Information Processing Theory in Context

When students are introduced to new information, do they collect, process, and store it like a computer? According to many cognitive psychologists, this is not too far from the truth when describing the structures involved in learners' mental operations. Beginning in the World War II era, many within the field of experimental psychology began to abandon traditional theories in favor of the cognitive school of thought for a number of reasons. Perhaps the most important of these was the fact that the atmosphere of the times demanded such a reevaluation. Scientists and engineers of the 1940s and 1950s were deeply involved in advancing technologies that assisted in the war effort like television, the telephone, and of course, the computer. As a result, an entirely new language to describe the transmission of information that included phrases like "communication channels," "coding information," and "dual processing" became ubiquitous (Miller, 2001). As a natural extension, the field of psychology needed to accommodate such a change. In this fledgling technology, cognitive psychologists saw a new way to look at how people processed information, drawing striking similarities between the computer and the human brain. From these developments, Information Processing Theory was born.
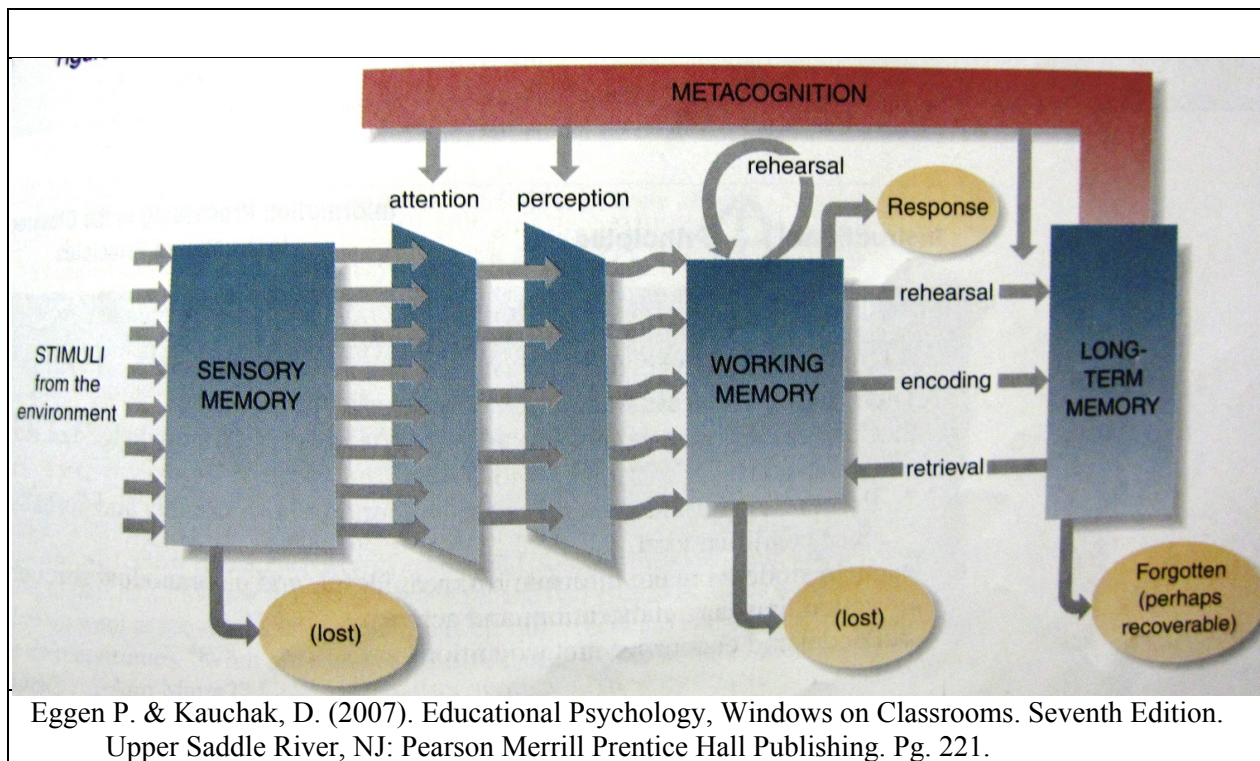
Information Processing Theory has become one of the most prominent psychological theories that serves to describe the process of learning. According to cognitive psychologists, learning can be defined as a change in a person's mental structures that creates the capacity to demonstrate different behaviors (Eggen & Kauchack, 2007). Information Processing Theory looks closely at how, independent of the context, stimulation from the environment goes through the processes of attention, perception, and storage throughout a series of distinct memory stores.

Although this descriptive process is often perceived as one of the primary strengths of the theory, I would argue that it is in fact one of its primary weaknesses. When we are considering the learner as a whole, I believe that any overarching theory used to explain mental processes must holistically look at both the learner him- or herself AND the social and environmental context in which the learning occurs. To fully understand my proposition, I need to first have an in-depth discussion of what Information Processing Theory contributes to understanding learning, what the theory's limitations are, which experiences have lead me to suggest a change, and how I actually intend to alter the theory.

The structure of the information processing system is fairly elaborate. When broken down into distinct stages however, it becomes fairly manageable. As previously discussed, Information Processing Theory first focuses heavily on three major memory stores that are involved in cognitive processes; sensory memory, working memory, and long-term memory. One scholar, Richard Hall, a professor of Information Science and Technology at Missouri University, described the interdependence of the memory stores in this way:

> "Sensory memory is sometimes called the "sensory buffer" in that it is like a temporally buffer in a computer that stores information briefly (sort of like your cache in a web browser). Then comes short term memory which is very much like a file that you're working on, before you save it (so short term memory is like RAM). And, long term memory is, of course, analogous to a hard drive" (Hall, 2009).

Using this description, it is no surprise how cognitive psychologists first began to draw parallels between human memory and computers in the 1950s and 1960s. The next portion of this discussion will be dedicated to describing the primary components of the Information Processing model. To aid in understanding, I've provided one version of the proposed model for this theory, shown in Figure 1 below.

Eggen P. & Kauchak, D. (2007). Educational Psychology, Windows on Classrooms. Seventh Edition. Upper Saddle River, NJ: Pearson Merrill Prentice Hall Publishing. Pg. 221.

The first of these memory stores, sensory memory, is the first store to come into contact with information. Although the capacity of this memory store is virtually unlimited, its power to retain information is extremely limited. The sensory memory store can retain new information for approximately one to four seconds before it is either stored in working memory or lost (Eggen & Kauchack, 2007). What is most important about the sensory memory store is that it gathers new information and allows the processing system to attach meaning to the material. If the information is consciously focused on and not dismissed as a distraction, it captures the

learner's attention. According to Information Processing Theorists, the attention phase represents the stage during which learning actually begins to occur in students (Eggen & Kauchack, 2007). After the attention phase is initiated, if the information is important enough and students recognize it as such, they will develop their individual perception of the stimulus. In relation to the sensory memory store, a student's perception of a stimulus is the most important phase, as it directly affects how students consciously understand the information in the next store, working memory (Eggen & Kauchack, 2007).

The working memory store, like sensory memory, is limited in capacity and in duration. According to our text, information can be stored in working memory for between ten and twenty seconds (Eggen & Kauchack, 2007). In terms of capacity, it is much more difficult to determine how much content can be temporarily stored. Information Processing Theory maintains that an individual's "cognitive load" depends upon how much data can be "chunked" (Eggen & Kauchack, 2007). The concept of chunking was first proposed by George Miller in 1956. Miller wrote that a given individual could hold 5-9 "chunks" of meaningful information in their working memory. Interestingly however, individual chunks can refer to digits, words, pictures, or even people's faces. (Ali-Hassan, 2005). While the time that information can remain in the working memory is longer than that of the previous store, if a learner does not once again assign perceptual importance and draw linkages to the content, it will likely be lost. Building off one of the major tenets of cognitive psychology, these connections tend to be made based on the level of association that is made to prior knowledge already stored by an individual. In this way, it is intuitive to believe that as a student grows older and learns more, the working memory will be more efficient and have a greater capacity due to a more accurate perception of the information presented and broader prior knowledge.

The third and final memory store in the Information Processing Theory model is long-term memory. After meaningful information is "chunked" in appropriate groupings within working memory, the material is encoded into long-term memory through rehearsal. Within long-term memory, there are two broadly accepted types of knowledge that is stored: declarative knowledge and procedural knowledge. Declarative knowledge is specific information like facts, definitions, procedures, and rules, while procedural knowledge is the information required to be able to perform a given task (Eggen & Kauchack, 2007). In contrast to the previous stores, long-term memory has a virtually unlimited capacity and duration when it comes to storing and recalling information. One dominant theory that has gained traction in recent years that helps to explain the capacity of long-term memory is the Dual Coding Theory, developed by Allan Paivio. Paivio maintains that there are two "tracks" on which students can encode information in long-term memory, a visual track and a verbal track. The theory explains that because these tracks are separate but additive in capacity, we can take advantage of the structure of long-term memory by stimulating both of these tracks simultaneously to build greater representations for the information and making it easier to recall it over time (Paivio, 1990). For example, providing a picture of an individual along with either writing or speaking that person's name is most conducive to learning than just one or the other.

The final two important characteristics of long-term memory detail how this memory store interacts with the other components of the information processing model. To use encoded information consciously, it must first be retrieved from the long-term memory store and brought into working memory. Recognition, correctly identifying previously stored information amongst distractions (e.g. multiple choice tests), and recall, reproducing information exactly how it was learned without contextual clues, are two ways of doing this (Hummel, 1997). Between these

two, recognition is less beneficial for learners, although it is significantly easier to perform. This is because recall does not provide social clues for the learner which requires them to draw the information from long-term memory without a scaffold. Finally, to solidify a learner's understanding of the content, the strategy of metacognition can be applied. Metacognition is defined as one's awareness and control over their cognitive processes, or one's ability to "think" about what they know and think (Eggen & Kauchack, 2007). Referencing to the model in Figure 1, when we apply metacognition, information stored in long-term memory is retrieved and placed back into the attention and perception stages before reentering the working memory store. In this way, learners can make their knowledge more concrete by consciously thinking about it before encoding it again into long-term memory.

This comprehensive model for learning and knowledge acquisition has been one of the most influential in terms of the field of Educational Psychology for the past fifty years. If this model is fully accurate, we would be making some important assumptions that need to be stated, however. First of these is that the emotions a student is feeling will have little to no effect on what or how much learning occurs (Eggen & Kauchack, 2007). Information Processing Theory assumes, in relation to its foundation in the human-to-computer analogy, that learning can be achieved in a passive and mechanical manner. While this sounds like a much simpler way to address how students attain knowledge, it leaves out well-researched support that learning is active and requires significant effort by the student. It also nearly eliminates the consideration for emotional, affective, and motivational aspects of learning, as well social, cultural, and epistemological factors, and biological, physiological, and evolutionary considerations of learning (Mayer, 1996).

The second important assumption that Information Processing Theory makes is that there is no need for a consideration of the social context in which the learning occurs (Eggen & Kauchack, 2007). Because the mental structures is the centerpiece of this theory, information processing theorists propose that social context is either not a factor at all, or is not as important as the mental structures that occur in the serial order proposed in the model. When applied to a specific learner, this theory suggests that in essence, a student's mind behaves consistently regardless of the learning situations in which he or she finds him- or herself; this would exclude from consideration certain people that they are interacting with, certain locations that they are learning in, or even what content they are studying. The primary reason for this shortcoming is the way in which the research used to develop the Information Processing Theory was collected. In a comprehensive study of the history of this model, well-known educational psychologist and the author of the Theory of Multiple Intelligences, Howard Gardner suggested that cognitive psychologists made a fatal error in collecting their information; "even when their [cognitive psychologists'] results held up, there was increasing skepticism about their actual value…information-processing psychologists developed increasingly elegant models about effects that did not prove robust…under real-life situations" (Gardner, 1985). Because the data was collected in an isolated and controlled environment, cognitive psychologists inadvertently made the assumption that learning occurs in a vacuum. This did not give full credit to the reality that learning is not insulated from the environment, but occurs in a broader and more meaningful social context.

To the credit of those who helped develop the Information Processing Theory, it is important to remember that cognitive psychologists did not set out to provide an explanation for factors related to a learner's milieu when processing information. According to our text, virtually

all cognitive theorists and many other educational psychologists accept the architecture of information processing, including the concepts of limited capacity memory stores, long-term memory storage, and the broad concept of metacognition (Eggen & Kauchack, 2007). Nonetheless, because of my experiences and the fact that Information Processing Theory has the potential to be a more comprehensive and meaningful theory, changes need to be made. My rationale for this contention stems from an interaction that I had with my nearly three-year old nephew, [nephew's name].

The first son of my eldest sister, [sister's name], [nephew's name] is an energetic, affectionate, and intelligent young boy. For three years, I have watched him grow from an infant who could make only indistinct mumblings and use symbols to communicate his needs, to an active learner who is endlessly processing different stimuli from his environment. It is clear to me while observing [nephew's name] that he is very much attached to his parents, who epitomize the role of nurturing and loving parents. On a regular basis, my sister and her husband encourage [nephew's name] to participate in meaningful and educational opportunities that allow him to self-discover and expand on his multiple levels of intelligence; these activities often take the form of shooting baskets in his four-foot tall indoor plastic hoop, exploring their expansive backyard during the summers, or reading his favorite "Thomas the Tank Engine" books each evening before bedtime. Within one particular instance of the latter activity, I observed a series of events that has led me to believe that, to be valid, Information Processing Theory requires some allowance for social context, especially in situations involving the recall of information from long-term memory.

This particular interaction occurred the last time I saw [nephew's name] at his family's house in Bloomington, Minnesota. Before he was sent to bed that evening, I was chosen by my

nephew to read to him one of his favorite books: <u>Cranes, Trains, and Troublesome Trucks</u> by W.V. Awdry. As I was sitting in the living room recliner, [nephew's name] climbed onto my lap and uttered the simple phrase, "read, Uncle Chris!" Because I do not get to see [nephew's name] more than once every few months, I obliged, and began reading the short book to him. At first, [nephew's name] seemed somewhat uneasy with the social situation; although he knows me by name, he doesn't know me very well yet, and I am certainly not the usual person to be reading him his bedtime stories. For the first few minutes, he sat rigidly on my knee, and didn't seem like he was particularly excited to have the story read to him. After the first couple of pages however, [nephew's name] slowly settled down and began to focus more intently on the book as I read it, pretending as if he could read the whole story on his own. Showing some characteristics of active learning, he spent much of his time sitting quietly, looking back and forth from myself to the illustrations in the book, and drawing connections between what he saw in the images, and what I was reciting.

Within a few minutes, we had finished the book, and [nephew's name] was ready for bed. But as many three-year olds tend to do, he tried to stall the inevitable. Running to the table, [nephew's name] scooped up the book, and went over to where his father, [brother-in-law's name], was sitting. "Daddy, read again!" [nephew's name] said. [brother-in-law's name] picked up [nephew's name] and put him on his lap to begin reading the same "Thomas the Tank Engine" book once more. As soon as [nephew's name] got onto his father's lap, he seemed to undergo some sort of transformation in his demeanor. First of all, [nephew's name] appeared to be physically more comfortable with his circumstances. He immediately shifted in more closely to his dad, leaning against his shoulder as he had done hundreds of times before. More importantly however, [nephew's name] was immediately more intent on the story. When

[brother-in-law's name] opened the book, [nephew's name] sat upright and became much more attentive than when I had read the same story to him less than ten minutes previously. What's more, when [brother-in-law's name] began to read to his son, [nephew's name] was able to recall the information much faster than before. After his dad started off by reading the first line of more than ten on each page, [nephew's name] would immediately begin reciting the rest of the page by heart. It was clear that [nephew's name] was not actually reading the book, as a comprehension of the story was not evident. Also, on a couple of occasions, his dad had to scaffold for him by providing one or two word prompts when [nephew's name] got stuck. After I expressed my surprise in the change in his behavior, I asked both [brother-in-law's name] and [sister's name] if [nephew's name] had ever done that before. They responded that it was really quite common for [nephew's name] to be able to recite the whole story, especially with that particular book. This struck me as odd not only because had I provided the same prompts in a similar tone to [brother-in-law's name]'s, but because [nephew's name] was also in virtually the same environment as he was when I read him the book. Using this series of interactions between my nephew, his dad, and myself, I can begin to describe how I think the Information Processing Theory should be altered, and what specific changes I would make to the model.

Returning to some of the basic assumptions of the original Information Processing Theory model, cognitive psychologists would assume that in the context of the two book readings, [nephew's name] should have acted in comparable ways. The social context of the two examples, reading with his uncle that he doesn't see often and reading with his dad whom he sees on a daily basis, would have made little difference. When [nephew's name] heard the first few words of the book from whichever source, it would have captured his attention in a similar way. Also, because he asked to have the book read to him both times, he should not have

distinguished between who was doing the reading. Despite this, it was clear that there was a significant metacognitive and perceptual difference in the way that [nephew's name] acted in this scenario. Not to oversimplify the scenario, a number of factors could have caused this difference in behavior. First of all, it could have been that [nephew's name] was simply more comfortable having the book read to him by his father. Intuitively, this seems like the most likely answer, as young children often establish a very close bond with their parents. It is also possible that [nephew's name] could have been slightly more tired while one of us was reading the story, which could have caused him to interact different. Finally, another likely possibility is that [nephew's name] could have simply needed time to refamiliarize himself with the full story to the point where he was comfortable reciting it. Regardless of the explanation, any and all of these factors can be attributed to a change in emotion, a contrast in social contexts, or a subtle effect caused by environmental factors, none of which the standard model for the Information Processing Theory takes into consideration.

For the lack of applicability of Information Processing Theory to a scenario in which social context is clearly a factor, I suggest an alteration in the model. To be able to effectively propose this change however, a couple of things need to be determined beforehand. First of all, consideration should be given to whether or not [nephew's name]'s recognition of the change in social context was carried out consciously or subconsciously. The difference is significant, as not all memory stores or processes within the information processing model occur at the same level of awareness. From my interactions with my nephew, I believe that his acknowledgement of the difference between his father and I was certainly made consciously. Not only was the change in his demeanor observable through his expressions, but the way in which [nephew's name] chose to behave throughout the process is based in a conscious choice and proved that he was aware of

his environment at the time. As a result, the action of consciously recognizing social context would be contradictory to the core principles of Information Processing Theory if it occurred before or while a stimulus is processed in the sensory memory store. Referring back to the previous discussion of the theory, the only processes that occur consciously are found within the relationship between the working memory and long-term memory stores; rehearsal, retrieval, and metacognition. The most cognitively demanding of these, and thus the process that I think could most likely accommodate the conscious recognition of social context is the latter operation, metacognition.

The adjustment I propose that could be made to the Information Processing Theory model to make it more accommodating for real-life circumstances is shown below in Figure 2. There are a couple of reasons why I chose to alter the model in this way. First of all, when [nephew's name] made his conscious recognition of the differences in social context while being read the book, he was neither rehearsing nor retrieving the content. Because his awareness of his environment appeared immediately in his interactions with his family members, it would not be appropriate to make my adjustments to the model in relation to either rehearsal or retrieval. In addition, I think that because the conscious recognition of social context is by no means a casual process, it should thus not be attributed to these less demanding processes.
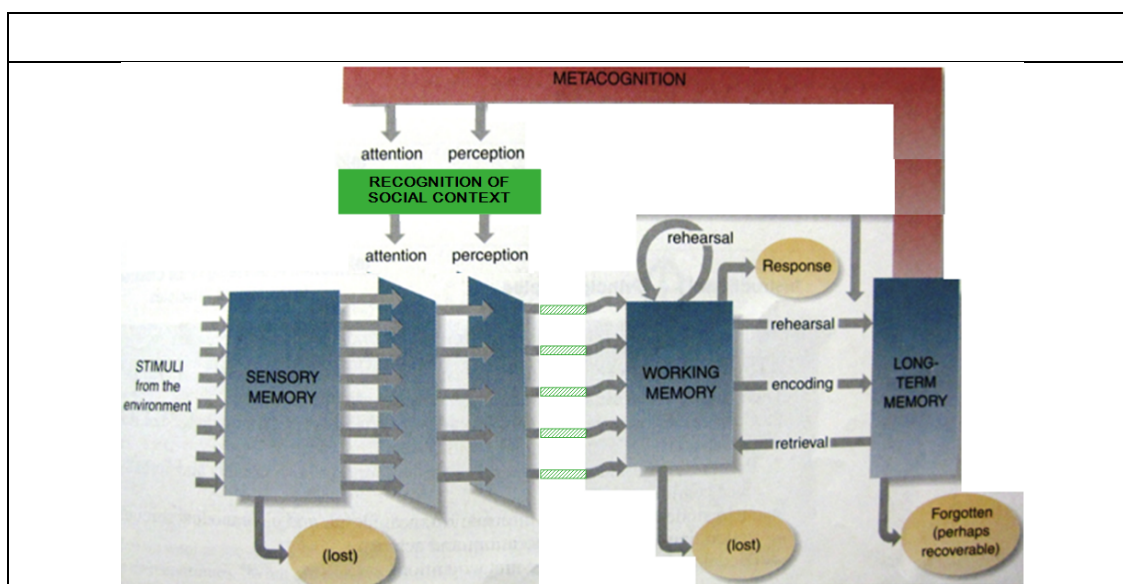
In contrast, the process of metacognition could most certainly accommodate such a change. In our text, two types of metacognition exist that support this claim. The first of these is meta-attention, or the knowledge of and control over your ability to pay attention (Eggen & Kauchack, 2007). Meta-attention is important to the process of recognizing social context, as the environment that a student finds him- or herself in can be more or less conducive to learning depending upon the circumstances. As a result, the learner may be required to exercise his/her ability to control his/her attentiveness, which could possibly prolong the process of the information being perceived and moving on into the working memory store. For example, while I was reading [nephew's name] the book, it took him much longer to become comfortable with the scenario, which was demonstrated by his lack of focus and restlessness. The second type of metacognition, metamemory, is also relevant to my changes. Metamemory is the ability of a learner to consciously know and have control over his/her learning strategies (Eggen & Kauchack, 2007). In the scenario with [nephew's name], because he was aware of the differing social contexts, one which he was more comfortable with and one that he was not, I believe that his ability to apply metamemory strategies was slowed. This resulted in his lack of ability to recite the material for me, but complete the task with relative ease when with his father. In Figure 2, both of these conditions are reflected by the "recognition of social context" and the conditional prolonged passage of information from perception to working memory.

I think these are positive alterations to the model for a couple of reasons. Most importantly, the changes do not completely disfigure the original model. The processes of rehearsal, encoding, and retrieval are all still intact as originally designed. What has changed is the consideration for the idea that when (and if) students perceive the social context of a situation to be relevant to their learning, it can either quicken or prolong the time it takes to store or

retrieve the information. This change is most appropriate, as my experiences with [nephew's name] have not led me to believe that the social context of the situation prevented him from remembering what the story was, but instead acted as a distracter that drew his attention away from the process of retrieval. In the same way, the environment than any person finds themselves in can consciously hinder his/her ability to learn, rehearse, and remember information. In our text, the author writes that "students who are aware of the importance of attention are more likely to create effective learning environments for themselves. The adaptation can be as simple as moving to the front of the class or turning off a distracting radio while studying" (Eggen & Kauchack, 2007). If this scenario is true, and the environment, or social context, that one finds him- or herself in can impede the process of information moving along our processing system, it should be reflected in the model.

Throughout this lengthy discussion of Information Processing Theory, I have attempted to make a couple of things clear. First of all, the original Information Processing Theory is most certainly a valuable explanation of learning. The support that Information Processing Theory receives when compared to other theories of learning is deserved. The theory is accurate, consistent, and intuitive in many ways as it draws meaningful parallels to the everyday technologies around us. It is not without its limitations however, as cognitive and developmental psychologists alike have both recognized the theory's weakness in neglecting real-world considerations for social context and human emotion. This is apparent not only as a result of the years of academic research on the topic, but through everyday interactions that we experience, as I did with my nephew, [nephew's name]. To be a comprehensive theory of learning, social context must be included not only in the discussion of Information Processing Theory, but also in the theory's model as well. As I have shown in this discussion and in the proposition of a revised

Information Processing Theory model, such a change can be not only minor, but extremely meaningful as well. After all, the true advantage of the human brain over the computer has always been, and will always be, the ability to consider both emotion and social context.

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