GROUP #27 Wiki Final
Delcid, Cinderella
Fall, Jenna
Kelley, Amanda
Tran-Nguyen, Elizabeth

Verbal Working Memory

===Overview===

Verbal working memory is the set of related operations responsible for identifying linguistic elements that determine the interpreted meaning of a statement. Linguistic elements include [[phonemes]], [[morphemes]], [[syntax]], [[semantics]], and [[pragmatics]]. Verbal working memory is specialized in the comprehension of complex sentences by assigning [[syntactic structure]] and using it to determine the meaning of a sentence. <ref> Caplan, D., and Waters, G. S. (1999). “Verbal Working Memory and Sentence Comprehension.” *Behavioral and Brain Sciences*, **22**(1), 77-94. doi:10.1073/pnas.95.3.876. </ref> The two mechanisms used by verbal working memory are interpretive processing and post-interpretive processing. Interpretive processing is the process of using features like [[part of speech]] to apply [[syntactic structure]] to sentences. During post-interpretive processing, the derived meaning is used for other tasks, such as storing information in long-term [[semantic memory]], reasoning, and planning actions. Verbal working memory is a form of [[working memory]], a short-term system that stores and manipulates limited information in order to carry out a task. <ref> Caplan, D., and Waters, G. S. (1999). “Verbal Working Memory and Sentence Comprehension.” *Behavioral and Brain Sciences*, **22**(1), 77-94. doi:10.1073/pnas.95.3.876. </ref> Verbal working memory is also affected by attentional systems and [[perception]], which can influence how a statement is stored and interpreted. <ref> Hulme, C., and Roodenrys, S. (1995) “Practitioner Review: Verbal Working Memory Development and its Disorders.” *Journal of Child Psychology and Psychiatry* **36** (3), 373-398. doi:10.1111/j.1469-7610.1995.tb01297.x. </ref> Verbal working memory develops as speech rate and memory span develop because it allows speech sounds to be rehearsed more quickly within an [[articulatory loop]]. It also develops along with improvements in [[cognition]], [[speech production]] mechanisms, and [[speech perception]] mechanisms. <ref> Hulme, C., and Roodenrys, S. (1995) “Practitioner Review: Verbal Working Memory Development and its Disorders.” *Journal of Child Psychology and Psychiatry* **36** (3), 373-398. doi:10.1111/j.1469-7610.1995.tb01297.x. </ref> The standard method of assessing verbal working memory is the [[reading-span task]], in which subjects are required to read aloud increasingly long sequences of sentences and to recall the final word of all the sentences in each sequence. A subject’s verbal working memory capacity is defined as the longest list length at which he or she is able to recall the last words on the majority of trials. <ref> Caplan, D., and Waters, G. S. (1999). “Verbal Working Memory and Sentence Comprehension.” *Behavioral and Brain Sciences*, **22**(1), 77-94. doi:10.1073/pnas.95.3.876. </ref>

===History and Background===

The term [[working memory]] was first used by [[Miller]], [[Galanter]] and [[Pribram]] to describe a short term storage space where plans are kept while they are being executed. <ref> {{cite book|last1=Miller |first1=G.A | last2=Galanter| first2=E | last3=Pribram |first3=K.H | title=‘’Plans and the Structure of Behavior.’’| year=1960 | location=New York | publisher=Rinehart Holt and Winston |isbn=0-03-010075-5 | pages=65}. </ref> In 1968, [[Atkinson]] and [[Shiffrin]] called working memory the short term store (STS); they created a [[model]] of the memory system in which environmental input stimulates [[sensory receptors]] and enters into [[sensory memory]] where information is detected and held for use in the STS. If information in the long term store (LTS), which is relatively permanent, is associated with information in the STS, it may be activated and enter the STS as well. Through rehearsal, information in the STS may be transferred to the LTS. <ref> Atkinson, R.C., & Shiffrin, R.M. (1968). “Human Memory: A Proposed System and Its Control Processes.” In K.W. Spence & J.T. Spence (Eds.), *The Psychology of Learning and Motivation Vol. 2*. (pp. 89-191). New York, NY: Academic Press. </ref> [[Baddeley]] and [[Hitch]] introduced two new subsystems overseen by a central executive in their [[model]] of working memory—the phonological loop (PL) which stores phonological information, and the visuo-spatial scratchpad, which is in charge of visual and spatial information. <ref> Baddeley, A.D. (1983). “Working Memory in Children.” *Philosophical Transactions of the Royal Society of London*, **302** (1110), 311-324. doi:10.1098/rstb.1983.0057. </ref> In 1983, Hitch and Halliday applied this model to children as well, after finding that children and adults’ memory span for words is affected by word length in the same way. The way that this model is implemented however, changes with development, they also found that older children use the PL to store picture names while younger children may use the visuo-spatial scratch pad. <ref> Hitch, G.J., Halliday, M.S., Hulme, C., Le Voi, M.E., Routh, D.A, Conway, A. (1983). “Working Memory in Children.” *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, **302** (1110), 325-340. doi:10.1098/rstb.1983.0058. </ref> Additionally, Siegel and Ryan found that in both normally achieving children and reading disabled children, there is an “age-related growth in working memory abilities.” <ref> Siegel, L.S., Ryan, E.B. (1989). “The Development of Working Memory in Normally Achieving and Subtypes of Learning Disabled Children.” *Child Development*, **60** (4), 973-980. doi:10.2307/1131037. </ref>

===Modern and Current Research===

Many theories have been proposed for verbal working memory to explain how working memory processes, maintains, and retrieves information in the brain. [[Baddeley and Hitch]]'s earlier model of [[multicomponent of working memory]] was extended by [[Cowan]], who suggested that working memory was a subset of the long-term memory store. [[Ericsson and Kintsch]] further proposed the addition of long-term working memory, which links long-term memories to short-term memories with retrieval structures.

Recent research has questioned the [[capacity]] of verbal working memory. Previous studies have found constraints on working memory, possibly due to limited mental resources that are shared between processing and storage components. Similarities of working memory and its development have shown that limited mental resources are shared between processing and storage components. <ref> Towse, J.N., Hitch, G.J., Hutton, U. (1998). "A Reevaluation of Working Memory Capacity in Children." *Journal of Memory and Language*, **39** (2):195-217, ISSN 0749-596X, doi:10.1006/jmla.1998.2574 .</ref> The role of temporal factors was based on time elapsed investigated in depth by varying tasks that required children to memorize a number of words. The overall tasks, such as counting span, operation span and reading span were all kept at the same level of difficulty. <ref> Towse, J.N., Hitch, G.J., Hutton, U. (1998). "A Reevaluation of Working Memory Capacity in Children." *Journal of Memory and Language*, **39** (2):195-217, ISSN 0749-596X, doi:10.1006/jmla.1998.2574. </ref> The results in this article suggested that children's retention declined while there was no effect in storage loads and processing speed, but that it is difficult to know the capacity of working memory because it varies in individuals. <ref>Towse, J.N., Hitch, G.J., Hutton, U. (1998). "A Reevaluation of Working Memory Capacity in Children." *Journal of Memory and Language*, **39** (2):195-217, ISSN 0749-596X, doi:10.1006/jmla.1998.2574. </ref> A model introduced to explain these memory capacity findings was the ''[[*time-based resource sharing model*]]''. <ref> Barrouillet, Pierre; Bernardin, Sophie; Camos, Valérie. (2004). "Time Constraints and Resource Sharing in Adults' Working Memory Spans." *Journal of Experimental Psychology: General* **133** (1):, 83-100. doi:10.1037/0096-3445.133.1.83. </ref> The model assumes that both processing and maintenance components of the main working memory tasks require attention and that memory traces decay as soon as attention is switched away. <ref> Barrouillet, Pierre; Bernardin, Sophie; Camos, Valérie. (2004). "Time Constraints and Resource Sharing in Adults' Working Memory Spans." *Journal of Experimental Psychology: General* **133** (1):, 83-100. doi:10.1037/0096-3445.133.1.83. </ref>

Imaging studies of verbal working memory show evidence of developmental changes in brain processes. Electrical activity in the brain during [[higher-order cognitive processing]], studied via [[EEG]], has been found to increase in power and coherence over the course of development. <ref> 10. Bell, M. A. and Wolfe, C.D. (2007). "Changes in Brain Functioning from Infancy to Early Childhood: Evidence from EEG Power and Coherence during Working Memory Tasks." *Developmental Neuropsychology* **31**(1), 21-38.doi:10.1080/87565640709336885. </ref> Improvements in working memory in early childhood correlate with greater volume in the [[fronto-parietal cortices]], suggesting a structural link. <ref> Tamnes, C.K., Walhovd, K.B., Grydeland, H., Holland, D., Ostby, Y., Dale, A.M., and Fjell, A.M. (2013). "Longitudinal Working Memory Development is Related to Structural Maturation of Frontal and Parietal Cortices." *Journal of Cognitive Neuroscience* **25** (10), 1611-1623. doi:10.1162/jocn_a_00434. </ref> [[PET (positron emission tomography)]] evidence has suggested that [[inhibition]] is also closely linked to verbal working memory. <ref> Jonides, J., Smith, E.E., Marshuetz, C., Koeppe, R.A., and Reuter-Lorenz, P.A. (1998). "Inhibition in Verbal Working Memory Revealed by Brain Activation." *Proceedings of the National Academy of Sciences* **95** (14): 8410-8413. doi:10.1073/pnas.95.14.8410. PMID: 9653200. </ref> Inhibition in verbal working memory is associated with a lateral portion of the [[left prefrontal cortex]]. The article provides behavioral evidence of a verbal working memory task that engaged inhibitory processing. The task in which subjects engaged was item recognition where subjects had to inhibit a response that was prepotent compared with a condition in which no prepotent response was created. <ref> Jonides, J., Smith, E.E., Marshuetz, C., Koeppe, R.A., and Reuter-Lorenz, P.A. (1998). "Inhibition in Verbal Working Memory Revealed by Brain Activation." *Proceedings of the National Academy of Sciences* **95** (14): 8410-8413. doi:10.1073/pnas.95.14.8410. PMID: 9653200. </ref>
Inhibitory processing represents verbal working memory in this particular task mentioned because it requires the subjects to give a verbal response where they need to inhibit a target letter and give an accurate response. Inhibitory processing correlates with verbal working memory by inhibiting a target production or internal representation. <ref> Jonides, J., Smith, E.E., Marshuetz, C., Koeppe, R.A., and Reuter-Lorenz, P.A. (1998). "Inhibition in Verbal Working Memory Revealed by Brain Activation." *Proceedings of the National Academy of Sciences* **95** (14): 8410-8413. doi:10.1073/pnas.95.14.8410. PMID: 9653200. </ref>

===Relation to Other Developing Abilities===

The maturation of working memory plays a role in multiple developing processes, contributing both to developmental [[learning disabilities]] and maturing social skills like [[Theory of Mind]]. Verbal working memory deficits are strongly associated with poor math abilities and with learning disabilities like [[dyslexia]], which causes reading difficulty. <ref> Hulme, C., and Roodenrys, S.

(1995) “Practitioner Review: Verbal Working Memory Development and its Disorders.” *Journal of Child Psychology and Psychiatry* **36** (3), 373-398. doi:10.1111/j.1469-7610.1995.tb01297.x. </ref> [[Specific Language Impairment]] (SLI), which manifests as abnormal speech development in children, has also been associated with verbal working memory, most likely because working memory facilitates word learning. <ref> Hulme, C., and Roodenrys, S. (1995) “Practitioner Review: Verbal Working Memory Development and its Disorders.” *Journal of Child Psychology and Psychiatry* **36** (3), 373-398. doi:10.1111/j.1469-7610.1995.tb01297.x. </ref> <ref> Montgomery, J. W. (2003). “Working Memory and Comprehension in Children with Specific Language Impairment: What We Know so Far.” *Journal of Communication Disorders* **36** (3), 221-231. doi:10.1016/S0021-9924(03)00021-2. </ref> Verbal working memory tasks have been used as part of the battery of tests used to diagnose SLI. <ref>Gathercole, S.E., Alloway, T.P., Willis, C., and Adams, A.M. (2006). “Working Memory in Children with Reading Disabilities.” *Journal of Experimental Child Psychology* **93** (3), 265-281. doi:10.1016/j.jecp.2005.08.003. </ref> However, the effects of verbal working memory performance on language and arithmetic ability can be separated from the effects of other measures of memory, suggesting that verbal working memory is only one of multiple factors that contribute to learning disabilities. <ref>Gathercole, S.E., Alloway, T.P., Willis, C., and Adams, A.M. (2006). “Working Memory in Children with Reading Disabilities.” *Journal of Experimental Child Psychology* **93** (3), 265-281. doi:10.1016/j.jecp.2005.08.003. </ref> Another developmental skill affected by verbal working memory is Theory of Mind. In children, the maturation of working memory and cognitive inhibition have been implicated in development of Theory of Mind. <ref>Carlson, S.M., Moses, L.J., and Breton, C. (2002). “How Specific is the Relation between Executive Function and Theory of Mind? Contributions of Inhibitory Control and Working Memory.” *Infant and Child Development* **11** (2), 73-92.doi:10.1002/icd.298. </ref> This association is supported by similar [[event-related potentials]] that have been observed in both Theory of Mind tasks and verbal working memory tasks. <ref> Liu, D., Sabbagh, M.A., Gehring, W.J., Wellman, H.M. (2009). “Neural Correlates of Children’s Theory of Mind Development.” *Child Development* **80** (2), 318-326. doi:10.1111/j.1467-8624.2009.01262.x. </ref>

==References==

{{Reflist}}

1. Caplan, D., and Waters, G. S. (1999). “Verbal Working Memory and Sentence Comprehension.” *Behavioral and Brain Sciences*, **22**(1), 77-94. doi:10.1073/pnas.95.3.876.

2. Hulme, C., and Roodenrys, S. (1995) “Practitioner Review: Verbal Working Memory Development and its Disorders.” *Journal of Child Psychology and Psychiatry* **36** (3), 373-398. doi:10.1111/j.1469-7610.1995.tb01297.x

3. Miller, G.A., Galanter, E., Pribram, K.H. (1960). *Plans and the Structure of Behavior*. New York: Holt, Rinehart and Winston. pp. 65. Available from https://archive.org/details/plansstructureof00mill.

4. Atkinson, R.C., & Shiffrin, R.M. (1968). “Human Memory: A Proposed System and Its Control Processes.” In K.W. Spence & J.T. Spence (Eds.), *The Psychology of Learning and Motivation Vol. 2.* (pp. 89-191). New York, NY: Academic Press.

5. Baddeley, A.D. (1983). “Working Memory in Children.” *Philosophical Transactions of the Royal Society of London*, **302** (1110), 311-324. doi:10.1098/rstb.1983.0057.

6. Hitch, G.J., Halliday, M.S., Hulme, C., Le Voi, M.E., Routh, D.A, Conway, A. (1983). “Working Memory in Children.” *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, **302** (1110), 325-340. doi:10.1098/rstb.1983.0058.

7. Siegel, L.S., Ryan, E.B. (1989). “The Development of Working Memory in Normally Achieving and Subtypes of Learning Disabled Children.” *Child Development*, **60** (4), 973-980. doi:10.2307/1131037.

8. Barrouillet, Pierre; Bernardin, Sophie; Camos, Valérie. (2004). “Time Constraints and Resource Sharing in Adults' Working Memory Spans.” *Journal of Experimental Psychology: General* **133** (1):, 83-100. doi:10.1037/0096-3445.133.1.83

9. Towse, J.N., Hitch, G.J., Hutton, U. (1998). “A Reevaluation of Working Memory Capacity in Children.” *Journal of Memory and Language*, **39** (2):195-217, ISSN 0749-596X, doi:10.1006/jmla.1998.2574.

10. Bell, M. A. and Wolfe, C.D. (2007). “Changes in Brain Functioning from Infancy to Early Childhood: Evidence from EEG Power and Coherence during Working Memory Tasks.” *Developmental Neuropsychology* **31**(1), 21-38.doi:10.1080/87565640709336885

11. Tamnes, C.K., Walhovd, K.B., Grydeland, H., Holland, D., Ostby, Y., Dale, A.M., and Fjell, A.M. (2013). “Longitudinal Working Memory Development is Related to Structural Maturation of Frontal and Parietal Cortices.” *Journal of Cognitive Neuroscience* **25** (10), 1611-1623. doi:10.1162/jocn_a_00434.

12. Jonides, J., Smith, E.E., Marshuetz, C., Koeppe, R.A., and Reuter-Lorenz, P.A. (1998). “Inhibition in Verbal Working Memory Revealed by Brain Activation.” *Proceedings of the National Academy of Sciences* **95** (14): 8410-8413. doi:10.1073/pnas.95.14.8410. PMID: 9653200.

13. Montgomery, J. W. (2003). “Working Memory and Comprehension in Children with Specific Language Impairment: What We Know so Far.” *Journal of Communication Disorders* **36** (3), 221-231. doi:10.1016/S0021-9924(03)00021-2

14. Gathercole, S.E., Alloway, T.P., Willis, C., and Adams, A.M. (2006). “Working Memory in Children with Reading Disabilities.” *Journal of Experimental Child Psychology* **93** (3), 265-281. doi:10.1016/j.jecp.2005.08.003

15. Carlson, S.M., Moses, L.J., and Breton, C. (2002). “How Specific is the Relation between Executive Function and Theory of Mind? Contributions of Inhibitory Control and Working Memory.” *Infant and Child Development* **11** (2), 73-92.doi:10.1002/icd.298

16. Liu, D., Sabbagh, M.A., Gehring, W.J., Wellman, H.M. (2009). “Neural Correlates of Children’s Theory of Mind Development.” *Child Development* **80** (2), 318-326. doi:10.1111/j.1467-8624.2009.01262.x

Further Reading

<ref> Engel de Abreu, P.M.J, Conway, A.R.A, Gathercole, S.E. (2010). “Working Memory and Fluid Intelligence in Young Children.” *Intelligence*, 10+. doi:10.1016/j.intell.2010.07.003. </ref>

<ref> Hughes, J. (2006). “Developing Working Memory Skills for Children with Down’s Syndrome.” *Down Syndrome News and Update*, 6(2), 57-61. doi:10.3104/practice.348 </ref>

<ref> Jonides, J., Koeppe, R., Marshuetz, C., Smith, E. (1998). Components of verbal working memory: Evidence from neuroimaging. *Neuroimaging of Human Brain Function*. 95(3), 876-882. doi:10.1073/pnas.95.3.876 </ref>