Human memory models: less complexity may deliver better explanations

Lizardo Vargas Bianchi

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Faculty of Sciences / Department of Psychology and Mental Health
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Until nowadays, memory researchers confront the challenge of explaining such a complex mind phenomenon. This essay will focus on two significant memory models, their strengths and liabilities. A brief review of cognitive psychology will serve as contextual reference, since both models root on learning, language, problem-solving and decision making studies. Since memory embraces different systems, the discussion will focus on integrated memory models where storage plays a major role, thus leaving aside systems like episodic, semantic, procedural or implicit memory.

The interest in memory has been present in psychology since the last decades of the nineteenth century. Ebbinghaus's (1885) original self-experimentation on memorizing senseless syllables, and the publication of his book on the topic, remain paramount in this field. (Hothersall, 2005)

Early influential American psychologists as James (1890), treated the matter and proposed an elegant model which included the stimulus, as well as the primary and secondary memory–namely short and long term stores.

Since then, memory remained present as a psychological variable, thus it gained particular interest since the dawn of behaviorism in North America, and the rise of cognitive psychology. This historical turning point in psychology's history is attributed to Chomsky's criticisms (1959) on some of Skinner's arguments on learning that were core to behaviourist postulates. (Greenwood, 1999). Though, authors as Mandler (2002) presents other circumstances that fostered this evolution, quoting scientific efforts in America as well as Europe, during the first half of the twentieth century.

It seems plausible to state that learning, language, problem-solving or decision-making, are core issues in designing a sound and practicable psychological thesis. (Shuell, 1986; Hall, 1989; Siegler, 1983). Memory plays a salient role in this field. A good example is learning, since it is cumulative per se, the individual may only acquire new knowledge if prior data is previously held.

An early attempt to develop a model aimed to explain human memory was made by Feigenbaum (1959). He based his thesis on previous research on memory organization from psychologist Von Neumann (Goldstein and von Neumann, 1947), as well as cognitive processes studied by Simon, (Newell, Shaw, Simon, 1958)

Feigenbaum (1959) manifested his intent to develop a theory that accounted for memorization as a threshold for human learning. But his report didn't enhance already

published statements and focused mostly in a sequential pattern of information processing.

This drawback in his research purpose could be attributed to a scientific bias. The author, as well as his predecessors' interest laid in the advancement of computing science, even though terminology commonly found in memory current literature (Eysenk and Keane, 2005) appeared in Feigenbaum's (1959) manuscript. Notions like cues, recall, forgetting, or iconic stimuli are mentioned. Despite that fact, those terms remained linked to computer science, hence no model of human memory was suggested.

Feigenbaum (1959) didn't seem to walk this route alone. Several research efforts made in the field during the first half of the twentieth's century, reduced memory to a storage process. (Jenkins and Russell, 1952; Bousfield, Berkowitz, and Whitmarsh, 1959). Psychologists did not particularly address memory, even after behaviorism was discarded (see Mandler, 2002, for a research review and context).

On the other hand, during the same epoch, British psychologist D. E. Broadbent (1958) presented influential studies aimed to propose a conception of human cognitive performance. Another significant contribution was Hovland's (1952) thesis on concept formation and attitudes. (Styles, 2005; Hothersall, 2005). Similar studies favored the re-evaluation of the scientific method for the study of psychological phenomena, including that of human memory.

Miller's also facilitated advancements in the matter through his concentration on learning, language and communication. He helped to systematize human memory, coining rules for memory formation, a stages structure, and recall features concerning stored knowledge. (Selfridge and Miller, 1950; Miller, 1958; Miller, 1960; Marks and Miller, 1964).

The work of Miller and his collegues was a major influence in the elaboration of an influential theory of human memory that exhibited a structure, components and dynamics: the multi-store model (MSM), by psychologists Atkinson and Shiffrin (1971). Their model also embraced James' (1890) thesis of primary and secondary memory, and arguments exposed in a previous article by Waugh and Norman (1965).

Atkinson and Shiffrin's model meant a significant contribution to the field. It captured and organized important elements and distinctions mentioned in the literature, exhibiting a simple and comprehensible model.

Although, some model's weaknesses may be pointed out. In the first place, it relies heavily in the subject's rehearsal of information. The authors argue that rehearsal is the key control process for the flow of information from STS to LTS, for recalling processes and to prevent information decay. But ordinary experience shows individuals don't actually rehearse data that is actually stored. (With clinical exceptions like with amnesic patients, see Brown, Della Sala, Foster, et.al., 2007) Hence the model doesn't seem completely ecological. (Eysenk and Keane, 2005)

Even if individuals procured it, the rehearsal buffer is narrow by nature. It's commonly accepted that information is processed more easily by fragments, but still the codification capability of any individual is limited (Miller, 1956). As well, various studies point to a practice of cognitive simplification in making a decision choice

between a limited range of options. This phenomenon is observed in consumers' construction of brand consideration sets prior to purchase. (Alba y Hutchinson, 1987; Hauser and Wernerfelt, 1990; Shocker, Ben-Akiva, et. al., 1991)

Secondly, MSM was designed in a rigid structure of storage compartments, each of them presented in a sequential flow-chart fashion. Yet again limiting its ecology, that characteristic wouldn't sort out an every day experience: the mind's multi-tasking ability. The model's sequentiality serves STS processing, a fact that would conclude in individuals being unable to combine tasks (Styles, 2005) or process information from both stores in parallel. Nevertheless, reported evidence suggests the contrary. (Schumacher, Seymour, Glass, et.al., 2001; Ellenbogen and Meiran, 2008) A similar phenomenon occurs with distraction or interference, when the individual is processing data in the STS and receives a different input at the same time.

Thus, a common reported liability resides in assuming that both STS and LTS are unitary compartments that don't operate in parallel. Not only theoretical buy neurological evidence supports this assumption. (see Smith and Jonides, 1999 for an example)

Despite criticisms, some studies give evidence of the existence of distinct and independent memory stores, each with particular functions. For example, individuals presented with lists to remember items, recalled first and last items best (primacy and recency effect is explained in this case by Glanzer and Cunitz, 1966).

Other evidence that supports SMS focus on some kinds of amnesia, as anterograde amnesia and Korsakoffs Syndrome, where a subjects reported normal STM functions, while LTM impairments. (Willingham, Nissen and Bullemer, 1989).

On the other hand, few years after Baddeley developed the 'Working Memory' (WM) model, aimed to counter the SMS thesis (Nairne, 2003). The model became a significant reference for further investigations. Core to Baddeley's model is the 'Central Executive' (CE), which basically acts as an attentional controller. (Eysenk and Keane, 2005; Baddeley, 1986). It moderates other models' components involved in diverse degrees of the codifying, retention and information processing: the phonological loop, the visuo-spatial sketchpad and the later added (Baddeley, 2000) episodic buffer, that serves as a general storage. (Eysenk and Keane, 2005)

The WM model was designed as a more versatile and open explanation of human memory, hence is more complex than its predecessor. The structure is non-unitary, since it's composed by three distinct elements, which in turn are fractioned and might be further broken down into smaller elements. But most importantly, the model overcame Atkinson and Shiffrin's single-tasking limitation, by including subjects' ability to carry out more than one task at once, even when both tasks required STM functions. (Styles, 2005)

In the last decades, a vast body of research has supported the model. Mostly due to WM's allowance of parallel handling of complex tasks (Young and Lewis, 1999; Engle, Kane and Tuholsky, 1999).

Despite that, occurrences manifest the existence of other specialized systems within STM, as evidenced reported from brain damaged patients that appear to suffer working

memory impairments, while other memory operations perform normally (Shallice & Warrington, 1974). This suggests that Baddeley's thesis still doesn't answer the whole human memory phenomena.

As Surprenant and Neath (2009) observe, there are no experimental reports proving the existence of a general working memory module. An explanation might be WM's complexity and certain vagueness in its concepts. For example, Parkin (1998) exhibited brain activity reports argued to be linked to CE functions, but that where strongly different among them and occurred different neural areas. The author suggested the lack of evidence of a neuropsychological region for CE.

Similarly, authors Han and Kim (2009) claim that more research is required to clarify the way in which CE manipulates stored data and control attention between competing visual inputs. Researchers Jones, Macken and Nicholls (2004) criticized the CE's phonological store, experimentally observing it didn't explain both the irrelevant speech and phonological similarity effect, although the model argues its phonological variable would suppress and hence not process nor store that sort of flawed data.

Surprenant and Neath (2009) point the contemporary absence of a widely accepted theory of memory, despite the plethora of reported and published material since the last 50 years past the cognitive revolution. The authors account that memory is a multi-variable phenomenon, noting that variables compromised during the process may generate complex interactions that restrain the development of an integrated human memory model applicable to most scenarios.

Jenkins (1979), better knowed due to his work in language, learning and speech, developed the tetrahedral memory model. His aim was to structure a framework of human memory in order to facilitate further experimentation. The author sustains that memory relies in four variables: subject characteristics, encoding ways, events (as data proper to be apprehended and stored), and retrieval conditions.

The model is consistent with the processing perspective of understanding human memory (contrary to the systems perspective, where previously exposed models are catalogued). Surprenant, A. and Neath, I. (2009) It is no coincidence that Jenkin's thesis was published in a collection of papers edited by Cermak and Craik (1979) titled 'Levels of Processing in Human Memory'.

The processing approach, initiated by Craik and Lockhart (1972) (see also Craik and Lockhart, 1990), emphasizes encoding and retrieval activity, discarding unitary storage systems. (Eysenk and Keane, 2005; Surprenant, A. and Neath, I. (2009). This theory is not free of criticisms and boundaries that require further elucidation. (Styles, 2005) Still, some researchers point that investigations on this field are increasingly turning to an attitude that support a procedural understanding of memory. (Crowder, 1993; Kolers and Roedinger, 1984, Brown, Neath and Chater, 2007)

Resuming the tetrahedral theory, it exhibits the advantage of parsimony. The model's components only account the relevant assumptions necessary to explain the human memory phenomena. Hence, giving it a great deal of explanatory power, as well allowing the researcher to manipulated the model's components ease according to his experimental purposes. (Roedinger, 2008)

Along the essay several research work has been shown to criticize and discard the unitary storage models. Most of it based on its over-simplicity and restrains to explain diverse phenomena. It seems procedural systems offer a better frame for future research. As suggested, the tetrahedral theory might be an interesting non-unitary alternative for this field of psychology.

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