

Prior Knowledge

Satyanarayan Janakiram

Bentley University

Human Factors in Information Design

HF 700: Foundation of Human Factors

Professor William Gribbons

April 07, 2025

Introduction

Long-Term Memory (LTM) function in humans is a complex mechanism for retaining vast amounts of information, triggering us to carry out multiple actions, and serving as the foundation for us to plan and solve problems. Squire (1992) classified LTM, which makes a broad distinction between explicit or declarative memory and implicit or nondeclarative memory. Squire (1992) also proposed components of long-term memory where “Semantic memory goes beyond the meaning of words and extends to sensory attributes such as color and taste and to general knowledge about the world, such as how to behave, and how this may differ between a farmers’ market and a supermarket”.

Digital interfaces are becoming complex, so product designers must think about how users' existing mental model frameworks influence their interactions with new systems (Norman, 2013). Designers need to understand how LTM provides crucial insights for creating the best user-centered designs and experiences with the knowledge that is organized, interconnected, and evolved from past experiences. We will also evaluate how cognitive theories have long fascinated researchers seeking to understand information processing mechanisms. These theories provided valuable frameworks for examining how users approach and interact with interfaces.

Following those discussions, this literature review will delve into examining the organization, interconnectivity, and evolution of prior knowledge in LTM with a case study evaluation of RXNT, a leading provider of Electronic Health Record (EHR) software that has revolutionized how healthcare organizations manage patient information in terms of how well the web application aligns with mental structures.

Organization of Prior Knowledge in LTM

Unlimited Storage Capacity: Long-term memory own what cognitive scientists describe as virtually unlimited storage capacity, distinguishing it from other memory systems such as working memory (Cowan, 2008). LTM can store vast amounts of information throughout a lifetime, whereas short-term memory capacity is limited. This remarkable characteristic can be analogized to efficiently packing items in storage—through systematic organization, seems to have never ending information which can be accommodated when properly structured (Tulving & Craik, 2000).

Organization Models:

Two organizational models which are well-known for Long-Term Memory are schemata and mental models.

Schemata

Bartlett described schemata as “an active organization of past reactions or experiences” based on associated meaning (1932). “The sensory cortex is the storehouse of past impressions. They may rise into consciousness as images, but more often, as in the case of special impressions, remain outside central consciousness. Here they form organized models of ourselves, which may be called **Schemata**.”

Schemata provide efficiency in information processing by allowing individuals to recognize patterns and make predictions based on previously encountered situations (Rumelhart, 1980). Rumelhart and Ortony (1977) offer a simplified view of schemata as “structures for representing the generic concepts stored in memory”. In addition to Schemata, Prototype and Exemplar Models focus on categorization by suggesting how we recognize and classify sensory inputs.

Mental Models

Related to Schemata, mental models pay more attention to problem-solving and the representation of existing knowledge for a specific domain. Mental models also facilitate interaction with complicated interfaces and guide expectations about system behavior. These models represent how individuals understand the causal relationships and functional mechanics of systems they interact with (Johnson-Laird, 1983).

Supporting Theories

Some influential theories for understanding knowledge organization in LTM. Rumelhart and Ortony (1977) characterized schemata as structures for generic concepts, emphasizing their role in interpretation and inference. Minsky's (1975) theory of frames described stereotyped situational structures that could be adapted to fit new circumstances by changing details as needed. Schank and Abelson's (1977) script theory proposed predetermined, stereotyped sequences of actions that define common situations, providing templates for understanding routine activities such as attending an event or visiting a museum. Scripts summarize the common occurrence of events, enabling us to predict what happens next even when some details are not there. It also helps interpret and fill in gaps in our understanding of new experiences by referencing familiar patterns stored in LTM.

Interconnectivity of Knowledge

Our memory is connected to all sorts of unique connections and information. This information is stored through connections between each node. Related ideas can help create a stronger and similar connection, which can help a person remember something faster. Your memory plays a big role with this idea or connection. For example, when you recollect a memory, ideas are initiated if multiple connections are similar or related. Collins & Quillian (1969) proposed the Semantic Network Model, which explains our brain is shaped in an organized structure. The theory proposes that ideas and concepts all create a relationship or connection, which forms a sub-set of networks. To further break this down, this is done through the links between each node. The links are defined as the relationship, while the node is the concept or idea. For example, if you take a general concept, “Automobile Manufacturing”, and can break this down into specific categories, such as Tesla & Ford. These two categories are connected and this is what would create this hierarchy and how Collins & Quillian (1969) define the organized structure. We take one big concept or idea and break this down into smaller categories and see the reliability of this relationship between the two. This concept was later adapted by Collins and Loftus(1975), who further explain that these concepts can have a strong relationship or a weak relationship. For example, the relationship between Tesla and Ford is a weak relationship; however, the relationship between Tesla and Automobile Manufacturing is a strong relationship. There are two concepts, sub-schemata and supra-schemata, that help explain the organization of these networks. A breakdown on a category, Tesla, such as a Model 3 would be a sub-schema. On the other hand, a supra-schemata is a general idea or category, such as “Automobile Manufacturing”. Anderson & Bower (1973) proposed a new theory, Propositional Networks, which is similar, but different to Collin’s theory on the Semantic Network Model. To break down the word, “proposition”, which means there is a subject and a verb or action of the subject. To further break down this model, let’s dive into logical inference and activation mechanisms. Logical inference makes several, logical connections and conclusions based on the proposition. For example, the proposition is “My brother is smart.” This proposition can be further taken into a conclusion that the brother attends an Ivy League School or other logical conclusion of the brother based on the verb/action. “Although strings of English words are commonly used to denote propositions, we would claim that words are never involved in abstract propositions” Anderson & Bower (1974). Like logical inference, an activation mechanism is how one propositions can create multiple, other propositions. Anderson and Bower proposed another theory called Spreading Activation, which further explains the theory describing how one memory can lead to or activate related memories which leads to a network of them. There are also some factors that influence this spread: link strength, recency/priming, frequency, and fan effect. Let’s start with the first factor, link strength, which is two or more ideas that are strongly intercorrelated. This shows the strong association between the two concepts and how they activate other related networks/tasks. The next factor, recency/priming, explains how recent thoughts can affect the thoughts

that come afterwards. If we take the word, “turkey”, for example, you’re more likely to relate it to “Thanksgiving” because turkey is most often associated with the national holiday, and the brain has quicker access because the previous thought has a strong connection to the thought it develops afterwards. The third factor is frequency which means how often something is used in the brain. Take “fire” and “hot” for example, which can make an immediate connection between these two ideas because we’ve used it so many times that it’s become ingrained in our brain. The more the same connection is made in your brain, it will become faster and easier to apply. The fourth factor, fan effect, which explains how activation is weakened when one concept is connected to various networks or ideas. For example, if a person you know has tried several, different teams in their school, then you might have a hard time remembering which team they’re trying for now. This shows that when having many different links or ideas, there is less activation and slower recalling. As explained, our memory is connected to all sorts of unique connections and information. Because of this, existing information is stored, however, can create an inconvenience for processing new information.

Isaacs & Lawrence (1973) introduced Piaget’s concept which explains cognitive development of human nature in four stages, and is broken down into two critical processes, Assimilation and Accommodation. Assimilation is the process of implementation of old information into new concept. For example, when a person looks at a bowl, he can assimilate it into known pattern as a tennis ball. The reason being is because a tennis ball is a similar shape a bowl. This is often how younger children associate existing objects and will correlate the same shape or idea to new objects they spot. On the other hand, Norman and Rumelhart (1976) proposed a new model, which is broken down into three stages, and further expands on how information is processed from people. The first stage is Accretion (assimilation), which represents the simplest form of learning where new information fits within existing mental models with minimum cognitive effort. The next stage, Tuning (Adjustment), which is similar to Piaget’s model, on the concept, Accretion. Tuning is modifying existing information when there is a conflict with the new information. This can help with our last stage Restructuring (Creating New Structures), in Norman & Rumelhart’s model that can add new cognitive structures to the brain due to the new information that is now added.

Metaphors help the users to understand the ideas by activating prior knowledge with cognitive shortcuts that compare two different concepts to familiar ones. For example, in UX design, the search icon (Metaphor) symbolizes finding something with a lens. The metaphorical mapping establishes a relationship between the physical action of finding something closely using a magnifying glass and the digital act of searching through information. Affordance was first introduced by **James J. Gibson** as the

relationship between the properties of an object and the capabilities of the user. For example, drag-and-drop (affordance), where you can drag files into it, implying deletion. The role is to suggest possible actions through design and structure.

Design Case Review

RXNT Systems – Electronic Health Records (EHR) and prior Knowledge Alignment

The screenshot shows the RXNT EHR Patient Dashboard for Kristen Miller. The interface includes a top navigation bar with tabs for Home, Messages, Tasks, and Today's Appointments. A left sidebar provides navigation for various clinical areas like Chart Summary, Encounters, Medications, Problems, Allergies, Procedures, Labs, Notes, Patient Documents, and Alerts. The main content area displays the patient's profile, including name, DOB, and insurance, followed by a 'PROBLEMS' section with a table of active diagnoses.

De...	ICD-10-CM	ICD-9-CM	SNOMED	Onset Date	Sta...	Status Date	Ty...	Date Diagnosed	La...	Se...			
Bre...	Z98.86	V45.83		07/31/2018	Act...	07/31/2018		07/31/2018			↑	↓	🗑️
H/...	Z98.82	V43.82		07/31/2018	Act...	07/31/2018		07/31/2018			↑	↓	🗑️
Re...	F33.42	296.36	46244001	04/04/2019	Act...	04/04/2019		04/04/2019			↑	↓	🗑️
Re...	I15.0	405.91	123799005	06/07/2019	Act...	06/07/2019		06/07/2019			↑	↓	🗑️
Mil...	J45.20	493.90	427679007	08/01/2019	Act...	08/01/2019		08/01/2019			↑	↓	🗑️
Ph...	J02.0	034.0	43878008	08/01/2019	Act...	08/01/2019		08/01/2019			↑	↓	🗑️

Figure 1: Electronic Health Records Dashboard

This case study examines how RXNT Systems has designed its Electronic Health Record (EHR) system by aligning with clinicians' existing mental models and established clinical procedures. The design strategy leverages familiar workflows, iconography, and metaphors to facilitate a smooth transition from traditional paper based processes to digital environments, ultimately supporting efficient decision making and improved patient care.

Alignment with Existing Mental Models

The screenshot displays a patient intake form for Kristen Miller. The form is organized into sections: 'VITALS' and 'BLOOD PRESSURE'. The 'VITALS' section includes fields for Body Weight (160 Lbs), Body Height (66 In), BMI (25.82), Body Temperature (99.0 F), Head Circum (In), Respiratory Rate (Breaths/Min), Heart Rate (Beats/Min), Pulse Oximetry (98%), Inhaled Oxygen, and Glucose (mg/dL). The 'BLOOD PRESSURE' section includes fields for Sitting Systolic (118 mm), Diastolic (70 Hg), Location, Pulse (beats/min), and Rhythm. A red box highlights the 'VITALS' section, and a red arrow points to the 'UPDATE' button in the top right corner of this section.

Figure 2: Patient intake form

Clinical Processes

RXNT EHR is built to mimic traditional clinical workflows, such as patient charting, order entry, and lab result review. By depicting the structure of paper-based patient intake records (Figure 2), the system reduces the cognitive load on clinicians who are already familiar with these formats. This digital imitation helps users quickly adapt to the new system because it resonates with their pre-existing mental models and daily practices.

Schemas and Scripts in Clinical Processes

RXNT's design capitalizes on the predictable nature of clinical routines. The EHR workflows structured around common sequences - such as "review, document, order" - align with clinicians' long-established practices. This familiar scripting supports rapid decision-making and minimizes the learning curve. However, despite the benefits, the complexity is inherent in these systems can sometimes lead to issues where the volume of interactions might overwhelm users.

Training & Automation

RXNT aims to avoid the necessity for extensive training. The activation of these pre-existing sequences means that users can navigate the system, even as it offers advanced features to handle more

complex tasks. The balance between intuitive design and functional depth is critical in maintaining user efficiency and satisfaction.

The system employs standardized medical icons and consistent terminology (i.e. lab icons) to tap into clinicians' semantic networks. This strategic use of iconography not only reinforces the mental mapping of patient data to real-world medical concepts but also ensures that the information is processed quickly and accurately.

Building on Prior Clinical Knowledge

RXNT EHR utilizes metaphors to ease the transition from analog to digital. For example, using an “intake” metaphor for patient intake form or a “dashboard” for an overview of patient status helps bridge the gap between traditional practices and modern technology. These advanced organizers provide structured overviews that simplify navigation and enhance data retrieval, ensuring that clinicians can find critical information swiftly and efficiently. The design of RXNT's EHR caters to both novice users, who benefit from guided workflows, and expert clinicians, who require access to more sophisticated functionalities. This dual approach ensures that the system remains accessible and useful across a wide spectrum of expertise levels.

Ongoing user research, including contextual inquiries and cognitive interviews, is integral to the continuous refinement of the system. Feedback helps RXNT system align its workflows more closely with clinical mental models and addresses emerging challenges, such as resistance to change or operational disruptions.

Conclusion

In conclusion, the design considerations for RXNT Systems demonstrate how understanding long-term memory (LTM) can fundamentally shape the user experience. LTM's characteristics, such as the unlimited capacity, organized storage, interconnectivity, and capacity for evolution – provide a well-developed conceptual structure that informs how products can both align with and gently reshape users' prior knowledge. By designing interfaces that resonate with established mental models and gradually introduce enhancements, UX designers can create experiences that feel intuitive and natural. The planned integration of long-term memory mechanics with users' existing knowledge creates interfaces that are simultaneously intuitive and effective, as demonstrated by the carefully considered approach in RXNT Systems' electronic health record design.

References

- Abraham, W. C., Jones, O. D., & Glanzman, D. L. (2019). Is plasticity of synapses the mechanism of long-term memory storage? *NPJ Science of Learning*, 4(1).
<https://doi.org/10.1038/s41539-019-0048-y>
- Allen, T. A., & Fortin, N. J. (2013). The evolution of episodic memory. *Proceedings of the National Academy of Sciences*, 110, 10379–10386. <https://doi.org/10.1073/pnas.1301199110>
- Anderson, J. R. (1974). Retrieval of propositional information from long-term memory. *Cognitive Psychology*, 6(4), 451–474. [https://doi.org/10.1016/0010-0285\(74\)90021-8](https://doi.org/10.1016/0010-0285(74)90021-8)
- Anderson, J. R. (1980). *Concepts, propositions, and schemata: What are the cognitive units?* United States Defense Technical Information Center.
<https://apps.dtic.mil/sti/pdfs/ADA085997.pdf>
- Anderson, J. R. (1983). Retrieval of information from long-term memory. *Science*, 220(4592), 25–30. <https://doi.org/10.1126/science.6828877>
- Anderson, J. R., & Bower, G. H. (1974). A propositional theory of recognition memory. *Memory & Cognition*, 2(3), 406–412. <https://doi.org/10.3758/bf03196896>
- Bartlett, F. C. (1932). *Remembering: A study in experimental and social psychology*. Cambridge University Press.
- Brady, T. F., Konkle, T., Alvarez, G. A., & Oliva, A. (2008). Visual long-term memory has a massive storage capacity for object details. *Proceedings of the National Academy of Sciences*, 105(38), 14325–14329. <https://doi.org/10.1073/pnas.0803390105>
- Gibson, J. J. (n.d.-a). James J. Gibson. *A History of Psychology in Autobiography, Vol V.*, 125–143. <https://doi.org/10.1037/11579-005>
- Brod, G., Werkle-Bergner, M., & Shing, Y. L. (2013). The influence of prior knowledge on memory: A developmental cognitive neuroscience perspective. *Frontiers in Behavioral Neuroscience*, 7(139). <https://doi.org/10.3389/fnbeh.2013.00139>
- Collins, A. M., & Loftus, E. F. (1975). A spreading-activation theory of semantic processing. *Psychological Review*, 82(6), 407–428. <https://doi.org/10.1037//0033-295x.82.6.407>
- Collins, A. M., & Quillian, M. R. (1970). Facilitating retrieval from semantic memory: The effect of repeating part of an inference. *Acta Psychologica*, 33, 304–314.
[https://doi.org/10.1016/0001-6918\(70\)90142-3](https://doi.org/10.1016/0001-6918(70)90142-3)
- Enterprises, J. (2024, October 18). *Cloud-based, Integrated Healthcare Software*. RXNT.
<https://www.rxnt.com/>

Gibbs, R. W. (1992). Categorization and metaphor understanding. *Psychological Review*, 99(3), 572–577. <https://doi.org/10.1037/0033-295x.99.3.572>

Isaacs, N., & Lawrence, E. (1973). The growth of understanding in the young child. In *Brief Introduction to Piaget* (pp. 5–47). Algora Publishing.

Klein, S. B., Robertson, T. E., & Delton, A. W. (2009). Facing the future: Memory as an evolved system for planning future acts. *Memory & Cognition*, 38(1), 13–22. <https://doi.org/10.3758/mc.38.1.13>

McGrenere, J., & Ho, W. (2000). Affordances: Clarifying and evolving a concept. In *Proceedings of Graphics Interface 2000*.

Meyer, D. E. (1973). Correlated operations in searching stored semantic categories. *Journal of Experimental Psychology*, 99(1), 124–133. <https://doi.org/10.1037/h0034763>

Norman, D. A. (1999). Affordance, conventions, and design. *Interactions*, 6(3), 38–43. <https://doi.org/10.1145/301153.301168>

Piaget, J. (1999a). *Judgement and reasoning in the child*. Taylor & Francis Group.

Quillian, M. R. (1967). Word concepts: A theory and simulation of some basic semantic capabilities. *Behavioral Science*, 12(5), 410–430. <https://doi.org/10.1002/bs.3830120511>

Rumelhart, D. E., & Norman, D. A. (1976). Accretion, tuning, and restructuring: Three modes of learning. United States Office of Naval Research. <https://apps.dtic.mil/sti/pdfs/ADA030406.pdf>

Rumelhart, D. E., & Ortony, A. (1978). The representation of knowledge in memory. In R. L. Klatzky & J. W. Cotton (Eds.), *Semantic Factors in Cognition*. Lawrence Erlbaum.

Schank, R., & Abelson, R. (1975). Scripts, plans, and knowledge. In *Proceedings of the 4th International Joint Conference on Artificial Intelligence* (Vol. 1, pp. 151–157). <https://www.ijcai.org/Proceedings/75/Papers/021.pdf>

Shiffrin, R. M., & Atkinson, R. C. (1969). Storage and retrieval processes in long-term memory. *Psychological Review*, 76(2), 179–193. <https://doi.org/10.1037/h0027277>

Squire, L. R. (2004). Memory systems of the brain: A brief history and current perspective. *Neurobiology of Learning and Memory*, 82(3), 171–177. <https://doi.org/10.1016/j.nlm.2004.06.005>