Bentley University

HF700: Foundation in Human Factors

Prior Knowledge

Long-term Memory &
Figma Case Review

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Introduction

This product review explores the importance of **long-term memory (LTM)** and prior knowledge as it relates to the field of design. LTM is the process of learning, storing, and retrieving information (Cowan, 2008). LTM consists of **prior knowledge**, such as space-time events, meanings, rules, strategies, cognitive maps, and other types of information (Fernández & Morris, 2018). This knowledge is acquired by formal and experiential learning over the course of one's lifetime and is stored in LTM at **infinite capacity** (Atkinson & Shiffrin, 1968). Because LTM has unlimited capacity, it is characterized as being highly organized, intricately interconnected, and constantly evolving. In contrast to bottom-up processing, which is based on the physical characteristics of a stimulus, LTM is a component of **top-down processing** and is dependent on knowledge and context (Frith & Dolan, 1997). LTM has supported human evolution by enabling the core learning of skills and behaviors necessary for survival in hunter gatherer times, such as the procedural knowledge for setting traps to hunt wild animals and catch fish (John Robert Anderson, 2000). Although the vast majority of humans are no longer hunter gatherers today, LTM is still important in our everyday lives because it allows us to unconsciously retrieve implicit memories and actively recall explicit memories (Tulving, 1985). For example, we can retrieve the semantic memory of the English language, the episodic memory of one's wedding day, or the procedural memory of tying one's shoes. For interaction design specifically, LTM includes **mental models** that critically govern how users will interact with digital systems (Johnson-Laird & Byrne, 1991). This paper will describe and apply the science of LTM to a Figma case study.

Highly Organized

Many scientific theories posit that LTM is highly organized. **Adaptive Control of Thought—Rational**, sometimes known as **ACT-R**, is a cognitive architecture theory created by JR Anderson that describes how the brain is structured so that different processing modules can enable cognition (John R Anderson, Matessa, & Lebiere, 1997). Additionally, **schema theory**, first studied by Jean Piaget in a series of cognitive development studies in children, proposes that the brain structures prior knowledge in LTM using schemas (Piaget, 1976). Schemas are knowledge structures or mental concepts about a particular subject that are developed and organized based on our experience and understanding of our environment (DiMaggio, 1997). While there are many different types of schemas taxonomically organized, there is a specific schema, called a script, that is significant in cognitive psychology. **Scripts** describe a sequence of activities that allow us to prepare for repeated events and act appropriately (Abelson, 1981). For example, scripts are a type of event schema that guide us for weddings because we can anticipate there will be a ceremony followed by a party or reception. While schemas allow us to understand a range of concepts, they also have the potential to alter memory of events at the point of time when they are being experienced. Schemas guide our attention and influence the concepts, or "chunks" of information, that are available to be encoded in our LTM. As a result, when we recall memories, schemas have the potential to bias the recollection of what actually happened. This schematic subjectivity at play when encoding memory is why eyewitness testimony is notoriously unreliable (Loftus & Hoffman, 1989).

Another theory proposing how LTM is organized is Minsky's **Frame Theory.** According to Minsky, when someone is faced with a new situation, they will select a "frame" from their memory that will be modified to reflect the current experience. A frame acts as "a data-structure for representing a stereotyped situation" and includes information such as how to use the frame, what to expect next, and what happens if the expectations do not conform to the given scenario (Minsky, 1974). Frames also interplay with attention as Minsky claims that individuals evoke a frame primarily concerned with the current topic or focus of attention. Yet, another way of thinking about the organization of LTM is Barsalou's more recent work on **ad-hoc, or goal-derived, categories** (Barsalou, 1983).While the aforementioned theories are predicated on taxonomic categories with membership based on a combination of conceptual and physical features that influence attention, Barsalou posited that there are other kinds of categories necessary to accomplish goals, called ad-hoc categories (Barsalou, 1991). Ad-hoc categories are actively formed from prior knowledge in order to achieve a specific goal in a certain context. Barsalou's research has greatly contributed to the field of cognitive psychology, leading to advances in the flexibility of semantic relatedness and the impact of particular behavioral goals on conceptual representations in LTM (Barsalou, 1982).

Interconnected

In addition to being highly organized, LTM is also intricately interconnected (Klimesch, 2013). The semantic network has traditionally been one of the most common approaches to understanding the interconnected nature of LTM. **Semantic memory** contains conceptual and propositional knowledge. A concept is a mental representation of something, such as a cat. A **proposition** is the smallest unit of meaning and a conceptual relation that may be evaluated true or false, such as a cat is a feline (Maida & Shapiro, 1982). Collins and Quillian initially proposed a hierarchical model of semantic memory in which concepts (nodes) are connected to one another via links (propositions) (Collins & Quillian, 1969). Collins and Loftus later de-emphasized this hierarchical structure and argued that every individual develops a semantic network in which each piece of information is linked with related information based on their own experience or knowledge (Collins & Loftus, 1975). As a result, direct links and lengths of links between nodes vary by individual, explaining why some people can recall certain topics faster than others (Ratcliff, 1978).

Collin and Loftus' theory resonates with Minsky's theory as Minsky similarly proposed that "we can think of a frame as a network of nodes and relations" and that "collections of related frames are linked together into frame-systems" (Minsky, 1974). However, Minksy differed from Collin and Loftus because he suggested the upper levels of a frame are fixed, representing elements that are consistently true about the ostensible situation, while there are also numerous terminals, or "slots," present in the lower levels that must be filled with certain instances or data (Minsky, 1974). Either way, because all ideas are interconnected, when the brain activates one concept it is simultaneously triggering or prompting related concepts to surface. This elevation and availability of concepts primed for ongoing cognition is called **spreading activation** or **semantic spreading** (Collins & Loftus, 1975). John R. Anderson conducted a series of experiments on how semantic spreading "fans" out from nodes to other linked concepts and proved that the farther the activation fans out in a semantic network, the more likely errors are to occur and response time slows (John R Anderson & Schooler, 1991). This concept is known as the **"fan effect".**

Due to the cognitive economy principle, long-term memories are stored efficiently and logically so we can easily retrieve information (Rescher, 1989). Strength of associations determine the ease of memory retrieval, and the strength of connections in LTM is determined by the **frequency** and **recency** of their use (John R Anderson & Schooler, 1991). The more frequently and recently the connections, or synapses, have been triggered in the past, the stronger the connections are. The regular changes in the strength of the synapses between brain cells is referred to as **synaptic plasticity (**Dudai & Evers, 2014**)**. Furthermore, fewer synapses result in weaker retrieval and interfering associations can inhibit proper retrieval (Bürki, Elbuy, Madec, & Vasishth, 2020).

<u>Constantly Evolving</u>

The third defining characteristic of LTM is that it is constantly evolving because we update and modify our memory based on lived experiences. Piaget's concepts of **assimilation** and **accommodation** offer two different methods by which our memories are modified. Assimilation is the cognitive process of integrating new knowledge into preexisting cognitive schemas, perceptions, and understanding (Piaget, 1976). Accommodation is the cognitive process of radically updating a schema or creating a new schema when faced with an entirely new experience (Piaget, 1976). Accommodation requires more mental effort than assimilation, so the brain will strive for **equilibration** and balance instances of assimilation and accommodation in order to conserve mental resources and efficiently facilitate cognitive growth (Ginn, 1995). In contrast to Piaget's concepts of accommodation and assimilation, Rumelhart and Donald Norman proposed a mode of learning called **tuning (Rumelhart & Norman, 1976)**. Tuning is the adjustment of knowledge to a specific task, usually through practice, and is a slower form of learning that accounts for developed expertise.

Becoming an expert entails creating effective high-level chunks and concepts that are constantly being prioritized, and to some degree reorganized, according to the cognitive requirements present in the specialized field (Elio & Scharf, 1990). Experts can easily trigger **trace memories**, or engrams, which are changes in neural tissue as result of encoding a memory (Moscovitch et al., 2005). Experts do not require nor benefit from **scaffolding**, a process or aid that assists a novice to solve a problem they otherwise would not be capable of doing (Sutton, 2015). They rarely commit errors, but when they do, it is typically a result of tunnel vision and culminates in severe consequences (Williams, 1985).

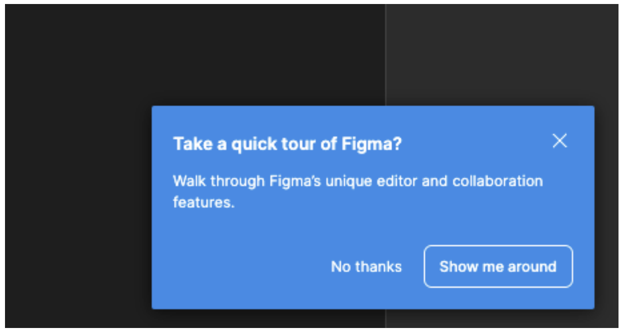
Case Review

Context

Figma is one of the leading web-based interface design applications that supports collaborative working for product teams. The platform is also supported by a desktop application on macOS and Windows. Adobe recently announced on September 15, 2022, a deal to acquire Figma for $20B, which will make it Adobe's largest acquisition to date (Peters, 2022). Figma is the main design tool for many product teams to create and share designs. The trifecta of platform personas includes the novice user, the occasional user, and the expert user. A platform like Figma must account for the variation of these three personas considering many different users access Figma at different intervals and depths for different reasons. For example, a seasoned UI or UX designer would be considered an *expert* Figma user because they are generally in Figma every day wireframing, creating new mock-ups, updating the style guide, etc. Business Analysts (BAs) and developers would be considered *occasional* Figma users because BAs access Figma to write functional user stories and developers access Figma to ensure their code output matches the finalized high-fidelity designs. On the other hand, product managers or program sponsors would be considered *novice* Figma users as they only use Figma sporadically to show project progress or present updates to executive audiences. This case study will explore Figma's onboarding process and assess how successful the product is in onboarding a novice user.

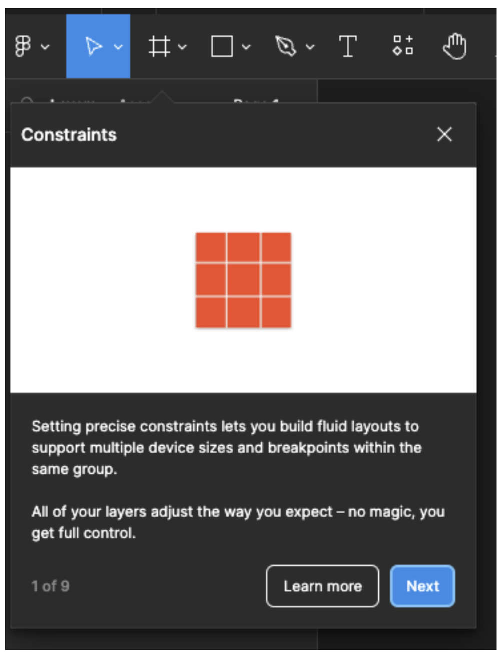
Analysis

A novice user does not have robust schema and relies on verbal and visual overviews to activate relevant feature information. When first launching Figma as a brand-new user, the onboarding modal portrayed in **Screenshot 1** appears in the lower right-hand corner of the screen.



Screenshot 1: Figma onboarding modal

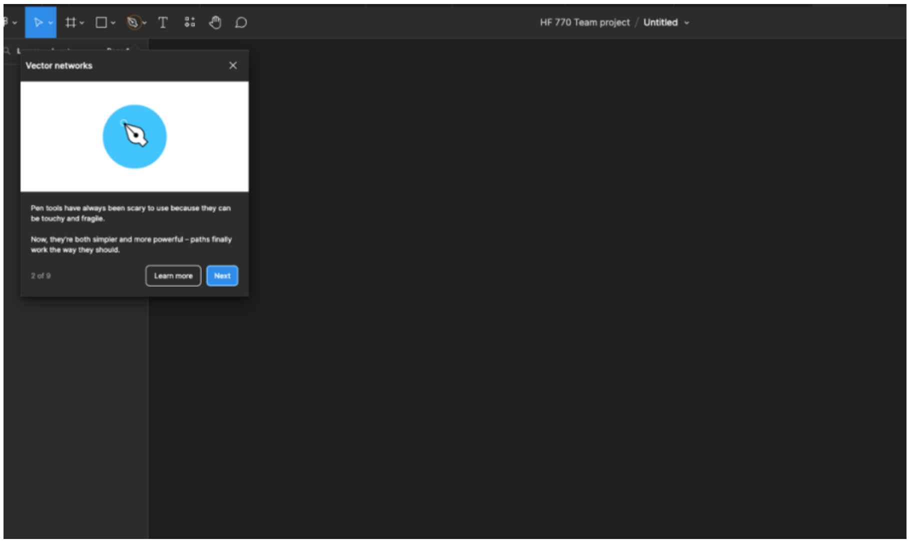
This is an excellent popup as it offers a novice user an in-context experience for learning the most relevant Figma features. While it provides the appropriate scaffolding or performance support for a new user, it also gives experts the option to turn it off/disable it by clicking the X close/exit icon. Upon clicking the "show me around" button, the onboarding flow takes you through a series of nine steps that highlights different key features of the platform as shown in **Screenshot 2**.



Screenshot 2: Figma onboarding flow

The tool bar walk-through employs redundant coding as one feature is represented with an icon, title, image, and blurb. This is very beneficial to a novice user because redundant coding surfaces more connections and greater diversity of connections to increase access in semantic spreading or semantic activation. These tutorial modals also depict realistic outputs of the features, which is phenomenal for novice users because they cannot fill in the gaps or reconcile abstractions due to their lack of robust schemas in this area.

It is also very easy to move through the nine steps of the onboarding flow as the "Learn More" vs. "Next" buttons empower the novice user to choose what level of detailed information they want to consume in order to manage their cognitive load and not feel too overwhelmed at the onset of platform usage. This onboarding flow creates a meaningful navigational pathway that immediately delivers value to a novice user. This is important to the business as a clear route in onboarding decreases abandonment rate, which is an important success metric for the business. Figma's onboarding flow does a great job of defining and minimizing technical language, as shown in the vector networks example in **Screenshot 3 below**.



Screenshot 3: Vector networks

While the vector tool might appear intimidating at first, Figma analogizes it to a pen and asserts it is easy to use. These highlights are also juxtaposed against open "white space", avoiding any visual intimidation from data density for the novice user.

Recommendations

While Figma overall offers a successful onboarding experience for novices, there are a couple improvements that can be made to orient new users to the platform. Even though it is tricky to trigger a very specific response because a vast network of prior knowledge also surfaces, Figma could consider appealing to users' mental models by including more graphical UI metaphors. For instance, the toolbar contains nine short cuts but none of the icons clearly signify the function of the feature. Incorporating more metaphors, even though they do not transcend time and need to be updated, could increase the usability of Figma for a new user. For example, a consistent graphical UI metaphor that is well known is a folder, but Figma does not employ this feature for its pages. Additionally, as most new users might be coming from Adobe Illustrator or Sketch, Figma could consider keeping some of the features and workflow consistent with those software in order to activate familiar mental models.

Conclusion

Top-down processing enables us to encode, store, and retrieve LTM. Because of its infinite capacity, LTM is highly organized, intricately interconnected, and constantly evolving.

Whether its Piaget's schema theory or Minsky's frame theory, unlimited concepts are efficiently organized in our LTM. According to Collins and Loftus' most recent semantic network theory, all these concepts are also interconnected and linked. Spreading activation occurs when one topic is retrieved, and the linked or associated topics also bubble up with it. Lastly, our LTM is always evolving as we go through life and encounter new experiences. Whether it is Piaget's assimilation and accommodation model or Rumelhart and Donald Norman's tuning hypothesis, there are many theories as to how we update and enhance our LTM to progress our cognitive development. As designers, we can leverage the science of LTM to create triggers, prompts, and advanced organizers that stimulate the appropriate memories of our users to interface with our product in a predictable and controlled manner.

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