Memory and Creativity

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Encoding Assigning a specific label to the information that is to be stored in long-term memory in order to make it suitable for storage, retrieval, and further processing.

Long-Term Memory System able to hold large amounts of episodic or semantic information permanently, organized as a network.

Retrieval Activation of the information retained in long-term memory, presumably with the use of valid retrieval cues or specific mental strategies.

Short-Term Memory System responsible for maintaining restricted number of pieces of information for several minutes; also acts as an information processing unit responsible for the manipulation of symbols during problem solving and other types of cognitive activity.

Storage The intermediate phase of the memory process, which consists of keeping the memorized information in the latent form that potentially allows retrieval and further processing.

MEMORY is a psychological structure that, apart from its many other functions, takes part in the cognitive mechanism of insight in creative problem solving and determines the specificity of information processing observed among creative individuals. The importance of memory phenomena to our understanding of creativity is enormous, for obvious reasons: creativity is an activity of the mind, and activities of the mind are executed through memory. Therefore, creativity cannot occur without the participation of memory processes and structures. However, the psychological theory concerning the relationship of memory with creativity has not been developed, and empirical results are rather scarce. For these reasons, the present article outlines the map of the problem at the very high level of abstraction and with large amount of speculation. The order of presentation is determined by the stages of memory processes, corresponding to the stages of information processing.

I. SHORT-TERM MEMORY AND CREATIVITY

Stimuli coming from the external world are first memorized for a short time by two structures: the sensory store and short-term store. The sensory store (e.g., iconic memory for images, or echoic memory for sounds) holds the information for less than 1 s. It performs the preparatory stage of stimulus elaboration, due to which the next stages are not overflowed with the surplus of information. There is no evidence whatsoever that sensory memory is connected in any way

with creative processes or creative abilities. As to the short-term memory (STM) store, which is able to keep the information for several minutes, the situation is less clear. This system not only maintains information but also performs basic manipulations with symbols, synonymous with human information processing; for this reason, it is called "working memory" as well. It is therefore rather unlikely that the central processing unit of the human mind would not take part in the cognitive mechanics of creative processes. There is, however, little empirical evidence on how working memory affects creativity.

Characteristically, STM is very limited in its capacity, because it is able to manipulate less than 10 pieces of information (words, numbers, etc.) simultaneously. It has been convincingly shown that the STM capacity determines the general cognitive ability level (i.e., intelligence). Unfortunately, no evidence concerning the relationship of the STM capacity with creativity has been obtained, although in some studies both intelligence and creativity tests were used to check this hypothesis.

The difference is probably rooted in the particularity of cognitive mechanisms of intelligence and creativity as two distinct dimensions of human intellect. Intelligence is an ability to tackle convergent, well-defined problems of average complexity. Such problems are well described in terms of a number of separate "chunks" of information that have to be memorized and manipulated for a short time in order to let the problem solver reach the solution. In other words, an intelligent problem solver has to split the problem into separate portions of information, keep these portions in short-term memory, and manipulate them in order to achieve a suitable solution. In such cases, the more items a problem solver is able to keep in the short-term store, the more competent he or she is in tests consisting of convergent, well-defined problems of average complexity. On the contrary, if a problem solver's STM capacity is small by nature, or declines temporarily, he or she inevitably loses some part of his or her intellectual ability, because some tasks that are critical for one's intellectual level may surpass the actual limitations of STM. [*See* PROBLEM SOLVING.]

There seems not to exist anything like that in the case of creativity. It is usually assessed with tests consisting of divergent tasks of low complexity (e.g., unusual uses or alternative definitions), which do not exploit short-term memory thoroughly. As far as the limited capacity of STM is concerned, such problems may even be regarded as relatively "easy." No surprise, then, that creative abilities assessed with divergent thinking tests do not correlate with the STM capacity.

Of course, creativity is not reduced to the divergent thinking ability, particularly if real creative endeavors rather than basic cognitive skills are taken into account. However, there is no point looking for the short-term memory determinants of "real" creativity, either. The problems undertaken by exceptionally gifted creators and great achievers are usually divergent, too, but also ill defined and very complex in nature. In fact, problem finding and problem definition constitute the vital part of creative processes in real life, that is, outside the psychological laboratory. Finding, definition, redefinition, and solution of such problems usually take a lot of time, effort, and motivation, but they do not seem to rely on the extended capacity of short-term memory. Individual differences in STM capacity may matter in the case of problems of average complexity, because, for instance, if a problem needs 10 items to be kept and manipulated in memory, a person with the capacity of 10 is naturally endowed to tackle such a problem, whereas a person whose capacity is only 6 is naturally unable to deal with it. But both hypothetical persons are structurally unable to deal with a problem consisting of 100 or 1000 items of information, that is, with very complex, unclear, ill-defined problems that require a creative approach. [*See* DIVERGENT THINKING.]

This does not mean that such complex problems are unworkable for any human being, whose STM capacity—even when relatively large—usually does not exceed 10 portions of information. Rather rarely, a very complex and ill-defined problem is being solved by a very creative individual by means of his or her exceptional capacities—but not necessarily the STM capacity, as it seems. Such creative endeavors are attainable through specific strategies of problem solving, and through inventive manipulations with the problem structure and problem definition. Such manipulations are sometimes referred to as "metacognitive strategies." For instance, a creative person organizes his or her knowledge of the problem hierarchically: a relatively small number of higher-order, abstract portions of in-

formation may contain many lower-order chunks of information, accessible for processing only after having been "unwrapped." Another metacognitive strategy used by creative individuals amounts to simplification of the problem structure so that it could be workable by STM. However, such manipulations refer to long-term memory processes, mainly selective encoding and "familiarization." [*See* METACOGNITION.]

II. LONG-TERM MEMORY AND CREATIVITY

Stimuli formerly elaborated by STM proceed to the long-term memory system (LTM). Contrary to STM, long-term memory is able to keep the information for an unlimited period; it is also assumed to possess unlimited capacity. This does not mean that the human mind is able to remember everything; however, forgetting and other imperfections of memory do not result from the capacity of the LTM store but from other sources, such as interference or inefficient strategies of remembering.

Three basic categories of memory processes define the efficiency of operations in LTM: encoding, storage, and retrieval. These operations, or stages of the memory process, determine the way in which LTM performs its basic functions, including the ones connected with creativity, problem solving, and insight.

A. Encoding

Information cannot be placed in the long-term store without having been encoded. It is an operation analogous to labeling products in the department store or allocating new books in the library to appropriate shelves. Only after the information is encoded can it be stored in memory as a part of respective knowledge structures. In most cases, encoding amounts to categorization. For instance, we categorize the scene shown in headline news as a "street accident" and a portion of textbook knowledge as "the quantum theory of particles." The psychological function of encoding is obvious: it allows assigning of information to the appropriate parts of the LTM store. In this way, it makes it possible to arrange LTM as an organized system of knowledge. It is also the necessary condition of future retrieval, because one cannot regain anything from the store without labeling it properly.

Creativity is probably connected with, and affected by, the specificity of encoding in three ways. First, we can encode information in a peculiar way, different from what other people do. For instance, a child can categorize the animals familiar to him or her into the categories of nice, shaggy, and awesome. This kind of categorization, though illogical and far from what biology offers, probably serves some important cognitive needs of the child. Such categorization is also unusual and different from how the majority of people think about animals and how they classify them. It is probably why small children perceive the world so originally. Children's originality is normally accounted for in terms of their being free from obstacles, conventions, and inhibitions typical of adult life. However, this phenomenon should also be regarded as a manifestation of the unusual way in which children categorize objects, and as a result of rather specific ways of encoding information that is stored in their LTM.

In the case of adult creative individuals, the instances of bizarre categorization are probably accompanied by the conventional, "uncreative" way of perceiving the world. In other words, an adult creative person is able to categorize the world in the "official," objective, commonly accepted way, as well as in an unusual, subjective, and personalized manner. This is the second exemplification of how the activity of this stage of the LTM operations affects creativity: alternative encoding. A person who encodes alternatively is able to take advantage of unusual encoding (e.g., making unpredictable associations, discerning similarities), while still being close to reality and conventions—a phenomenon recognized by Ernst Kris as "regression in the service of the ego." Some techniques of creativity training deliberately focus on the phenomenon of alternative encoding, with the conviction that divergent thinking and unexpected associations are more likely to result from the ability to memorize the same item of information in many different ways.

The third property of encoding found in creative persons is "selectivity." It is particularly important for the construction of the cognitive representation of the problem. Problems worth creative endeavor are usually too complex and ill defined to be memorized completely and categorized with the use of some clear-cut

terms. Selection of information is therefore necessary; however, successful problem solvers are able to memorize only the important elements of the problem, while ignoring less important and superfluous ones. Less efficient solvers try to memorize everything, thus being unable to focus on the very gist of the problem situation. It is very unclear what are the origins and determinants of this ability to encode information in the selective way, as well as to what extent it is susceptible to development and training. However, the selectivity with which some people store information in their LTM store inevitably makes them more efficient solvers of complex, ill-defined problems; therefore, it makes them more creative.

Peculiar, alternative, and selective encoding are responsible for creative behavior in many ways. They help us to produce original associations, they are responsible for our "perceiving things" differently, and they allow simplification of the structure of too-complex problems through selectivity of encoding. In many instances, creative behavior is a result of natural, effortless use of specific encoding, although from the observer's perspective it may make the impression of being a result of rather difficult and complex processes. In other words, creative processes are sometimes less "exotic" than they seem to be from the point of view of somebody who normally does not encode information in a peculiar way.

Creativity also benefits from so-called "prospective encoding," which consists of setting up criteria for future acquisition of knowledge that might be relevant to a problem at hand. Careful examination of the problem and its requirements helps us to establish exact criteria of information needed for the continuation of creative problem solving. Such knowledge may not be available at the moment but it can be easily acquired upon the appearance of particular learning opportunities. The mental set established due to the prospective encoding induces highly selective acquisition of knowledge; consequently, it enhances the likelihood of sudden and insightful recognition of the new possibilities to deal with the problem.

B. Storage

Storage amounts to keeping previously encoded information for long time. Contrary to naive conceptions of storage, it is an active process, likely to impose unexpected changes on the seemingly dormant information kept in LTM. Three phenomena connected with storage are worth investigating from the creativity point of view: selective forgetting, familiarization, and spontaneous recovery.

Selective forgetting is apt to account for the phenomenon of incubation. According to the classical four-stage model of creative thinking, incubation is a stage of unconscious idea production following preparation but preceding illumination and elaboration. Modern cognitive approaches do not deny the empirical evidence that the incubational break sometimes helps with the creation of new ideas, though they usually do not accept the notion of subconscious incubation of solutions. Therefore, it has been suggested that, during the "incubational" break, we selectively forget the superfluous information, particularly the unnecessary elements of the cognitive representation of the problem. Our memory preserves only a part of the information that has been gathered concerning the problem: its definition, requirements, and context. After having forgotten a huge part of this information, we are more likely to "view the problem from a new perspective," that is, to experience sudden and holistic understanding of the problem, synonymous with insight. [*See* INCUBATION.]

"Familiarization" is another term introduced by Herbert Simon to account for the phenomenon of incubation. Simon assumed that problems worth creative endeavors are complex and difficult, requiring a lot of time and effort to be solved. During the long process of problem solving, almost all trials to seek for the solution are unsuccessful, except the final ones that result in solution. It does not mean that the former trials are worthless: Their function amounts to familiarization of the problem, that is, making it more and more understandable, clear, and simple. Simplification of the problem structure and definition makes it possible for them to be grasped with a small number of items of information. This, in turn, makes the problem possible to manipulate with the system of short-term memory, which has a very limited capacity to handle information. In other words, every instance of problem solving relies on the vital operations of working memory, which performs the basic operations of information processing. But to be suitable for such operations, the

problem has to be simplified to great extent; otherwise, the working memory system is likely to be overflowed. Familiarization is a means to make the problem simplified enough to be dealt with by the system of working memory. Thus, numerous unsuccessful trials to find a solution have an important simplifying function, due to which problems originally too complex become more and more workable for the memory system of very limited capacity.

Spontaneous recovery consists of the increase in the likelihood of recalling information if it is kept dormant for some period of time, compared to the likelihood of recall at the beginning of the learning process. It is assumed that the vital information is blocked by other pieces of knowledge learned more recently or acquired with the learner's conviction about their importance. After some period of time, the blocking pieces of information lose their activation, thus giving way to the previously inaccessible knowledge. It is also assumed that the LTM store gets more and more organized with time, a process taking place without any intention or effort on the learner's side. Due to such hypothetical processes, we can sometimes remember more information if some amount of time has passed than at the beginning of the learning process—a phenomenon known as "reminiscence." These phenomena are important for creative thinking and problem solving because they may be responsible for elimination of mental sets, blocks, and other obstacles often preventing us from attaining original solutions. It is why incubational breaks probably help us to work out creative solutions, although there are other cognitive mechanisms apt to operate with similar results (e.g., selective forgetting and familiarization).

Selective forgetting, familiarization, and spontaneous recovery are possible mechanisms of insight, which—according to the modern cognitive theories—is basically a memory phenomenon. From the phenomenological perspective, insight is a sudden flash of understanding ("aha!" response). From the cognitive perspective, though, its mechanics is probably rooted in the operations taking place in long-term memory during the storage phase. However, the recognition of such a theoretical possibility requires that storage be viewed as an active, purposeful, and "creative" phase of the LTM operations. The spontaneous changes of the LTM structure during the storage phase do not guarantee that insight will occur and be apt to help us solve the problem in a creative way, but without these cognitive operations the phenomenon of insight would be very difficult to account for beyond its purely phenomenological aspects.

C. Retrieval

Retrieval consists of recalling the information previously encoded and then kept in the LTM store. It is the reverse of encoding, and its efficiency mostly depends on encoding strategies used in the first stage of the memory process.

The main problem of retrieval amounts to accessibility of information stored in LTM. Creative ideas are often just recovered from memory, or they result from uncommon combinations of stored memories, although they may make an impression of being crafted out of nothing. In other words, a creative idea—or at least the very core of it—remains in the LTM store for a long time, "waiting" to be noticed and used. The difficulty lies in accessing such an idea or its bud, because it is not kept in memory in its ready-made, easy to retrieve form. If it were like this, it would probably be memorized and retrieved easily by many people; therefore, such an idea would rather frequently reappear and, by definition, could not be called creative. So, the act of creation consists, by and large, of the use of effective retrieval strategies, through which the vital information may be accessed and used in problem solving.

Hence, the problem lies in making the already stored information accessible, so that it can take part in the creative process. This aim is achieved in two ways: by the use of appropriate retrieval cues and by the application of effective strategies of search of the LTM store. The "retrieval cue" is a means to decode information kept in the LTM store, analogous to the operation of retrieving an item from the shelf of a real storehouse, library, or other kind of depot. Normally, the information is retrieved from LTM with the use of exactly the same code (e.g., a category or label) with which it had been put into the LTM store. These are the instances of the commonplace use of memory, resulting in uncreative behavior. However, the information may be retrieved with the use of entirely new codes, providing that a problem solver is able to recode the items constituting his or her knowledge, that is, to label the pieces

of information kept in the LTM store in a new way, different from the initial encoding. Analogical thinking is enhanced in this way, since notions, memorized events, and other pieces of our knowledge can be retrieved on the basis of their similarity to other areas of our experience. It is a process particularly important for creativity if the analogies and similes are remote and unusual, which means that the pieces of knowledge utilized for the building of analogy have to be retrieved with cues other than those used during the acquisition of knowledge. [*See* ANALOGIES.]

As to LTM search strategies, the problem consists of making the search as global as possible. Our inability to use previous experience while solving a new problem, a phenomenon frequently described in the literature as mental "ruts," and other blocks to creativity, may result from a "local" memory search. This kind of search is limited to the narrow, well-defined areas of knowledge stored in the long-term memory, and does not apply to other areas of knowledge even though these regions could be highly relevant to the problem at hand. A problem solver is unable to use some fragments of his or her knowledge because they are "too distant" from the areas defined by the problem space, and as such they look "irrelevant" to the problem. Of course, the distance between the knowledge responsible for the problem representation and some potentially useful but neglected areas of experience may be superficial or seeming. Furthermore, the boundaries between different fields of knowledge and expertise are usually fuzzy and conventional, and sometimes artificial; however, they define the peripheries within which the memory search is normally performed. In consequence, the search is rather likely to be local, that is, limited to the knowledge base that is directly applicable to the problem being currently solved. To make the search global, that is, referring to the whole network of semantic memory and conceptual knowledge, as well as to the vast number of episodes stored in LTM, the problem solver has to cross the between-domain boundaries through analogy, metaphorical grasp, and mostly the redefinition of the problem statement.

The creative search of memory does not have to be entirely global; sometimes it suffices to make the search less local, that is, less limited to the narrow conceptual boundaries defined by the initial problem statement. Redefinition of the problem statement naturally makes a problem solver more likely to cross the conceptual boundaries, as the newly defined problem requires a new set of information and provokes new associations. However, making the search "less local" may be a deliberate strategy used by the problem solver, utilized during the sessions of creative problem solving, not necessarily being preceded by problem redefinition. On the other hand, redefinition of the problem is rather unlikely to occur without the global (or "less local") search because only the truly uncommon information retrieved from memory is able to make us perceive the problem in a fresh way.

Creative individuals are more inclined toward a global memory search than less creative people. The semantic memory network of creative people is more compound and thus more apt to perform remote, unusual associations. The creative semantic memory is also more likely to get activated as a whole network rather than as restricted associative regions, if a priming stimulus is presented. The higher the general activation of the semantic network, the more likely it is that a person will perform the global search of the information needed during the problem-solving session. Contrarily, if the activation is limited to small areas of the semantic network, defined by the routine meaning of the priming stimulus, it is rather likely that a person will perform only the local search, with all its uncreative consequences.

III. CONCLUSIONS

Obviously, creativity is not just the proper use of one's memory. However, the purely creative phenomena known from the studies of creative problem solving, like insight, analogical transfer of knowledge, or unusual remote associations, probably result from the peculiarity of memory processes. It is therefore justified to conclude that memory of creative individuals differs qualitatively from memory of less creative people. The quantitative differences, for instance, the sheer amount of knowledge about some topic, are probably less important because there is no evidence that the more one knows the more creative one is. On the contrary, experts are frequent victims of rigidity and men-

tal ruts, unless their knowledge is flexible and creative due to the specificity of its organization.

Bibliography

Eysenck, M. W., & Keane, M. T. (1995). *Cognitive psychology: A student's handbook* (3rd ed.). Hillsdale, NJ: Erlbaum.

Maruszewski, T., & Nosal, C. S. (Eds.) (1995). *Creative information processing: Cognitive models.* Delft, The Netherlands: Eburon Press.

Matlin, M. W. (1994). *Cognition* (3rd edition). Fort Worth, TX: Harcourt Brace.

Runco, M. A. (Ed.) (1994). *Problem finding, problem solving, and creativity.* Norwood, NJ: Ablex.

Smith, T. B., Ward, T. B., & Finke, R. A. (Eds.) (1995). *The creative cognition approach.* Cambridge, MA: MIT Press.

Sternberg, R. J. (Ed.) (1988). *The nature of creativity: Contemporary psychological perspectives.* Cambridge, UK: Cambridge University Press.

Sternberg, R. J. (Ed.) (1994). *Thinking and problem solving.* San Diego, CA: Academic Press.

Sternberg, R. J., & Davidson, J. E. (Eds.) (1995). *The nature of insight.* Cambridge, MA: MIT Press.