1	2	2	1	0	2	Proximity of no fire areas
2	1	2	2	1	4	1	2	2	5	Proficiency of units available to fire
0	0	2	5	2	3	4	4	1	1	Technique of attack (low angle, high angle)
4	5	3	2	1	5	0	1	1	0	Conformity to scheme of maneuver of supported units
5	3	2	1	1	5	1	0	2	2	Time of opening fire

TABLE VIII

FREQUENCY MATRIX FOR BASIC-SCHOOL SUBJECTS
FOR AREA MISSION IMPORTANCE

Extremely Important							Slightly Important			
10	2	2	0	2	1	1	0	0	0	Position of units available to fire
11	3	2	0	2	0	0	0	0	0	Proximity of friendly troops to the target
0	5	4	2	0	2	2	2	0	1	Ammunition (amount on hand)
0	0	3	3	4	3	0	1	2	2	Ammunition (supply available)
1	0	1	2	3	1	1	0	0	9	Ammunition (lot)
0	2	3	3	1	2	1	0	2	3	Ammunition (charge)
4	2	8	0	0	1	3	0	0	0	Fuze action
4	0	5	4	1	1	0	1	1	1	Current instructions from cmdr. and higher hq.
5	1	9	2	0	0	1	0	0	0	Projectile type
1	2	5	3	0	3	1	1	0	2	Validity of current corrections
0	2	3	2	0	2	2	3	1	3	Survey control
1	6	2	2	2	0	2	2	0	0	Number of rounds
0	1	3	3	0	2	0	1	2	6	Range spread
0	1	4	3	0	2	0	1	1	6	Lateral spread
0	0	1	5	3	1	0	3	3	2	Weather
2	2	4	3	2	0	2	2	1	0	Terrain
11	2	3	1	0	1	0	0	0	0	Type of target
9	2	2	4	0	1	0	0	0	0	Size of target
4	3	6	3	1	1	0	0	0	0	Density of target
6	3	1	2	2	3	0	1	0	0	Mobility of target
5	1	3	1	1	0	3	2	1	1	Offensive capability of target
7	5	1	2	2	0	1	0	0	0	Cover at target
3	3	5	1	0	0	0	3	0	3	Proximity of no fire areas
1	3	1	0	3	4	0	0	3	3	Proficiency of units available to fire
1	3	2	2	3	2	0	1	2	2	Technique of attack (low angle, high angle)
3	4	3	1	2	0	0	1	2	2	Conformity to scheme of maneuver of supported units
4	3	1	5	1	2	0	1	0	1	Time of opening fire

TABLE IX

FREQUENCY MATRIX FOR ALL SUBJECTS
FOR AREA MISSION TIME

Extremely Demanding								Slightly Demanding		
19	4	5	1	3	4	2	2	1	4	Position of units available
31	4	2	3	1	1	1	1	0	1	Proximity of friendly troops to the target
4	5	4	5	2	3	5	7	2	8	Ammunition (amount on hand)
1	1	4	4	4	1	8	8	5	9	Ammunition (supply available)
1	0	2	1	1	3	7	9	5	15	Ammunition (lot)
2	4	3	2	1	7	5	7	4	10	Ammunition (charge)
2	5	6	4	3	8	6	6	2	3	Fuze action
13	8	4	3	3	0	1	3	4	6	Current instructions from cmdr. and higher hq.
5	5	2	7	2	5	5	6	4	4	Projectile type
3	1	2	3	2	4	8	6	6	10	Validity of current corrections
0	1	2	0	3	5	8	4	3	19	Survey control
4	2	7	5	9	4	6	2	2	4	Number of rounds
2	1	1	2	3	5	4	5	5	17	Range spread
2	1	1	2	3	4	4	5	6	17	Lateral spread
1	1	2	1	3	6	6	6	4	15	Weather
3	5	3	5	3	4	4	4	4	10	Terrain
11	8	3	3	5	5	2	2	2	4	Type of target
4	5	7	3	6	5	2	6	2	5	Size of target
3	2	6	3	9	5	0	8	2	7	Density of target
8	3	2	6	3	3	2	8	6	4	Mobility of target
8	4	1	2	3	2	3	7	4	11	Offensive capability of target
6	3	7	5	5	3	2	4	5	5	Cover at target
10	9	8	3	2	2	1	4	2	4	Proximity of no fire areas
1	4	4	1	3	2	3	9	4	14	Proficiency of units available to fire
4	1	5	3	8	3	6	5	2	8	Technique of attack (low angle, high angle)
8	5	7	2	5	4	2	3	4	5	Conformity to scheme of maneuver of supported units
14	3	5	1	3	4	2	5	1	7	Time of opening fire

TABLE X

FREQUENCY MATRIX FOR TRAINED SUBJECTS
FOR AREA MISSION TIME

Extremely Demanding									Slightly Demanding	
10	2	1	1	2	2	0	1	0	3	Position of units available to fire
16	1	1	2	0	0	0	1	0	1	Proximity of friendly troops to the target
2	2	1	2	1	2	4	3	1	4	Ammunition (amount on hand)
0	1	1	3	1	1	4	3	2	6	Ammunition (supply available)
1	0	2	0	1	1	2	6	3	5	Ammunition (lot)
1	2	2	1	0	3	3	4	1	5	Ammunition (charge)
2	2	2	2	1	4	3	5	0	1	Fuze action
7	4	3	1	2	0	0	0	2	3	Current instructions from cmdr. and higher hq.
3	1	1	1	1	4	4	3	2	2	Projectile type
1	0	2	3	1	2	3	4	1	5	Validity of current corrections
0	0	1	0	1	2	4	2	2	10	Survey control
2	1	3	3	4	2	4	1	0	2	Number of rounds
0	0	1	0	3	2	3	2	2	9	Range spread
0	0	1	0	3	1	3	2	3	9	Lateral spread
0	0	0	0	2	3	3	4	0	10	Weather
0	2	1	2	2	1	3	2	2	7	Terrain
5	3	1	2	3	4	1	0	2	1	Type of target
1	3	2	3	3	3	0	3	2	2	Size of target
0	1	5	3	3	1	0	4	2	3	Density of target
5	2	0	2	2	1	1	2	4	3	Mobility of target
5	1	0	0	2	2	1	2	2	7	Offensive capability of target
1	2	4	2	1	2	0	1	4	5	Cover at target
7	4	3	0	1	1	0	2	2	2	Proximity of no fire areas
1	1	2	0	1	2	2	4	1	8	Proficiency of units available to fire
2	1	3	0	5	0	3	3	0	5	Technique of attack (low angle, high angle)
5	1	5	1	2	2	2	1	2	1	Conformity to scheme of maneuver of supported units
7	2	2	0	1	2	2	2	0	4	Time of opening fire

TABLE XI

FREQUENCY MATRIX FOR BASIC-SCHOOL SUBJECTS
FOR AREA MISSION TIME

Extremely Demanding								Slightly Demanding		
9	1	4	0	0	2	1	1	0	0	Position of units available to fire
11	3	1	1	1	0	1	0	0	0	Proximity of friendly troops to the target
2	3	2	2	1	1	1	2	1	3	Ammunition (amount on hand)
0	0	2	1	3	0	4	2	3	3	Ammunition (supply available)
0	0	0	1	0	2	4	2	1	8	Ammunition (lot)
1	1	1	1	1	3	2	1	3	4	Ammunition (charge)
0	3	3	1	1	4	3	0	2	1	Fuze action
6	2	1	1	1	0	1	2	2	2	Current instructions from cmdr. and higher hq.
2	3	1	4	1	1	1	2	2	1	Projectile type
2	1	0	0	1	2	3	1	5	3	Validity of current corrections
0	1	1	0	2	3	2	1	1	7	Survey control
1	1	3	2	2	2	2	1	2	2	Number of rounds
2	1	0	2	0	2	1	1	3	6	Range spread
2	1	0	2	0	2	1	1	3	6	Lateral spread
1	1	2	1	1	2	3	0	4	3	Weather
2	3	2	3	1	2	1	0	2	2	Terrain
6	5	1	0	1	0	1	1	0	3	Type of target
3	2	3	0	2	1	2	2	0	3	Size of target
3	1	1	0	4	3	0	2	0	4	Density of target
3	1	1	3	0	1	1	5	2	1	Mobility of target
2	3	1	1	0	0	1	4	2	4	Offensive capability of target
5	1	2	3	2	0	2	2	1	0	Cover at target
1	5	2	3	1	1	1	2	0	2	Proximity of no fire areas
0	3	2	0	2	0	0	4	3	4	Proficiency of units available to fire
2	0	2	3	2	3	1	1	2	2	Technique of attack (low angle, high angle)
2	3	2	0	3	2	0	1	2	3	Conformity to scheme of maneuver of supported units
7	0	1	1	2	1	0	3	1	2	Time of opening fire

TABLE XII

FREQUENCY MATRIX FOR ALL SUBJECTS
FOR PRECISION MISSION IMPORTANCE

Extremely Important						Slightly Important				
23	3	8	3	4	1	0	0	2	1	Position of units available to fire
21	3	4	3	1	5	1	3	3	1	Proximity of friendly troops to the target
5	8	6	9	2	6	2	2	1	4	Ammunition (amount on hand)
2	7	6	4	5	3	7	5	0	6	Ammunition (supply available)
19	7	11	2	0	2	0	2	1	1	Ammunition (lot)
12	14	9	4	1	3	0	1	0	1	Ammunition (charge)
10	7	11	4	1	5	1	1	1	4	Fuze action
13	4	2	6	2	4	2	6	3	3	Current instructions from cmdr. and higher hq.
9	8	10	5	0	4	1	2	3	3	Projectile type
18	7	4	6	1	0	3	1	2	3	Validity of current corrections
20	6	5	4	3	2	1	2	0	2	Survey control
11	5	11	1	3	3	6	1	0	4	Weather
4	8	10	5	3	6	3	2	0	4	Terrain
14	7	6	4	8	0	2	1	0	3	Type of target or registration point
9	6	10	1	3	3	4	1	1	7	Size of target or registration point
14	7	7	7	4	1	2	0	0	3	Permanence of target or registration point
6	4	3	1	1	4	2	9	2	13	Offensive capability of target
6	5	3	2	5	4	3	5	4	7	Cover at target or registration point
7	8	7	4	4	2	4	4	1	4	Proximity of no fire areas
9	8	4	8	4	6	1	2	1	2	Proficiency of units available to fire
10	2	7	2	5	9	2	1	3	4	Technique of attack (low angle, high angle)
5	4	3	7	5	3	2	5	3	8	Conformity to scheme of maneuver of supported units
2	3	3	2	1	7	7	3	4	13	Time of opening fire

TABLE XIII

RANK FREQUENCY MATRIX FOR ALL SUBJECTS
FOR PRECISION MISSION IMPORTANCE

Number of times each factor ranked 1-10										
1	2	3	4	5	6	7	8	9	10	
10	8	4	3	2	2	2	1	1	1	Position of units available to fire
8	9	4	0	0	2	2	2	1	1	Proximity of friendly troops to the target
1	2	1	3	3	1	4	3	3	4	Ammunition (amount on hand)
0	1	2	1	0	1	1	1	1	0	Ammunition (supply available)
2	1	6	4	3	3	5	2	3	1	Ammunition (lot)
0	1	1	8	4	3	1	3	4	1	Ammunition (charge)
0	0	0	3	5	4	4	5	2	3	Fuze action
3	2	4	1	2	1	1	2	1	3	Current instructions from cmdr. and higher hq.
0	0	3	1	3	3	6	3	5	2	Projectile type
3	5	1	3	1	2	4	2	3	2	Validity of current corrections
4	2	4	2	2	4	1	1	5	2	Survey control
0	0	1	1	2	1	3	3	1	4	Weather
0	0	0	0	1	1	4	3	2	0	Terrain
6	2	2	2	4	1	2	1	1	2	Type of target or registration point
0	1	0	2	1	2	2	0	0	2	Size of target or registration point
2	1	3	0	2	2	1	1	3	2	Permanence of target or registration point
0	3	0	4	1	0	0	1	0	1	Offensive capability of target
0	1	0	0	1	2	0	0	1	2	Cover at target or registration point
0	1	3	5	4	2	0	3	0	2	Proximity of no fire areas
3	0	2	1	1	3	0	3	1	1	Proficiency of units available to fire
0	0	2	0	1	3	0	2	4	1	Technique of attack (low angle, high angle)
2	3	0	0	1	1	0	0	1	4	Conformity to scheme of maneuver of supported units
0	1	1	0	0	0	1	2	1	3	Time of opening fire

TABLE XIV

FREQUENCY MATRIX FOR TRAINED SUBJECTS
FOR PRECISION MISSION IMPORTANT

Extremely Important								Slightly Important		
13	2	4	0	2	0	0	0	0	1	Position of units available to fire
8	1	3	3	0	2	1	2	2	0	Proximity of friendly troops to the target
3	4	4	5	0	3	1	0	0	2	Ammunition (amount on hand)
1	3	4	1	2	1	5	1	0	4	Ammunition (supply available)
10	4	6	0	0	0	0	1	1	0	Ammunition (lot)
8	7	4	1	1	1	0	0	0	0	Ammunition (charge)
5	0	7	2	1	3	1	1	1	1	Fuze action
8	2	0	3	1	1	1	3	1	2	Current instructions from cmdr. and higher hq.
3	2	6	3	0	3	0	1	2	2	Projectile type
7	3	3	4	0	0	2	0	0	3	Validity of current corrections
11	2	2	1	2	0	0	2	0	2	Survey control
6	3	4	0	2	1	2	1	0	3	Weather
1	4	4	2	2	4	1	2	0	2	Terrain
4	5	3	3	3	0	0	1	0	3	Type of target or registration point
3	4	4	1	2	0	3	0	0	5	Size of target or registration point
6	5	4	3	2	0	0	0	0	2	Permanence of target or registration point
1	2	2	1	1	1	2	4	0	8	Offensive capability of target
2	2	0	1	2	2	2	3	2	5	Cover at target or registration point
6	3	2	2	2	1	2	2	1	1	Proximity of no fire areas
5	3	1	5	2	3	0	1	0	2	Proficiency of units available to fire
5	1	1	0	2	5	2	1	2	3	Technique of attack (low angle, high angle)
2	1	1	5	1	2	0	3	3	4	Conformity to scheme of maneuver of supported units
2	2	0	0	1	2	5	0	2	8	Time of opening fire

TABLE XV

RANK FREQUENCY MATRIX FOR TRAINED SUBJECTS
FOR PRECISION MISSION IMPORTANCE

Number of times each factor ranked 1-10										
1	2	3	4	5	6	7	8	9	10	
9	2	2	1	0	2	1	0	1	0	Position of units available to fire
2	5	2	0	0	1	1	1	0	1	Proximity of friendly troops to the target
1	1	1	2	1	0	2	1	3	1	Ammunition (amount on hand)
0	1	1	1	0	1	0	1	1	0	Ammunition (supply available)
1	1	5	2	2	2	2	1	1	0	Ammunition (lot)
0	1	1	5	1	3	1	2	1	0	Ammunition (charge)
0	0	0	1	4	1	2	3	1	1	Fuze action
2	2	1	0	2	0	0	1	1	1	Current instructions from cmdr. and higher hq.
0	0	0	0	2	2	3	2	3	1	Projectile type
0	1	1	1	0	1	3	1	2	1	Validity of current corrections
3	1	2	1	0	2	1	1	2	1	Survey control
0	0	0	1	1	0	2	2	0	2	Weather
0	0	0	0	0	0	0	3	1	0	Terrain
0	2	1	0	2	0	1	0	0	2	Type of target or registration point
0	0	0	1	1	1	1	0	0	1	Size of target or registration point
2	1	0	0	1	1	1	0	2	1	Permancence of target of registration point
0	1	0	3	0	0	0	0	0	1	Offensive capability of target
0	0	0	0	0	0	0	0	0	0	Cover at target or registration point
0	1	2	2	3	0	0	1	0	0	Proximity of no fire areas
0	0	1	0	0	2	0	0	1	1	Proficiency of units available to fire
0	0	0	0	0	2	0	0	1	1	Technique of attack (low angle, high angle)
1	0	0	0	1	0	0	0	0	3	Conformity to scheme of maneuver of support units
0	1	1	0	0	0	0	1	0	2	Time of opening fire

TABLE XVI

FREQUENCY MATRIX FOR BASIC-SCHOOL SUBJECTS
FOR PRECISION MISSION IMPORTANCE

Extremely Important						Slightly Important				
8	1	4	2	1	0	0	0	2	0	Position of units available to fire
10	2	1	0	1	2	0	1	1	0	Proximity of friendly troops to the target
1	4	2	2	1	2	1	2	1	2	Ammunition (amount on hand)
0	4	2	1	3	1	2	3	0	2	Ammunition (supply available)
6	3	5	1	0	1	0	1	0	1	Ammunition (lot)
2	7	5	1	0	1	0	1	0	1	Ammunition (charge)
2	7	3	2	0	1	0	0	0	3	Fuze action
5	1	2	2	1	2	0	3	2	0	Current instructions from cmdr. and higher hq.
4	5	3	2	0	0	1	1	1	1	Projectile type
9	4	1	1	1	0	1	0	1	0	Validity of current corrections
7	3	2	3	1	1	1	0	0	0	Survey control
5	1	5	1	1	2	3	0	0	0	Weather
3	4	4	2	1	1	2	0	0	1	Terrain
9	1	1	0	5	0	2	0	0	0	Type of target or registration point
5	2	3	0	1	3	1	0	1	2	Size of target or registration point
7	2	3	2	1	1	1	0	0	1	Permanence of target or registration point
4	2	1	0	0	0	0	5	1	5	Offensive capability of target
3	3	3	1	2	1	1	0	2	2	Cover at target or registration point
1	2	5	1	2	1	2	2	0	2	Proximity of no fire areas
3	5	2	2	1	3	0	1	1	0	Proficiency of units available to fire
3	1	5	1	2	4	0	0	1	1	Technique of attack (low angle, high angle)
3	2	2	1	4	0	1	2	0	3	Conformity to scheme of maneuver of supported units
0	1	3	2	0	3	1	3	1	4	Time of opening fire

TABLE XVII

RANK FREQUENCY MATRIX FOR BASIC-SCHOOL SUBJECTS FOR PRECISION MISSION IMPORTANCE

Number of times each factor ranked 1-10										
1	2	3	4	5	6	7	8	9	10	
1	5	2	1	2	0	0	1	0	0	Position of units available to fire
5	3	2	0	0	1	1	0	1	0	Proximity of friendly troops to the target
0	0	0	1	2	1	2	2	0	2	Ammunition (amount on hand)
0	0	0	0	0	0	1	0	0	0	Ammunition (supply available)
1	0	1	1	1	1	2	1	1	1	Ammunition (lot)
0	0	0	2	2	0	0	0	3	1	Ammunition (charge)
0	0	0	2	1	2	1	2	1	0	Fuze action
1	0	2	1	0	1	1	1	0	2	Current instructions from cmdr. and higher hq.
0	0	3	1	1	0	2	1	1	1	Projectile type
1	4	0	2	1	1	1	1	1	1	Validity of current corrections
0	0	2	1	2	1	0	0	2	1	Survey control
0	0	0	0	1	1	1	1	1	2	Weather
0	0	0	0	1	1	3	0	1	0	Terrain
6	0	0	2	0	1	1	1	1	0	Type of target or registration point
0	1	0	0	0	1	1	0	0	1	Size of target or registration point
0	0	3	0	1	1	0	1	1	0	Permanence of target or registration point
0	2	0	1	0	0	0	1	0	0	Offensive capability of target
0	1	0	0	1	1	0	0	1	2	Cover at target or registration point
0	0	0	2	1	1	0	1	0	2	Proximity of no fire areas
2	0	1	1	0	1	0	3	0	0	Proficiency of units available to fire
0	0	2	0	1	1	0	0	1	0	Technique of attack (low angle, high angle)
1	2	0	0	0	1	0	0	1	1	Conformity to scheme of maneuver of supported units
0	0	0	0	0	0	1	1	1	1	Time of opening fire

TABLE XVIII

FREQUENCY MATRIX FOR ALL SUBJECTS
FOR PRECISION MISSION TIME

Extremely Demanding									Slightly Demanding	
16	3	4	2	6	4	1	1	0	7	Position of units available to fire
21	5	2	0	4	2	1	3	2	5	Proximity of friendly troops to the target
2	6	5	5	5	4	3	5	2	8	Ammunition (amount on hand)
2	1	2	1	5	7	4	9	3	11	Ammunition (supply available)
8	6	9	4	1	4	6	4	1	2	Ammunition (lot)
7	4	8	6	4	6	5	1	2	2	Ammunition (charge)
3	7	6	5	2	4	5	4	1	8	Fuze action
10	4	1	6	1	4	2	5	5	7	Current instructions from cmdr. and higher hq.
4	5	9	4	2	3	5	2	2	9	Projectile type
16	4	3	4	2	3	3	5	1	4	Validity of current corrections
10	5	7	4	3	4	2	3	0	7	Survey control
6	0	6	5	4	5	2	5	3	9	Weather
6	2	6	5	4	3	6	2	4	7	Terrain
13	4	6	4	3	1	2	3	2	7	Type of target or registration point
6	3	5	3	8	1	4	5	0	10	Size of target or registration point
7	4	3	4	6	5	1	4	2	9	Permanence of target or registration point
6	2	2	2	4	5	3	6	4	11	Offensive capability of target
5	2	3	5	7	5	3	5	3	7	Cover at target or registration point
9	6	6	4	4	0	2	5	3	6	Proximity of no fire areas
5	7	0	4	3	5	5	2	4	9	Proficiency of units available to fire
6	5	3	7	6	2	5	2	1	8	Technique of attack (low angle, high angle)
5	5	4	4	2	4	4	6	2	8	Conformity to scheme of maneuver of supported units
5	6	3	2	2	1	6	9	3	8	Time of opening fire

TABLE XIX
FREQUENCY MATRIX FOR TRAINED SUBJECTS
FOR PRECISION MISSION TIME

Extremely Demanding								Slightly Demanding		
8	2	2	0	5	0	0	0	0	4	Position of units available to fire
10	1	1	0	3	1	0	2	1	3	Proximity of friendly troops to the target
1	3	2	3	3	0	2	2	1	5	Ammunition (amount on hand)
1	1	2	0	2	3	0	5	1	7	Ammunition (supply available)
6	3	5	3	0	2	1	2	0	0	Ammunition (lot)
6	2	4	3	3	2	0	0	0	2	Ammunition (charge)
3	3	3	2	1	2	2	1	0	5	Fuze action
5	1	1	3	1	2	1	3	1	4	Current instructions from cmdr. and higher hq.
2	2	3	2	2	0	4	0	0	7	Projectile type
7	1	2	3	1	1	0	3	0	4	Validity of current corrections
6	2	3	2	1	2	1	1	0	4	Survey control
1	0	4	1	2	3	2	1	2	6	Weather
2	1	1	4	1	2	3	0	3	5	Terrain
5	2	2	3	3	0	0	1	1	5	Type of target or registration point
2	3	2	1	5	0	1	3	0	5	Size of target or registration point
2	3	1	1	4	2	0	3	1	5	Permanence of target or registration point
3	0	0	0	3	3	1	3	3	6	Offensive capability of target
1	0	1	3	4	2	2	2	2	5	Cover at target or registration point
5	2	2	2	2	0	1	3	3	2	Proximity of no fire areas
3	3	0	1	1	3	3	1	1	5	Proficiency of units available to fire
4	1	1	3	3	0	3	1	0	6	Technique of attack (low angle, High angle)
2	2	1	2	0	2	3	5	0	5	Conformity to scheme of maneuver of supported units
2	2	1	1	1	1	2	4	2	6	Time of opening fire

TABLE XX

FREQUENCY MATRIX FOR BASIC-SCHOOL SUBJECTS
FOR PRECISION MISSION TIME

Extremely Demanding								Slightly Demanding	
8	0	2	1	0	3	1	1	0	2 Position of units available to fire
9	4	1	0	0	1	0	1	1	1 Proximity of friendly troops to the target
0	3	3	2	1	3	0	3	1	2 Ammunition (amount on hand)
0	0	0	1	3	3	3	4	1	3 Ammunition (supply available)
1	3	3	1	0	2	4	2	1	1 Ammunition (lot)
0	2	3	3	0	3	5	0	2	0 Ammunition (charge)
0	3	2	3	1	1	2	2	1	3 Fuze action
5	2	0	2	0	0	1	2	4	2 Current instructions from cmdr. and higher hq.
1	3	4	1	0	3	0	2	2	2 Projectile type
7	3	1	0	1	1	2	2	1	0 Validity of current corrections
3	3	3	1	2	2	0	2	0	2 Survey control
5	0	2	2	2	1	0	3	1	2 Weather
4	1	3	1	1	1	2	2	1	2 Terrain
7	2	2	0	0	0	2	2	1	2 Type of target or registration point
3	0	3	0	3	0	2	2	0	5 Size of target or registration point
4	0	2	2	2	1	1	1	1	4 Permanence of target or registration point
2	2	2	2	1	0	1	2	1	5 Offensive capability of target
3	2	2	2	3	1	1	1	1	2 Cover at target or registration point
3	4	2	2	1	0	1	2	0	3 Proximity of no fire areas
2	4	0	1	2	2	1	0	3	3 Proficiency of units available to fire
1	3	2	3	2	1	2	1	1	2 Technique of attack (low angle, high angle)
3	2	3	2	1	2	0	0	2	2 Conformity to scheme of maneuver of supported units
3	3	2	1	0	0	2	4	1	2 Time of opening fire

APPENDIX B

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA - 93940 IN REPLY REFER TO:

A STUDY OF THE DECISION MAKING PROCESS INVOLVED
IN FORMULATING THE S-3'S FIRE ORDER

For my thesis at the Naval Postgraduate School, I am making a study of the decision making process involved in formulating the S-3's fire order by using psychometric scaling procedures.

To accomplish this study two missions are considered, an area mission and a precision mission. For each mission a list of factors (not necessarily all inclusive) to be considered when formulating the order has been specified. First, for each mission, you are asked to rate the relative importance of each factor listed. Second, for each mission, you are asked to rate the relative amount of time that each factor demands in formulating your order.

Finally as a check on the consistency of the analytic procedure, the 10 most important factors are to be selected and ranked as to their importance using the list of factors for a precision mission.

In order to make the study valid, individual opinions of a large number of qualified officers are needed. A qualified officer is one that has had experience as an S-3, fire direction officer or assistant fire direction officer.

The important thing is that you indicate your thought on how you consider these factors when formulating your fire orders. Consequently, please do individual work and do not talk to others about the form until everyone has completed it.

If you should be given a form but you feel unqualified to complete it, simply note this on the form and return the blank form.

The thought and time that you spend in completing this form is deeply appreciated.

BACKGROUND DATA:

Service_____

Rank_____

Time In Service_____

COMBAT EXPERIENCE: Yes___, No___

If yes, Where: Vietnam___, Korea___, Other_____
(specify)

Position: S-3___, FDO___, Assist FDO___,

Btry Cmdr___, FO___, Other_____
(specify)

OTHER EXPERIENCE:

S-3___, FDO___, Assist FDO___, Btry Cmdr___, FO___, Other_____
(specify)

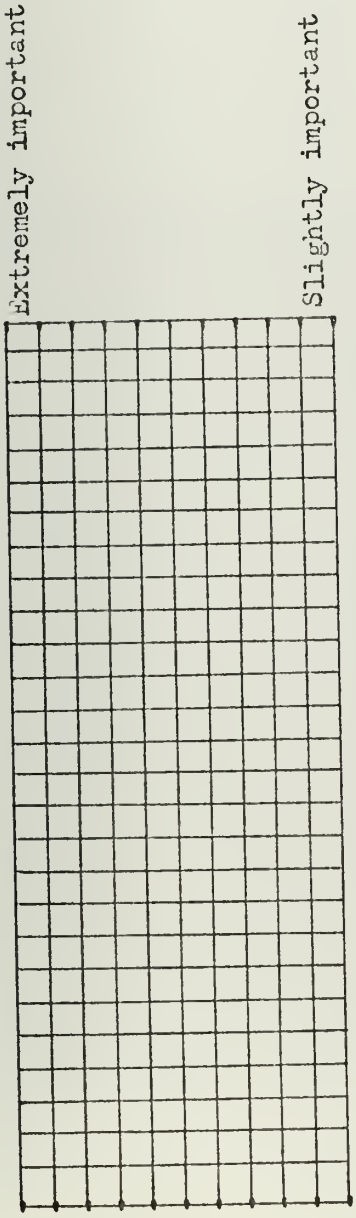
FORMAL SCHOOLING:

Artillery Basic Course_____

Artillery Career Course_____

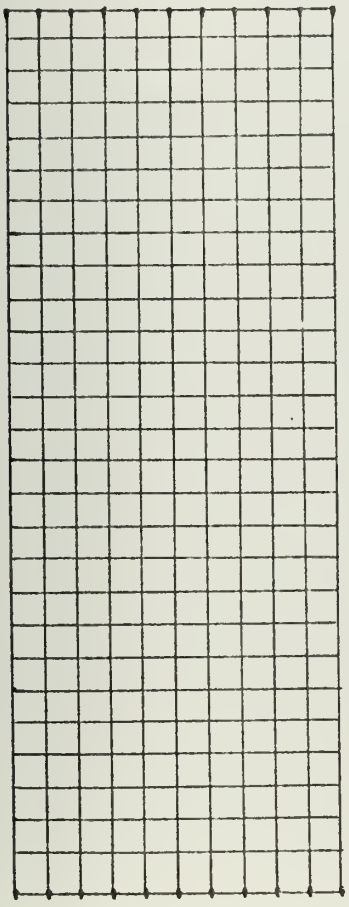
Other_____
(specify)

This is a list of some of the factors that an S-3 considers before issuing his fire order. A call for fire for an area mission has been received. If you were the S-3 of a direct support artillery battalion how would you rate the relative importance of each factor for being included in the decision making process to obtain your fire order? You might consider a factor to be "extremely important", "slightly important" or to fall some place between these two extreme positions. The relative importance can be indicated by placing an "x" in the block that you think will reflect the importance that you attach to each factor.



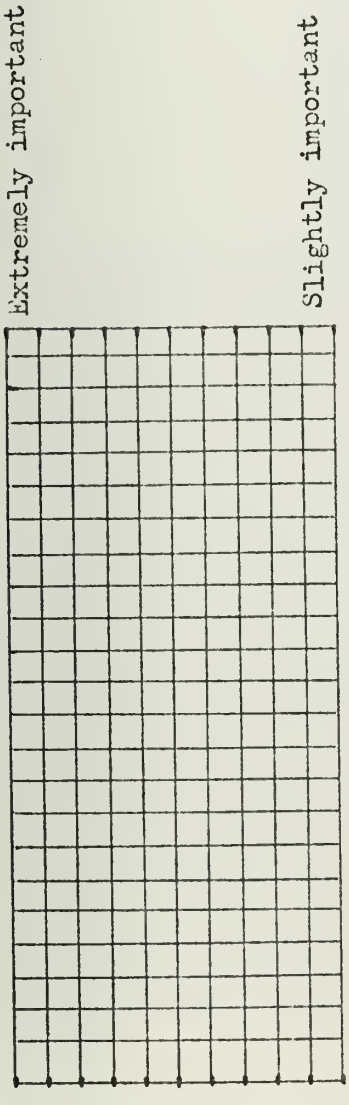
Position of units available to fire
Proximity of friendly troops to the target
Ammunition (amount on hand)
Ammunition (supply available)
Ammunition (lot)
Ammunition (charge)
Fuze action
Current instructions from commander and higher headquarters
Projectile type
Validity of current corrections
Survey control
Number of rounds
Range spread
Lateral spread
Weather
Terrain
Type of target
Size of target
Density of target
Mobility of target
Offensive capability of target
Cover at target
Proximity of no fire areas
Proficiency of units available to fire
Technique of attack (low angle, high angle)
Conformity to scheme of maneuver of supported units
Time of opening fire

The situation and the list of factors are the same as those of the preceeding page (area mission). The time available for the S-3 to make his decision is a major limitation. Considering this time limitation, how do you rate each factors demand for using this valuable time? You might consider a factor to be "extremely demanding", "slightly demanding" or to fall some place between these two extreme positions. The demand for time can be indicated by placing an "x" in the block that you think will reflect this demand.



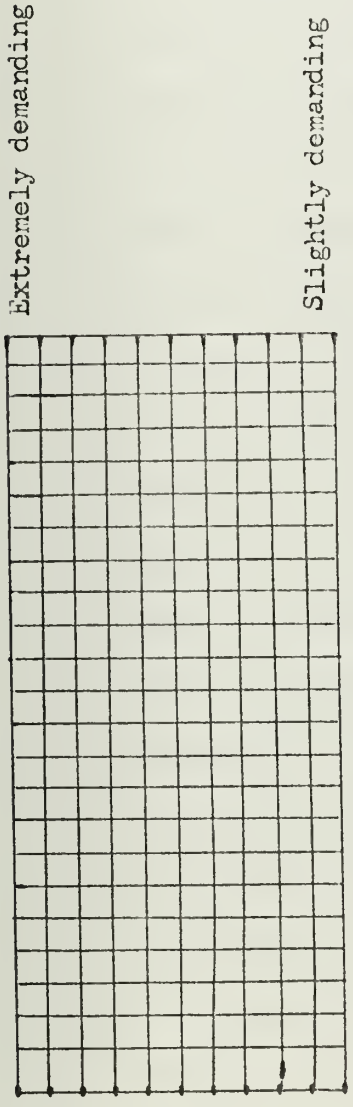
Position of units available to fire
Proximity of friendly troops to the target
Ammunition (amount on hand)
Ammunition (supply available)
Ammunition (lot)
Ammunition (charge)
Fuze action
Current instructions from commander and higher headquarters
Projectile type
Validity of current corrections
Survey control
Number of rounds
Range spread
Lateral spread
Weather
Terrain
Type of target
Size of target
Density of target
Mobility of target
Offensive capability of target
Cover at target
Proximity of no fire areas
Proficiency of units available to fire
Technique of attack (low angle, high angle)
Conformity to scheme of maneuver of supported units
Time of opening fire

The situation now changes in that a call for fire for a precision mission (registration or destruction) has been received. How would you rate the relative importance of each factor for being included in the decision making process to obtain your fire order? You might consider a factor to be "extremely important", "slightly important" or to fall some place between these two extreme positions. The relative importance can be indicated by placing an "x" in the block that you think will reflect the importance that you attach to each factor.



Position of units available to fire
Proximity of friendly troops to the target
Ammunition (amount on hand)
Ammunition (supply available)
Ammunition (lot)
Ammunition (charge)
Fuze action
Current instructions from commander and higher headquarters
Projectile type
Validity of current corrections
Survey control
Weather
Terrain
Type of target or registration point
Size of target or registration point
Permanence of target or registration point
Offensive capability of target
Cover at target or registration point
Proximity of no fire areas
Proficiency of units available to fire
Technique of attack (low angle, high angle)
Conformity to scheme of maneuver of supported units
Time of opening fire

The situation is still for a precision mission. The time available for the S-3 to make his decision is a major limitation. Considering this time limitation, how do you rate each factors demand for using this valuable time? You might consider a factor to be "extremely demanding", "slightly demanding" or to fall some place between these two extreme positions. The demand for time can be indicated by placing an "x" in the block that you think will reflect this demand.



Position of units available to fire
Proximity of friendly troops to the target
Ammunition (amount on hand)
Ammunition (supply available)
Ammunition (lot)
Ammunition (charge)
Fuze action
Current instructions from commander and higher headquarters
Projectile type
Validity of current corrections
Survey control
Weather
Terrain
Type of target or registration point
Size of target or registration point
Permanence of target or registration point
Offensive capability of target
Cover at target or registration point
Proximity of no fire areas
Proficiency of units available to fire
Technique of attack (low angle, high angle)
Conformity to scheme of maneuver of supported units
Time of opening fire

Finally, the situation is still a precision mission. In this case, select the 10 most important factors. Then rank these factors from 1 to 10. Assign the rank of 1 to the most important factor.

___Position of units available to fire

___Proximity of friendly troops to the target

___Ammunition (amount on hand)

___Ammunition (supply available)

___Ammunition (lot)

___Ammunition (charge)

___Fuze action

___Current instructions from commander and higher headquarters

___Projectile type

___Validity of current corrections

___Survey control

___Weather

___Terrain

___Type of target or registration point

___Size of target or registration point

___Permanence of target or registration point

___Offensive capability of target

___Cover at target or registration point

___Proximity of no fire areas

___Proficiency of units available to fire

___Technique of attack (low angle, high angle)

___Conformity of scheme of maneuver of supported units

___Time of opening fire

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13. ABSTRACT

The decision making process involved in formulating the S-3's fire order of a direct support artillery battalion was studied using psychometric scaling procedures.

Two missions were considered, an area mission and a precision mission. For each mission a list of factors usually considered when formulating the order was drawn up in questionnaire form. Each list was rated as to the relative importance of factors for being included in the decision making process and for the relative amount of time each demanded in the decision making process. The questionnaires were submitted to 131 subjects that were or had been S-3's and fire direction officers. Forty-five completed questionnaires were returned.

All lists were scaled using the method of successive-categories. As a check, one list was scaled using the method of partial-rank order. The resulting scales provide a means for comparing the importance and time demands of many critical factors according to mission type and according to the amount of formal training received by questionnaire respondents.

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FIRE DIRECTION OFFICER DECISION MAKING						
PSYCHOMETRIC SCALING						
S-3's FIRE ORDER						

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