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Enlivening The Machinist Perspective: Humanising The Information Processing Theory With Social And Cultural Influences

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Abstract

The information processing theory has been a prevalent framework for understanding cognitive function for over five decades. Theory which explains human cognitive processing similar to computer processing has limitations however, as contemporary literature continues to illuminate. The first section of this paper is organised according to features of the information processing model including sensory input, sensory memory, attention, pattern recognition, working memory, encoding, retrieval, and long term memory, with a brief description of each component followed by compelling, recent literature describing social and cultural influences on the component. In the second section, the information processing model is redefined to incorporate social and cultural influences on cognition, reflecting the significance of social and cultural influences on human cognitive function. The third section includes implications for teaching and learning, highlighting the relevance of helping learners to make connections.

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Keywords: cognition; information processing theory; cultural; social; influence; sensory; working; long term; memory; model

1. Introduction

Understanding how the human mind works is a source of considerable intrigue. An area within that understanding is cognition, the "mental action or process of acquiring knowledge and understanding through thought, experience, and the senses [and resulting] perception, sensation, notion, or intuition" (Oxford Encyclopedic English dictionary, 1991). Human cognition has largely been considered as universal, with all people having basic cognitive processes that work the same way, from 18th century philosophy through developmental and cognitive psychology to current

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cognitive science today. One view in particular has extended beliefs in the universality of cognition. Evolving in the 1960s with the use of computers, the information processing theory compares human cognitive processing with computer processing. No singular author takes credit for the information processing theory, also known as the machinist perspective, but it is widely accepted and the basis from which much research has developed.

In computer processing, information is data inputted into a computer, which receives, extracts, organises, and stores the data through a series of steps, and expresses it as output as a product of computing. The information processing theory views humans as machines which similarly input, process, store, and retrieve information. The neurological processing system of the brain is the hardware, and rules for reasoning, like data processing, are the software, while input fuels output as behaviour and beliefs (Masuda & Nisbett, 2001). The focus is on internal systemic processes while social context and influences on processing are mostly ignored (Miller, 2011). The theory is represented in a model (Fig. 1) combining parts and processes as the generally accepted components of cognition.

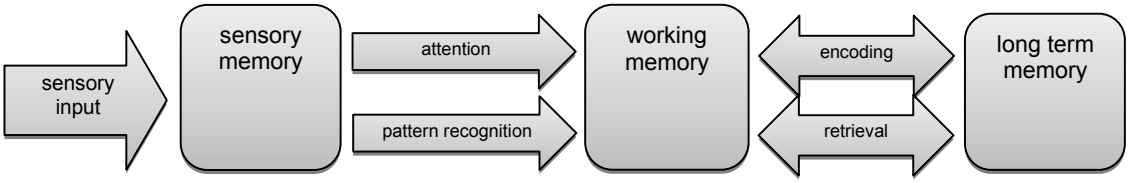

Fig. 1. The information processing model.

The information processing theory has been a prevalent framework for understanding cognition, a systematic, relatively accessible way to make sense of complex functions of the human brain that are needed for thought and action. As a basis for many aspects of human learning, the model has also been a foundation for instruction which is developed with the components of the theory in mind. Yet, theory which explains human cognition like computer processing has limitations. Our understanding of the world is not gained merely through following a series of steps toward a product. Our thoughts, experiences, senses, and perceptions are influenced by many factors. Even Piaget (1973), pioneering cognitive development with emphasis on the individual, recognised social influences on cognitive development. Vygotsky (1978) highlighted social and cultural contexts in his theory of social cognition. Indeed, we are not machines. We are living organisms, continually influenced by our social and cultural contexts, and from which we cannot be separated. Social and cultural influences inherently shape our cognition and our learning.

Through inquiry and research in the last 20 years, we continue to understand more about the complexities of human cognition and the extent to which social and cultural aspects influence the individual components of the information processing theory, refuting the notion of universality of people's basic thinking processes. Beliefs in the universality of cognition are understandable, as disseminated views have often been Western European based and seen through similar lenses. However, many cognitive processes previously thought to be universal may be highly malleable (Nisbett, Peng, Choi, & Norenzayan, 2001). Cognitive processes including reasoning for everyday activities can be learned and changed in people of the same culture, even with brief training (Smith, Langston, & Nisbett, 1992). It makes sense that the deeply engrained influences of people from different cultures and socialisation – who think and respond differently and have different understandings of the world – can shape cognitive processes too.

The information processing theory and the analogy of mind as computer have helped to show, for example, that information transfers from different memory stores, and to make sense of cognition, the process of learning, and the development of instruction. How might we reconcile a machinist view, then, with important social and cultural influences which are decidedly human? Using the information processing theory as a framework, the first section of this paper is organised according to features of the model, with a description of each component and some of the recent literature on its social and cultural influences. The research prompts, at minimum, a refinement of the well-known theory. In the second section, the information processing model is redefined to reflect the significance of social and cultural influences in cognition. The revision is an interim model on the way toward a fully new model of cognition. The third section includes implications for teaching and learning. Merits of the theory are acknowledged while providing insights into cognition that are difficult to forego in favour of a machinist view. The intention is not

to highlight differences but to illustrate that cognition is organic and dynamic, creating opportunities to respond with sensitivity to individuals, and fuller understanding in teaching and learning.

2. Information processing components and their influences

2.1. Sensory Input

Before any thought process begins, raw material outside cognition becomes available to initiate it. Sensory input includes things that exist in the world, as things that we receive from the environment and perceive with our senses, such as what we see and hear. As sources of input, environments differ socially and culturally. Consider differences in daily contexts, through a spectrum of natural to human-made surroundings, along with human complexities. Within these contexts, social and cultural elements comprise much of the diversity as fundamental sensory input.

Sensory information is not simply what is present as unfiltered input but also what is shaped as input for us. For example, adults guide children's involvement in everyday activities through participation or instruction based on cultural values. Depending on what a culture values, such as spatial acuity or collaboration, different input is emphasised so the raw material varies across cultures. Research shows that people who live in different physical environments learn to perceive the world in different ways (Segall, Campbell, & Herskovits, 1963, as cited in Ross & Wang, 2010). Interestingly, Kitayama, Duffy, Kawamura, and Larsen (2003) found that Americans living in Japan and Japanese living in the United States focus more like members of the home culture, deepening the influence of cultural context on cognition. Even before any real thinking begins, social and cultural influences affect sensory input as foundational material for cognitive processes.

2.2. Sensory Memory

Sensory memory, or sensory registry, is the very beginning of cognitive processing, a stage of stimulus perception that involves the senses. Information that is taken from the environment registers for only a few seconds as stimulus that activates the nervous system, and is recorded on the sensory memory exactly as it was first sensed if it is not processed any further. During this brief storage, sensory memory screens incoming stimuli for information that is relevant for the task at hand. The information is deemed unnecessary and is discarded, or it is deemed relevant and worth bringing into working memory for further processing.

While this occurrence is almost instantaneous, it is not simply mechanical. The selection process – the subtle, immediate, and relatively unconscious decision to discard or retain information – is inherently shaped by social and cultural influences. As the sensory memory briefly holds all of the stimuli that it receives, quick judgements about the relevance of information, however nuanced, are guided by people's beliefs and knowledge – beliefs and knowledge which have deep cultural and social bases. For example, in research that built upon studies of own-race biases, Perrachione, Chiao, and Wong (2010) found that listeners were able to sense auditory stimuli that identified race, which contributes to the selection of sensory information for further processing. While culture commonly determines what an environment includes, sensory memory selects which information from among the initial stimuli is relevant and carried forward.

2.3. Attention

Attention involves the selection of some information for further processing while inhibiting other information from further processing. Attention helps us to selectively channel our mental efforts from among competing sensory information so our senses do not become overwhelmed. Focused attention allows concentration on one source of information, while divided attention involves more than one source of information, likely with the loss of some information when more mental effort taxes attentional resources (Prinz, 2006). Driscoll (2001) affirmed that attention is influenced by many factors including the meaningfulness of the stimulus for the person.

Social and cultural influences affect people's attention. Nisbett, Peng, Choi, and Norenzayan (2001) noted that Chinese and members of other Eastern cultures focus on harmony and understand the world with continuity,

interrelatedness, and inseparable parts of a whole, while Greeks and members of other Western cultures focus on individual power and understand the world as a collection of discreet objects that can be categorised. The authors asserted that social organisation influences cognitive processes by focussing attention on different parts of the environment, with different cultures directing attention on some aspects of the visual field at the expense of others. The authors noted that Eastern and Western differences in attentional focus indicate that people may not be seeing the same stimulus at all, even in controlled situations.

Nisbett and Miyamoto (2005) noted key differences across cultures in levels of attention to context. Ji, Peng, and Nisbett (2000) found that young American adults showed more figure independence and attention to objects than young Chinese adults who showed more attention to relationships among figures and background. Kitayama, Duffy, Kawamura, and Larsen (2003) also found that Americans, whose environments are fairly organised and uncluttered with distinctive objects, focus on objects in a scene, while Japanese, whose surroundings are more interwoven and complex, focus on background contexts and relationships among objects. People who are socialised in cultures with high-context linguistic system like Japanese have attentional bias for vocal tone compared with people who have a low-context language and culture like English (Kitayama & Ishii, 1999). People in some cultures simultaneously attend to many more events than do people in other cultures (Chavajay & Rogoff, 2000). In Australia, Aboriginal children have better visual spatial abilities and perform better on visual memory tests than White children, attributed to Aboriginal attention to beetle movements from an early age (Kearins, 1981). As cultural patterns of interdependence lead people to focus attention on others rather than on themselves, Wu and Keysar (2007) found Chinese children better able than American children to consider another's perspective during interactions. Further, Gutchess, Welsh, Boduroglu, and Park (2006) found that people of different cultures used different areas of the brain for attentional control.

2.4. Pattern Recognition

Matching new information to information that is already in existing memory is important in learning. New information must have some meaning for a person or it will not be retained. Meaning is possible if new information can be somehow connected to existing knowledge. Theories of pattern recognition differ in how a match is made but agree that it is a process of matching incoming stimulus with information that is already stored in memory.

Pattern recognition, through which some meaning is gleaned in new information by matching it with existing knowledge, has compelling social and cultural influences. The way different cultures view and recall the world may provide examples of their pattern recognition in the first place. For example, after viewing a scene (as new information), participants were asked to recall it (Ji, Peng, & Nisbett, 2000). Members of Eastern cultures, who tend to view the world holistically with interrelated parts and context, recalled the features of a scene as interrelated, with relationships among features as relevant. Pattern recognition was through the interconnectedness in the content of the scene. Members of Western cultures, who tend to view the world analytically as a collection of objects which can be categorised, recalled the features of a scene by categorising its content, listing animals together, and so on. Pattern recognition, and meaning, for them was through categorising and grouping of like objects.

2.5. Working Memory

Termed working memory by Miller, Galanter, and Pribram (1960), this component is akin to consciousness. It is the site of awareness and thinking (Willingham, 2009). Working memory, or short term memory, combines new information from the environment with things we already know stored in long term memory, bringing the information together in new ways for the task at hand. Many theories of working memory have been developed, such as Baddeley and Hitch's (1974) influential view of working memory as comprised of several parts, including a buffer to handle verbal information called the phonological loop and a buffer to handle visual processing called the visual sketchpad. As the component where information is temporarily stored and manipulated, working memory capacity is limited, easily overloaded with attempts to keep track of too many items at the same time. The many connections made in working memory occur through many processes.

Working memory is the area where connections are made in information for the critical and creative thinking (Huitt, 1992) that contributes to problem solving, reasoning, conceptualising, and synthesising. Asian people may

think in a more intuitive, less linear, less 'verbalisable' way, so sharing aloud their reasoning in solving complex logic problems causes more cognitive load than it does for European Americans (Kim, 2002). Making analogies is another way to make connections. In a study using an analogy task with children with the same age, prerequisite knowledge, and similar baseline performance, Chinese children performed better than American children on problems that were more relationally complex (Richland, Chan, Morrison, & Au, 2010). The study affirmed that "Chinese children's greater experience with sociali[s]ed relational inputs would provide them with an advantage in complex analogies" (p. 152) and that prior knowledge is required for analogical reasoning development.

2.6. Encoding

Involving working memory, encoding is a process of incorporating new information into existing memory structure. Lasting knowledge requires complex means to make connections and transfer information longer term. For longer term retention of information, connections are made through encoding with strategies such as inferencing, organising, and elaborating. It is generally accepted that a stimulus with a close match to existing mental structures is added to the representation without changing the structure. If the stimulus is not a close match, the existing structure changes to adapt it, and the structure broadens. If the stimulus is very different from existing structures, an entirely new structure is created, although linked to other structures. Encoded information is stored in long term memory.

Ji, Zhang, and Nisbett (2004) found that Westerners tend to organise items as belonging to the same category (squirrel and seagull, as animals), while East Asians tend to consider items as having functional relationships (squirrel and tree). Elderly American participants used categorisation as a memory strategy more than elderly Chinese participants (Gutchess et al., 2006). Finding from the same study also indicated that if a strategy is not typically used in a culture, more cognitive effort may be needed. Ross and Wang (2010) involved cultural and environmental influences on encoding, storage, and retrieval.

2.7. Retrieval

We make use of long term memory by moving it into working memory with a process called retrieval. Retrieval occurs when we search and access information that is already stored in long term memory which is needed in working memory for the cognitive task at hand. Paller and Wagner (2002) considered retrieval as interrelated with encoding in the process that transforms experiences into memories, explaining that a person's 'bound trace' of an internal representation, in connecting it with perceptual frameworks, contextual details, and self-generated thoughts, was a way to store the experience and later recall it.

Initially parsing a story into fewer parts than European Americans, Asian Americans also later retrieved the story as a collective while European Americans later recalled more discrete parts of the story than Asian Americans, further indicating the cultural tendency for Asians to perceive the interrelation of objects and events (Wang, 2009). Schwartz, Boduroglu, and Gutchess (2014) found that Turkish participants made more mistakes recalling noncategorical word lists than did Americans, while Americans made more categorical errors than did Turks, suggesting that Americans use categories for organisation and retrieval of information more than Turks and a cultural influence on accurate recall and memory.

2.8. Long Term Memory

When new information is incorporated into the existing memory structure and transferred into long term memory, the permanent change of real learning occurs. Long term memory is the expansive, permanently stored representation of everything that one knows. Knowledge in long term memory is dormant until it is recalled to working memory to use in current thinking, becoming part of consciousness when it is needed. Knowledge in long term memory is organised in different ways. It can be explicit, or declarative, knowledge of things that we know we know, as the semantic knowledge of facts and the episodic knowledge of the time and place of personal events (Abbott, 2002). The knowledge can also be implicit, as things that we are not really aware of influencing us because

we do them without thinking about them, such as conditioned stimulus and response (Skinner, 1953), and our procedural knowledge of how to do things such as putting on our shoes.

As the recall of past knowledge and experience, memory is a combination of many aspects of cognition. Zachs and Swallow (2007) noted that memory and perception are closely related. Paller and Wagner (2002) found that the ability to remember involved many processes engaged at encoding, retrieval, and in between, and some as a result of how processes interrelate. Ross and Wang (2010) demonstrated clearly that, while "memory is about encoding, storage, and retrieval" (p. 401), it is not simply about the parts of the brain called the hippocampus and frontal and parietal lobes, but is largely influenced by culture. Implicit memories are impacted by cultural and social factors, often evident in the many ways that cultural norms guide our unconscious responses and procedural knowledge. Explicit memories, deeply tying what we know and where we have been to our environments, are also impacted by cultural and social factors. Human reality includes the meanings that are represented partly in the declarative and procedural knowledge of every person (Kitayama, 2000). As having the right factual and procedural knowledge for a task allows us to think effectively (Willingham, 2009), it is important to acknowledge that our socialisation contributes greatly to how well we are equipped cognitively to manage tasks.

Studies often reflect how cultural values and beliefs are important in memory. Many Eastern cultures view self as relational, interconnected with others in many ways, while many Western cultural concepts of self involve unique individuals who are different from others (Triandis, 1989). For example, European American adults considered their autobiographical memories as more important than Chinese adults, reflecting these cultural beliefs (Wang & Conway, 2004). European Americans also recalled more entries from their personal journals than Chinese (Wang, Conway, & Hou, 2004). As another example, young adults from East Asia had earliest childhood memories that occurred 6-16 months later than young adults of European decent, whose average age of earliest memory was 3.5 years (MacDonald, Uesiliana, & Hayne, 2000). More generally, Ryan (1992) asserted that socially shared ideas that memory declines with ageing can lead to poorer memory performance. Both European and Asian Americans recalled emotional experiences that were consistent with their cultural values (Oishi et al, 2007).

3. Redefining the information processing model

The information processing theory has served to incorporate much of what we have understood cognitive processes to be. Yet, research into the social and cultural factors of cognition continues to reveal its restrictions. Focussing on sensory input as external stimuli with little attention to a person's internal stimuli, illuminates both the restrictive parallel with machines and the lack of recognition of social and cultural influences. The influences are extensive enough that they also encompass other components which are often considered as adjuncts to the information processing model. Background knowledge, a person's previously acquired knowledge and experience that inform the cognitive task at hand, is an additional component shown to have social and cultural influences (Garth-McCullough, 2008; Ryan, 2010) as is executive function, the multi-faceted supervisory component that oversees and regulates a person's cognitive processes (Anderson, 2002; Lan, Legare, Ponitz, Li, & Morrison, 2011).

Theories are being generated along with calls in research to better reflect social and cultural influences on cognition. Many organic elements require representation, as do the interrelation of aspects such as humans' construction, creation, and capacity to choose. More apparent now are models of cognition which recognise people as conscious participants with capacity for differences. Among the compelling arguments, Kohler (2010) asserted that a more organic view of cognition is needed which recognises human experience, agency, and plasticity, urging us to think human outside the machine paradigm. Contemporary views are promising as more in depth models of cognition are considered. In the interim, a revision of the information processing framework is presented here.

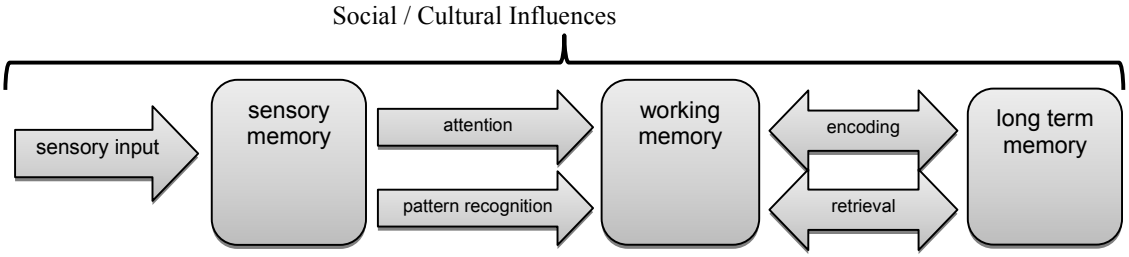

Fig. 2. Redefined information processing model with social/cultural influences.

The revision (Fig. 2) involves components of the model with an umbrella of Social/Cultural Influences. Represented in a simple visual addition, the revision indicates both wide reaching impact and relevance for each constituent part of the model including sensory input, sensory memory, attention, pattern recognition, working memory, encoding, retrieval, and long term memory. Sensory input is included because our individual environments and what exists as potential input are also influenced. Portraying the influences in a compartmentalised way does not adequately depict their impact. This model, with the all-encompassing presence of social and cultural influences, better reflects the relevance of the influences throughout the components of the information processing theory. This model begins with the machinist perspective to, at minimum, incorporate social and cultural influences in cognition and learning. While the revision is significant and can serve reasonably well, in many ways an entirely different model is indicated, which can continue to be defined.

4. Why it matters – implications for teaching and learning

The information processing theory remains a widely accepted basis for learning and teaching. It helps to understand aspects of cognition and informs teaching by emphasising that information presented in meaningful ways enables students to connect new and existing information so long term learning can occur. The theory has lost some popularity, and it is important to recognise limitations for its application. When even assessment is culturally biased (Nampijja, Apule, Lule, Akurut, Muhangi, Elliott, & Alcock, 2010), individual nuances are not served by accepting views of learning as mechanical. In this increasingly multi-cultural world, more educators know the importance of recognising differences, classrooms function more inclusively, and strides have been made in instruction to recognise individual differences. Recommendations continue to vary learners' input, tasks, and product types to increase the likelihood of facilitating connections for learners. Working within the bounds of the machinist view without responding to more organic social and cultural influences is no longer an option for enlightened educators.

5. Conclusion

Merging social and cultural influences with the field of cognition and learning, the intent of this exploration is not to show that people from different cultures think differently but to emphasise that aspects of the information processing theory are not sufficient as the basis for developing learning opportunities. A perspective that does not recognise individual differences is not adequate for effective learning and teaching. It is encouraging that differences are being acknowledged and that contemporary literature continues to illuminate the relevance of social and cultural influences on cognition. Research in the next several years will further demonstrate social and cultural influences on cognition, bettering our understanding of the diversity in how people think. Indeed, what is ultimately indicated is a break from the information processing model more fully. Until then, this paper provides examples of cultural influences in each aspect of cognition along with a revision to the model to represent the relevance of the influences.

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