Chunking

Authored by
mohammad looti

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Chunking," in psychology, is phenomenon whereby individuals group responses when performing a memory task. Tests where individuals can illustrate "chunking" commonly include serial and free recall, as these both require the individual to reproduce items that he or she had previously been designated to study. Items generally include words, syllables, digits/numbers, or lists of letters. Presumably, individuals that exhibit the "chunking" structure in their responses are forming clusters of responses based on the items' semantic relatedness or perceptual features. It is believed that the assimilation of different items according to their properties occurs due to individuals' creating higher order cognitive representations of the items on the list that are more easily remember than individual items. Representations of this order are highly subjective, as they depend critically on the individual's perception of the features of the items position in their semantic network. Size of these groups generally include anywhere between two and six items that had previously been studied. Chunking" maintains a number of characteristics when observed in recall tasks.

The first is that, when individuals incorrectly recall an item in a serial recall task, it tends to come from an item that they placed in the same grouping. That is, individuals that employ this strategy to recall will commonly misplace items according to their grouping. Since one must recall items in the order they were presented during the serial recall task, items that are even one position out of place are deemed incorrect. Therefore, according to how many items an individual breaks the list into, misplacement of the item will be limited to within the confine of the size of the group.

Another feature of the "chunking" effect is that a modality effect is present. That is, the mechanism used to convey the list of items to the individual has an impact on how much "chunking" occurs. Experimentally, it has been found that auditory presentation results in a larger amount of grouping in the responses of individual, as compared to visual presentation.

A significant result of the use of the "chunking" strategy is that probability of recall is greater for individuals that employ it. As stated above, the grouping of the responses occurs as individuals place them into categories according to their inter-relatedness based on semantic and perceptual properties. As shown through various studies, the groups produced via this strategy are easier for an individual to recall and maintain in memory during study and testing. Therefore, when "chunking" is evident in recall tasks, one can expect a higher proportion of correct recalls.

The most convincing evidence for the existence of "chunking" in individuals' responses during recall tasks is illustrated in the analysis of response times. When looking at this aspect of the test/response phase of a recall task, one observes response time as a function of output position. Therefore, this analysis allows for the measurement of the process of recall in each task participant. The curves illustrates that each item in a cluster typically requires about the same amount of time to recall. This can be observed as strings of items where the response times are both similar, as well as very rapid. However, one can also see in these response time curves that the time between the "chunks" follows a different trend entirely. Items or periods of output where the individual is not recalling items that belong to a group require a significantly larger amount of time. Therefore, prior to the beginning and end of recall of a group of items in a "chunk," there is a jump in response time in the curve.

"Magic number seven"

The word chunking comes from a famous 1956 paper by George A. Miller, The Magical Number Seven, Plus or Minus Two: Some Limits on our Capacity for Processing Information. At a time when information theory was beginning to be applied in psychology, Miller observed that whereas some human cognitive tasks fit the model of a "channel capacity" characterized by a roughly constant capacity in bits, short-term memory did not. A variety of studies could be summarized by saying that short-term memory had a capacity of about "seven plus-or-minus two" chunks. Miller wrote that With binary items the span is about nine and, although it drops to about five with monosyllabic English words, the difference is far less than the hypothesis of constant information would require. The span of immediate memory seems to be almost independent of the number of bits per chunk, at least over the range that has been examined to date." Miller acknowledged that "we are not very definite about what constitutes a chunk of information."

Miller noted that according to this theory, it should be possible to effectively increase short-term memory for low-information-content items by mentally recoding them into a smaller number of high-information-content items. "A man just beginning to learn radio-telegraphic code hears each dit and dah as a separate chunk. Soon he is able to organize these sounds into letters and then he can deal with the letters as chunks. Then the letters organize themselves as words, which are still larger chunks, and he begins to hear whole phrases." Thus, a telegrapher can effectively "remember" several dozen dits and dahs as a single phrase. Naive subjects can only remember about nine binary items, but Miller reports a 1954 experiment in which people were trained to listen to a string of binary digits and (in one case) mentally group them into groups of five, recode each group into a name (e.g. "twenty-one" for 10101), and remember the names. With sufficient drill, people found it possible to remember as many as forty binary digits. Miller wrote:

"It is a little dramatic to watch a person get 40 binary digits in a row and then repeat them back without error. However, if you think of this merely as a mnemonic trick for extending the memory span, you will miss the more important point that is implicit in nearly all such mnemonic devices. The point is that recoding is an extremely powerful weapon for increasing the amount of information that we can deal with."

Chunking in motor learning

Chunking is a flexible way of learning. Karl Lashley, in his classic paper on serial order (Lashley, 1951), argued that the sequential responses that appear to be organized in linear and flat fashion concealed an underlying hierarchical structure. This was demonstrated in motor control by Rosenbaum et al. (1983). Thus sequences can consist of sub-sequences and these can in turn consist of sub-sub-sequences. Hierarchical representations of sequences have an edge over linear representations. They combine efficient local action at low hierarchical levels while maintaining the guidance of an overall structure. While the representation of a linear sequence is simple from storage point of view, there can be potential problems during retrieval. For instance, if there is a break in the sequence chain, subsequent elements will become inaccessible. On the other hand, a hierarchical representation would have multiple levels of representation. A break in the link between lower level nodes does not render any part of the sequence inaccessible, since the control nodes (chunk nodes) at the higher level would still be able to facilitate access to the lower level nodes. Schematic of a hierarchical sequential structure with three levels. The lowest level could be a linear representation, while intermediate levels denote chunk nodes. The highest level is the entire sequence.

Chunks in motor learning are identified by pauses between successive actions (Terrace, 2001). He also suggested that during the sequence performance stage (after learning), subjects download list items as chunks during pauses. Terrace also argued for an operational definition of chunks suggesting a distinction between the notions of input and output chunks from the ideas of short-term and long-term memory. Input chunks reflect the limitation of working memory during the encoding of new information, i.e., how new information is stored in long-term memory, and how it is retrieved during subsequent recall. Output chunks reflect the organization of over-learned motor programs that are generated on-line in working memory. Sakai et al. (2003) showed that subjects spontaneously organize a sequence into a number of chunks across few sets, and that these chunks were distinct among subjects tested on the same sequence. Sakai et al. (2003) showed that performance of a shuffled sequence was poorer when the chunk patterns were disrupted than when the chunk patterns were preserved. Chunking patterns also seem to depend on the effectors used.

Memory training systems

The phenomenon of chunking as a memory mechanism can be observed in the way we group numbers and information in our day-to-day life. For example, when recalling a number such as 14101946, if we group the numbers as 14, 10 and 1946, we are creating a mnemonic for this number as a day, month and year. An illustration of the limited capacity of working memory as suggested by Miller can be seen from the following example: While recalling a mobile phone number such as 9849523450, we might break this into 98 495 234 50. Thus, instead of remembering 10 separate digits that is beyond the "seven plus-or-minus two", we are remembering 4 groups of numbers.

Various kinds of memory training systems and mnemonics include training and drill in speciallydesigned recoding or chunking schemes. Such systems existed before Miller's paper, but there was no convenient term to describe the general strategy. The term "chunking" is now often used in reference to these systems.

Chunking as the learning of long-term memory structures

This usage derives from Miller's (1956) idea of chunking as grouping, but the emphasis is now on long-term memory rather than on short-term memory. A chunk can then be defined as "a collection of elements having strong associations with one another, but weak associations with elements within other chunks" (Gobet et al., 2001, p. 236). Chase and Simon (1973), and later Gobet, Retschitzki and de Voogt (2004), showed that chunking could explain several phenomena linked to expertise in chess. Several successful computational models of learning and expertise have been developed using this idea, such as EPAM (Elementary Perceiver and Memorizer) and CHREST (Chunk Hierarchy and REtrieval STructures). Chunking has also been used with models of language acquisition.