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What is This?

From Association to Organization

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Abstract

Recent as well as historical critiques of association theory, which is based on automatic linking mechanisms, lead to a consideration of an alternative: organization theory. The latter theory postulates that human memory is organized, instead, in a nested, hierarchical fashion that structures storage and retrieval. Organization theory also postulates that there is a limit of four expandable units in organized memory and that the same limit is found in recall and production units.

Classical association theory holds that the establishment of "links" between and among mental and behavioral events is a major basis of human learning and memory. Similar assumptions underlie modern connectionism, which holds that connections among units are subserved by neural networks. Association theory has recently undergone some revisions, in part toward a view of organized human memory that has been available since George Katona's original statement of organization theory (Katona, 1940). In this article, I briefly review both current and older departures from the associationist view and summarize organization theory and relevant empirical findings. In the last section, I discuss the contribution of findings on the limits of human memory units (Miller, 1956) to organization theory.

The Critique of Association Theory

An influential early criticism of association theory appeared in a series of articles by G.E. Müller (1911–1917), who doubted its applicability to a number of mental and behavioral phenomena.[1] In 1962, Asch & Ebenholtz (1962) argued that associations should be considered like other cognitive processes, and in 1969, Asch (1969, p. 101) concluded that associating involves the operations of relating that are at the basis of recognition and recall. More recently, there have been a number of extensive arguments (cf. Mitchell, De Houwer, & Lovibond, 2009) against the basic assumption of association theory that associative links are formed, usually between pairs of events, so that one event evokes the "linked" event automatically. Organization theory views memory as the product of meaningful integrated structures.

Another basis for critiques of association theory, and inspiring alternatives to it, is Dickinson's (2001) argument that many associations are formed on the basis of causal knowledge. For example, he noted that the causal effect of a cue can be changed without involving the original cue. De Houwer (2009) argued that associative learning depends on the formation of propositions about relations between events that are assumed to be generated by nonautomatic processes. In a further expansion of the propositional view of associative links, Mitchell et al. (2009) concluded that conditioning, associations, and learning are a product of propositional reasoning processes that depend on the unconscious processes of memory retrieval and perception. One of their arguments for a propositional approach involves the case of associative blocking, in which a conditioned stimulus blocks the establishment a new "link" between a novel conditioned stimulus and the unconditioned stimulus. Mitchell et al. interpret blocking as involving propositions that specify the manner in which events are related—for example, that a bell *signals* food. From their review of the literature on human conditioning they concluded that "learning requires cognitive resources" (p. 189) including rules and reasoning processes.

In a review of "associative" phenomena from the point of view of organization theory, I suggested that there are three classes of structures (G. Mandler, 1979):

- *Coordinate structures* that link several related mental objects so that access to one part of the structure entails access to the whole structure (e.g., stories or memories of a social occasion)
- *Subordinate structures* that involve tree-like hierarchical relations; relational operators function between instances and superordinate nodes (e.g., categorization of animals, plants).

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- *Proordinate structures* represented by serial structures and propositional relations (e.g., the acquisition of tastes and fears).

From the organizational point of view, the relations proposed by Dickinson as well as by De Houwer and Mitchell et al. would primarily be classified as proordinate—that is, serial.

Organization Theory

The original impetus for organization theory was Katona's work, which was a direct outcome of the influence of Max Wertheimer and Gestalt psychology and assumes that human memory is generally organized and relational. Katona's use of "organization" differs from other general and specific uses of the term (e.g., Squire, Knowlton, & Musen 1993; Tulving, 1995), which refer to various aspects of memory processes and mechanisms and the ways they are related to one another.

According to organization theory, meaningful/semantic memory is structured in a network. George Miller introduced organizational concepts into his influential 1956 article: "By organizing the stimulus input simultaneously into several dimensions and successively into a sequence of chunks, we manage to break [the] informational bottleneck" (p. 97). A related formulation was that sets of objects or events are organized when one can specify consistent relationships among the members of the set (G. Mandler, 1967). Another term used for organizational principles is that of structure, and W.R. Garner's (1962, p. 141) description of structure is equivalent to a description of organization: "By structure I mean the totality of relations between events. . . . Meaning . . . refers to the entire set of relations . . . " Garner (1966) extended this view to perception, which he described as involving "knowing, understanding, comprehending, organizing" (p. 11).[2]

Empirical work on organization can be traced to Weston Bousfield, who produced the first reports on the clustering of category-related words (Bousfield & Sedgewick, 1944; Bousfield, 1953). In 1952, Jenkins and Russell (1952) demonstrated pairwise clustering of word associations. The next step was taken by Tulving (1962), who used the concept of subjective organization, defined as the recall of items in the same order on different trials. The original investigation appealed to pairwise relationships as a basis of memory organization. A later experiment showed that pairs of items are not adequate to support memory consolidation (G. Mandler, Worden, & Graesser, 1974). Members of pairs of words that were recalled contiguously (i.e., in an organized fashion) on trial n were presented noncontiguously or had half of the recalled pairs eliminated on trial n + 1. The noncontiguous condition showed no difference in recall from the groups with intact pairs. Thus effective subjective organization requires units larger than two. I turn next to an examination of organized memory and the size of the basic memory unit.

We took a step toward organizational theory in G. Mandler and Pearlstone (1966). The object in this and subsequent studies was to show that individuals could advantageously impose previously existing mental structures on to-be-remembered materials—and that those structures organized memorial productions. In contrast to classical concept-formation experiments, subjects were free to determine the categories used in sorting an unrelated list of words. Performance on that task was contrasted with a task that constrained the categories to be used. "Free" subjects took about half the number of trials that the constrained group did to reach a criterion of consistent sorting but showed the same level of recall. In the context of a subsequent series of experiments on the organization of memory (G. Mandler, 1967), we found that recall is a function of the number of categories used. Subjects sorted 100 "unrelated" words into anywhere from two to seven categories. Immediately after the sorting task, the subjects were required to recall as many words as possible. The median slope of the relationship between number of categories selected and recall was 3.9, meaning subjects remembered 3.9 items for each category established during sorting.[3] The median correlation was high: .70. Recall was very robust, with 20% recall after 15 weeks. The relationship held even if subjects were told how many categories to use. In order to eliminate any artifacts—for example, the possibility that subjects using few categories were also poor on a memory task—we repeated the experiment with individual participants (G. Mandler, 1968). Subjects were instructed to use a specific number of categories (from two to seven). The slopes for individual subjects ranged from 3.46 to 4.17 (mean of 3.80). Bower (1970) showed more generally how groupings are organized and determine retrieval of items in memory. In addition, a study that required recall from specified categories showed that clusters of category members from any specific category contained four items (Fig. 6; Graesser & G. Mandler, 1978). In human development, organizational processes are necessary for the transformation of perceptual processes to more powerful conceptual ones (J.M. Mandler, 2004), and the limiting size of four is also generally true of human infants (Carey, 2009).

Another approach to human memory similar to organizational theory is the influential treatment of depth or level of memory processing by Craik and Lockhart (1972). In the level-of-processing (LOP) framework, access to memory items depends on the amount of cognitive work expended on these items. Specifically, deep (organizational) processing leads to more efficient and lasting memory than, for example, shallow (e.g., orthographic) processing. Bower and Bryant (1991) showed extensively how LOP was related to organizational theory (see also G. Mandler, 2002). For an extensive review of the relevance of organizational principles to narrative and pictorial material, see J.M. Mandler (1984), which illustrated some of the ways in which story and scene schemata follow organizational principles. Shimmerlik (1978) has reviewed the relevance of organization theory to the learning of prose, particularly in an educational setting.

From current work that uses organizational principles, there is accumulating evidence that testing and retrieval, rather

than presentation or study, improve recall and recollection (Larsen, Butler. & Roediger, 2009; Roediger, Agarwal, Kang, & Marsh, 2010).[4] Zaromb & Roediger (2010) showed that testing facilitates organizational processes, such as access to higher-order units and to items within those units, as well as the organization of the lists. Roediger et al. (2010) ascribed the effect to *effortful* testing. For an organizational interpretation of effort, consider the acquisition of word pairs, which involves the generation of a unitary (holistic) mental representation of two items (Mandler, Rabinowitz, & Simon, 1981). When retrieving a word pair, the mental effort focuses on that representation, which will initially be relatively vague (especially in terms of its boundaries) and with subsequent retrieval will become a more focused and unique representation—effort involves structural arrangement and rearrangement.

One of the purposes of this section was to demonstrate the relevance of the unit of organization, which appears to contain four related items, and which leads us to extensive research on unitization and the "magical number" that circumscribes the size of the organizational unit.

Unitization Theory: The Unit of Organization

The finding that memory organization converges on the size of a basic unit of organization that consists of approximately four items leads directly to an initially unrelated theoretical development—George A. Miller's (1956) pathbreaking unitization hypothesis. Miller summarized the evidence that human immediate memory was limited, and he suggested that it could accommodate seven plus or minus two units. In order to understand the large capacity of memory, Miller introduced the unitization hypothesis, namely that memory can be expanded by enriching the seven or so chunks by recoding or reorganization to accommodate more information. The unitization hypothesis has received general acceptance, operating at various levels of memory—including, for example, implicit memory (Dorfman, 1999).

Since Miller's original statement about the limits of human memory, the problem has been exhaustively explored and the magical number has been subsequently revised. After Broadbent (1971) suggested that the limit was three units, subsequent investigation and review by Cowan (2001) settled on four as the magic number. An important paper by Luck and Vogel (1997) investigated memory for simple features. They showed that we can retain information about only four colors or orientations at one time but also that visual working memory can register both color and orientation of objects. They concluded that what is stored are integrated objects rather than individual features, providing further evidence for Miller's unitization hypothesis and reflecting mental organization.

These various investigations and conclusions lead to the view that the limits of human memory are best explained in terms of organization theory. The hierarchical structure of memory determines its organization and memory retrieval. The unit of memory is limited to four plus or minus one instances, which are, however, subject to expansion and integration—thus further enlarging memory capacity. More generally, the basic size of four elements forms the basis of organized memory storage.

Currently, organization theory is primarily a theory about memory organization, storage, and retrieval and, by implication, a view of the organization of knowledge. In the middle of the last century, related theories positing limited capacities arose, as shown in the work on short-term memory (Atkinson & Shiffrin, 1968) and working memory (Baddeley & Hitch, 1974). Further research is needed to investigate organization theory's relevance to phenomena such as individual differences, working memory, and attentional capacities.

Recommended Reading

Mandler, G. (2007). *A history of modern experimental psychology: From James and Wundt to cognitive science*. Cambridge, MA: MIT Press. Includes the history leading up to organization theory.

Miller, G.A. (1956). (See References). The original unitization paper.

Mitchell, C.J., Houwer, J.D., & Lovibond, P.F. (2009). (See References). The most extensive current critique of association theory.

Notes

1. Other early critiques were made by Bartlett, Claparède, Wertheimer, and others.

2. Another suggestion was that cognitive flexibility can under certain circumstances arise out of transformed structures (G. Mandler, 1962).

3. It is relevant that in the Mandler and Pearlstone study, the mean number of items placed in the "free" categories also clustered around four.

4. For an early applied demonstration of the testing effect, see Pashler, Rohrer, Cepeda, and Carpenter (2007).

Declaration of Conflicting Interests

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