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Everyone has a photographic memory. Some just don't have film.

—Steven Wright

Working Memory

Working memory (or *short-term memory*) is information temporarily held accessible in the mind. It is used in the completion of mental tasks such as comprehending language, following instructions, and solving mathematical problems. Many working memory measures correlate with intelligence rather strongly, and the average capacity of working memory increases with age in childhood. An adult can concurrently hold in mind about 4 separate, simple items, or often about 7 items by using mnemonic strategies (such as remembering a telephone number by silently rehearsing it and breaking it into groups of 3 or 4 digits). Working memory is important for educational psychology in at least two ways. First, knowledge of the demands of a task on working memory helps in predicting the task difficulty. Second, knowledge of individual differences in working memory capability helps in understanding why scholastic performance varies.

Working memory differs from the vast information that one has learned over a lifetime, or long-term memory. To illustrate, suppose one knows the sentence *The quick brown fox jumped over the lazy dog*. If, on Tuesday, one recalls only that the sentence began, "The quick brown fox" whereas on Wednesday, one recalls only that the sentence ended, "jumped over the lazy dog," it is impossible to recover the message. However, if one is able to restore the central concepts from both parts of the sentence into working memory at once, one can imagine the fox jumping over the dog. If a story problem includes too many ideas at once, the listener or reader may find it impossible to integrate them in working memory. Similarly, it would be unwise to ask a preschool child to "put the small paint brush on the middle shelf, put the large brush along with the paint on the top shelf, and move everything that was already on the middle shelf down to the bottom." One must break up this request into smaller parts to be carried out separately.

There appear to be multiple working memory mechanisms. A very small but important set of ideas can be in the focus of one's attention and awareness at once. However, working memory goes beyond what is in focus. There also are mechanisms to hold more information just beyond awareness. This may include mental representations of the progression of speech sounds in a sentence that one heard seconds ago, or the spatial arrangement of players in a basketball game one is watching. Psychologists posit temporary holding areas for such information, termed *buffers*, with different buffers for different types of information. Some researchers, such as Nelson Cowan, think of the buffers collectively as temporarily activated portions of long-term memory. Each type of mental representation may slip out of the focus of attention momentarily, but it might be recovered from the buffer. Thus, individuals may not be able to concentrate simultaneously on all

parts of a sentence they have just heard, but they might be able to repeat it by shifting their focus from one part of the sentence to the next while making use of information persisting for several seconds in a phonological buffer.

George Miller found that knowledge and understanding can help to overcome limits of working memory. This can be done by associating several items to form one larger, meaningful group or *chunk*. For example, consider a child learning the U.S. Pledge of Allegiance. Items present in working memory at once can be memorized and interassociated. At first, learning "I pledge allegiance to the flag" may heavily tax working memory. However, after the phrase is learned, it can serve as a single chunk. If the next two phrases also are learned as chunks, it becomes possible to join these three chunks using working memory: "I pledge allegiance to the flag/of the United States of America/and to the republic for which it stands . . . ." In turn, this entire sequence eventually may become one chunk, which can then be associated with further material. Working memory can be used repeatedly to build up larger and larger segments. However, to access information within a chunk, it must be unpacked. If a person is asked what letter of the alphabet comes after *f*, he or she may have to recite the alphabet from *a* to reach the right point in his or her automatic routine.

People can be abnormal in either working memory buffers or the ability to use attention. Defects in working memory for speech, and sometimes spatial information, can underlie language, reading, and mathematical disabilities. Children with various learning disabilities also often have problems staying on task or remembering what the instructions were. They may try to pay attention and yet cannot ignore distractions, personal troubles, or daydreams. Some recent research suggests that working memory task training helps children with disabilities improve educational performance.

Nelson Cowan

See also Aptitude; Attention Deficit Hyperactivity Disorder; Fluid Intelligence; Individual Differences; Learning Disabilities; Long-Term Memory; Short-Term Memory

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