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Toward a Unified Theory of Cognition: A Kantian Analysis

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TOWARD A UNIFIED THEORY OF COGNITION: A KANTIAN ANALYSIS

by

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Abstract

The goal of this paper is to provide classroom teachers a more unified theory of cognition. The current cognitive theories of information processing, schema theory, and constructivism exhibit limitations and a lack of cohesion that make their implications for teachers unclear. This paper will be presented in five sections. 1) The first describes problems with current cognitive theories and the need for a unified theory of cognition 2) The second provides a review of the literature of current cognitive theories. 3) The third section consists of research in the history of cognitive theory both in philosophy and psychology. 4) The fourth describes how a fresh look at the philosophy of Immanuel Kant can provide a more unified cognitive theory to educational psychology. 5) Finally, the paper offers specific implications for instruction under these headings:

1. Teachers should describe the concept to be taught as a rule.
2. Teachers should introduce the concept rule by experience or by example.
3. Teachers should use the concept rule as a framework for effective questioning.
4. Teachers should describe the rule with abstract language only after students have understood the rule.

Chapter 1: Identification of the Problem

Introduction

The goal of this paper is to provide classroom teachers a unified theory of cognition. The current cognitive theories of information processing, schema theory and constructivism have provided insights that have greatly improved classroom practice. However, when considered independently and as a whole, they exhibit limitations, which make their application in classrooms difficult. Viewed independently, each theory suffers from vagueness and an inability to describe common phenomena. When considered as a whole, their relationship is unclear and at times contradictory. Specifically, information processing provides a general understanding of cognitive architecture while schema theory and constructivism provide a general understanding of cognitive processes, but classroom teachers still need a theory that can unify understanding of architecture and processes, of structure and function. This paper will propose such a unified theory.

This paper will be presented in five chapters. The first describes the limitations of current cognitive theories and the need for a unified theory of cognition. The second provides a review of the literature of current cognitive theories. The third chapter consists of research in the history of cognitive theory both in philosophy and psychology. The fourth describes how a fresh look at the philosophy of Immanuel Kant can provide a more unified cognitive theory. The final chapter offers specific implications for instruction under these headings:

- Teachers should describe the concept to be taught as a rule.

- Teachers should introduce the concept rule by experience or by example.
- Teachers should use the concept rule as a framework for effective questioning.
- Teachers should describe the rule with abstract language only after students have understood the rule.

The limitations of information processing theory

- How does background knowledge affect information processing?

Kelly & Lindsay (1996) emphasize the unconscious influence of background knowledge:

> Past experiences can have pervasive effects on an individual's current behavior without that individual necessarily having a conscious recollection of those experiences. Perception, problem solving, thinking, and judgment can all be altered by the effects of specific past experiences in the absence of conscious remembering. (p. 31)

However, classic information processing, with its one-way flow of information from sensory memory to working memory to long-term memory, cannot explain how background knowledge affects perception and reasoning. For example, information processing cannot explain why an expert physician might perceive an abnormality in an x-ray that a novice might not perceive. Beers (1987) refers to the work of Shaw & Bransford (1977) when stating, "the machine metaphor responsible for the information processing approach typically glosses over questions concerning the nature and origin of the information process, how information is selected and how its value is determined" (p. 374). Furthermore, information processing, in its classic structure, suggests a "rigid architecture of the mind" (Mayer 1996, p. 157), which is not able to explain the role of beliefs and expectations in learning (Mayer, 1996). For example, information processing cannot explain why a learner with a high self-concept of mathematical ability might work

longer and harder on a difficult math problem than a student with a correspondingly low self-concept.

- How do errors or differences in information processing occur?

Suppose two students are briefly shown the sentence, "The cowboy rode tall tall in the saddle." One student might recall it exactly as written, while another student might recall it as, "The cowboy rode tall in the saddle." Information processing cannot explain how the second student's expectations affected his perception of the stimulus.

- How does information enter long-term memory (LTM) without ever being in working memory (WM)?

Classic information processing suggests all information passes through WM before being encoded in LTM. However, there is evidence that information may go directly to LTM (Anderson, 2000; Pashler & Carrier, 1996). Pashler and Carrier (1996) suggest information typically follows the path from WM into LTM through voluntary elaboration, but they also state, "being in STM [short-term or working memory] may be neither necessary nor sufficient for copying into LTM" (p. 18). They cite as evidence the work of Shallice and Washington (1970) who found that patients with grossly defective verbal STM could perform normally in delayed recall of word lists. This illustrates how information can directly enter LTM.

Not only can information be passively recorded directly into LTM, there is also evidence that learners actively develop understanding in the unconscious LTM. Consider the language acquisition device, suggested by Noam Chomsky (1972, 1976), by which children form and follow syntactical rules (so that a child might say, "I goed [sic] to the store" or, "This one is gooder [sic]"). Children use these words without having actually

heard them or consciously forming the rules to create them. This is evidence that the LTM is not simply a repository at the end of the information processing line, but LTM can actively construct understanding directly from experience.

- How are memories unconsciously elaborated in LTM?

The passive LTM of information processing could perhaps explain changes in knowledge due to forgetting, if forgetting occurs by decay or interference. Memories could be passively reduced by decay, or memories could passively interfere with conscious access of other memories. However information processing cannot explain additive or creative elaborations of memories. Consider an experiment conducted by Conway and Ross (1984) in which a group of students were asked to rate their study skills and then were assigned to a study skill instruction group (experimental group) and a waiting list group (control group). After the program, students in the experimental group exaggerated the weakness of their initial study skills as well as the improvement in their grades due to the program (there was no real change). The experimental group had an expectation of change that caused them to unconsciously reconstruct the past to fit the expectation. This cannot be explained by passive interference or decay, but only by unconscious elaboration. Loftus (1993) describes the creation of false memories:

> Numerous studies have shown that people misremember that they voted in a particular election when they actually had not (Abelson, Loftus, & Greenwald, 1992). One interpretation of these findings is that people fill in gaps in their memory with socially desirable constructions, thus creating for themselves a false memory of voting. (p. 532)

Loftus and Loftus (1980) conclude, "It may not be possible, in some circumstances, to ever discover from interviewing someone what happened in that person's past. Not only might the original acquired memory have departed from reality in some systematic way,

but the memory may have been continually subject to change after it was initially stored" (p. 419). We are "revisionist historians" (Johnson & Sherman, 1990, p. 497). Information processing cannot explain the unconscious elaboration of memories.

- How does information "pop" into one's consciousness?

Information processing suggests that WM consciously retrieves information from LTM. Hearing the question, "What is the fourth planet from the sun?" a person will consciously retrieve a list of planets and count through the list and answer, "Mars." It is as if the conscious and active hand of WM is accessing the volumes of knowledge on the unconscious passive bookshelf of LTM. While this may be an accurate view of some cognitive processes, it is obviously an oversimplification. The analogy breaks down when we realize how frequently information enters consciousness without conscious effort. It is as if the bookshelf is continuously and actively thrusting books into the hand, which is busier putting books back on the shelf than it is pulling them off. Information processing cannot explain this common phenomenon.

The unconscious consists, at least in part, of past experiences and expectations for the future. Neither the experiences nor the expectations are passive and fixed; both are active and fluid. Our present consciousness is continually affected by our experiences and expectations. Yet the relationship goes the other way as well; the present continually affects the construction and reconstruction of experience and expectations. Johnson and Sherman (1990) give us an interesting metaphor to describe how past experiences and expectations of the future are related to present cognition:

> Past, present and future are not discrete divisions among an orderly succession of life's events. Rather, past, present and future fold backward and forward like Japanese origami. They collapse onto each other, emerge from each other, and constantly determine each other, as we construct and reconstruct both [sic] past,

present and future in the present, and the past and future construct the present. (p. 482)

There is a constant and fluid movement of information among our senses, our conscious present, and our unconscious experiences and expectations. Therefore, any theory that describes a one-way flow of information from sensory memory to conscious working memory to unconscious long-term memory and that describes long-term memory as passive, is inadequate.

The limitations of schema theory

- What exactly is a schema?

Critics of schema theory (Sadoski, Pavio, & Goetz, 1991) charge, "schema theory is encumbered by a lack of consistent definition" (p. 463) being "variously defined by comparison to stereotypes, prototypes, templates, scripts, plans, and grammars" (p. 466). Prominent developers of schema theory give us little hope of clarity stating, "schemata are not linguistic entities but abstract symbolic representations of knowledge which we express and describe in language" (Rumelhart & Ortony, 1977, p. 111). These same authors give us four essential features of "schemata- the generic concept of memory… a) they have the variables b) they embed one within another c) they represent generic concepts which vary in their level of abstraction d) they represent knowledge rather than simple definitions" (p. 101). To describe schemata as varied, generic, and indistinguishable does little to pinpoint meaning. Brown (1979) makes the point with a touch of humor:

> One of my favorite games is to remove the word *schema* from a paper written in schematese and look for changes in meaning. Take, for example, the sentence 'preexisting knowledge schemata function to orient people in a certain way.' Where is the loss of clarity in removing the word *schemata*? It is somewhat

surprising to find there is rarely a loss of meaning following such ablation tactics. (p. 231)

It is ironic that teachers are told that the more new knowledge is incorporated into pre-existing schemata the more meaningful it should be, yet the very term "schemata" is not as meaningful as it should be. If teachers are expected to help students create schemata, then teachers should have a clear idea of what they are. Currently schema theory is not providing this much needed clarity.

- How do schemata relate to our cognitive architecture?

In relation to long-term memory (LTM), working memory (WM), and meta-cognitive processes, where are schemata formed? Where are they stored? Where do they operate? If "schemata are defined as 'frameworks' with 'slots' to be filled, or 'packets' of knowledge contained within larger 'packets' of knowledge" (Sadoski et al., 1991, p. 466), then schemata could be formed and stored in the passive LTM of information processing theory. However, schema theory stresses the active role of schemata. Beers (1987) describes active schemata: "The features of text to which readers attend depend upon the schemata guiding the attention of readers" (p. 373).

Information processing in its rigid sense suggests that processing is a "bottom-up" process, an inductive process in which raw data enters through the senses and is abstracted into generalizations. However, schema theory gives an avenue to explain "top-down" processing, a deductive process in which our pre-existing generalizations guide attention, perception and even reasoning. In discussing the schema-theoretic viewpoint of reading comprehension, Andre (1987) maintains, "Processing is both bottom-up and top-down" (p. 270). This view of the active top-down influence of schemata does not mesh with the purely bottom-up processes of classic information processing. For all the

valuable emphasis it places on the role of background knowledge in learning, schema theory has not successfully defined itself independently or in relation to information processing.

For its part, information processing theory is reaching toward a more integrative bottom-up *and* top-down approach as evidenced by Koenke's (1984) identification of three models of information processing theory: bottom-up, top-down, and interactional models – wherein "comprehension is an interaction between the processing of the text and the use of the reader's experiences and expectancies" (p. 116). While there is a need and desire to relate schema theory and information processing, such a unified theory has not yet been developed and widely accepted.

The limitations of constructivism

- What exactly is constructivism?

Mayer (1996) describes constructivism as educational psychology's third metaphor (following behaviorism and information processing). Mayer offers, "the central tenet of constructivism is that humans are knowledge constructors" (p. 151) as opposed to the mere knowledge recorders of behaviorism or the knowledge processors of information processing. Mayer believes that the continuing search to define this metaphor is a "hot topic" (p. 151) that will ultimately lead educational psychology down one of two paths: the scientific path based on empirical quantitative and qualitative research, or the critical path based on "philosophical, political, and humanistic sources" (p. 160).

Derry (1992) agrees that constructivism is a divided perspective, being separated into 3 schools, cognitive constructivism, cognitive symbolic processing, and radical constructivism. She dismisses radical constructivism as "largely a philosophical

movement" (p. 415) while she describes cognitive constructivism as primarily concerned with the use of schemata in reading, while cognitive symbolic processing has pursued the subject matter psychologies in the information processing framework.

Both Mayer's and Derry's remarks lead one to conclude that constructivism is not really a cognitive theory per se, but a unique and important perspective to analyze existing theories. The constructivist perspective is a collection of important principles:

1) knowledge is constructed, not merely recorded or processed, by individuals, (Phillips, 2000);
2) knowledge construction is affected by the experiences and development of the learner (Piaget,1952, 1959, 1970);
3) knowledge construction occurs in a social context (Vygotsky, 1978, 1986).

These principles in themselves do not establish a cognitive theory, but they are important founding principles of cognitive theory. A theory that unified schema theory with information processing theory must also use as its foundation these principles of constructivism. Therefore, a theory that explicitly related schema theory and information processing theory, incorporating the principles of constructivism, would help clarify and unify constructivism as well.

- How does knowledge construction relate to our cognitive architecture?

Constructivism can answer some questions that information processing alone cannot. As discussed above, information processing cannot explain how errors or differences in learning occur. However, the constructivist principle that knowledge is constructed, not merely processed, can explain how two learners, exposed to the same perceptual stimulus, can construct unique knowledge. However, like schema theory,

constructivism does not describe exactly how or where knowledge is constructed or stored in relation to our cognitive architecture as described by information processing.

Also, like schema theory, this limitation is not merely descriptive but prescriptive. If teachers do not know exactly how knowledge is constructed, they will not know exactly how to help students construct knowledge. If as Mayer (1996) states, constructivism "was not developed solely in laboratories and passed on to educators but was rather the result of the need to explain what happens in real educational settings" (p.151), then constructivism must pursue this need through reconciliation with information processing and schema theory.

The Need and Possibility of a Unified Theory of Cognition

Evidence indicates that teachers in K-12 classrooms "do not routinely locate and translate research-based knowledge to inform their efforts" (Hiebert, Gallimore, & Stigler, 2002, p. 3). The understanding required to interpret the information in a range of theories often overwhelms teachers and detracts from their abilities to use these theories to inform their practice. After a thorough study of information processing, constructivism and schema theory, a classroom teacher would still be left with these important and unanswered questions:

- If students construct their own understanding, what is my role?
- How can I help students adapt to the limitations of working memory?
- How do I capitalize on learners' beliefs and motivations to increase learning?
- How do I accommodate learner background differences and the influences these differences have on the processes involved in knowledge construction?
- How can I help students construct schemas if I am not sure what they are?

This problem of relating theory to practice is becoming increasingly significant in the wake of criticisms directed at the AERA and the increasing number of teachers who participate in AERA conferences. "Critics have accused the Washington-based group of doing too little to bridge the gap between research and classroom practice" (Viadero, 2000, p. 6). A theory that helps to clarify and relate information processing, constructivism and schema theory would help classroom teachers be more effective.

Educational psychology is not currently providing schools such a unified theory of cognition. Immanuel Kant, the German philosopher on whose ideas much of this paper is based believed, "the greatest and most difficult problem to which man can devote himself is the problem of education" (Kant, 1804/1966, p. 11), and "the prospect of a theory of education is a glorious ideal" (p. 8). However, current thought seems to view this ideal, not only as glorious, but unattainable.

In honor of the American Psychological Association's centennial in 1992, the Journal of Educational Psychology published two articles from respected authors Richard Mayer and Sharon Derry that peered into the future of educational psychology. Neither author described educational psychology as close or even moving toward a truly unified approach. Mayer believes that unifying our current understanding of cognition would be too broad an approach, excluding important distinctions in the "psychologies of subject matter" (Mayer, 1992). In contrast, Derry believes that unifying our current understanding of cognition would be too narrow an approach, being only concerned with mere symbolic processing and not encompassing the social nature of learning beyond the classroom. Must we choose between Mayer's tight focus on psychologies of subject matter or Derry's expanding focus beyond the classroom?

Mayer (1992) contends that in educational psychology "fractionation is giving way to a unified cognitive approach" (p. 406). However, what he calls the "unified cognitive approach" is not a single theory of cognition but separate and distinct "psychologies of subject matter" (p. 409). He sees educational psychology with its psychologies of subject matter as the "meeting ground for cognition and instruction" (p. 411). Educational psychologists equipped with psychologies of subject matter can function as mediators between classic experimental psychologists who have failed to find general laws of learning and classroom teachers who struggle to implement research-based practices. He proposes, "whereas a focus on general psychology failed to produce general laws of learning and cognition, domain-based research offers a potentially productive attempt to understand human learning within specific subject matter domains" (p. 409). Is it true that the cognitive approach that has unified us also prevents us from being unified? To some the paradoxical answer is, "Yes." According to Di Vesta (1987), "Underlying the assumptions of the learner as an active processor is another assumption that there is no one set of generalized learning laws with each law applying to all domains" (p. 208-209).

Certainly people who argue against a unified theory along these lines are using too strict a measure. Even the natural sciences do not boast "laws" in the sense that Mayer suggests educational psychology has "failed to find" or that DiVesta (1987) doubts even exist. Kitcher (1990) points out, "individual psychology is a historical science," and that, "cognitive science as applied to individuals is in the same position as a geology or evolutionary biology. Again, however, none of this speaks against the possibility of a bona fide scientific theory of the processes involved in this phase of

reasoning" (p. 204). For example, Newton's "laws" of motion provided a functional framework for physics and engineering for decades until Einstein proved them inadequate.

Educational psychology has progressed through the "laws" of structuralism, functionalism, behaviorism, as each school of thought has proved the previous ones inadequate. Even if we are unable to find unalterable unified laws of learning, there is much to be gained from seeking a unified theory. To further illustrate the point, consider how geology cannot explain the formation of one individual rock, yet it can explain the formation of rocks in general (Kitcher, 1990). Similarly, educational psychology may not be able to describe the formation of one individual thought, but it can explain the formation of thoughts in general. The fact that any belief, expectation or situation can affect our cognitive processes does not negate the possibility of a limited, but unified, cognitive theory.

While Mayer sees unification of current cognitive theory as too broad of a goal, Derry (1992) objects that it is too narrow. Commenting on the possibility of a more unified cognitive approach, she questions the "potential for further progress, given the constraints imposed by current use of subject matter boundaries, combined with present theoretical orientations" (p. 414). In response to Mayer's optimism regarding psychologies of subject matter, Derry contends, "cognitive psychology is currently especially deficient in its capacity to guide the search for the true nature of complex problem solving as it is manifested in the world of work and every activity that occurs outside classrooms" (p. 414). She refers to Greeno (1989a, 1989b) when she laments, "current theoretical framing assumptions... have not propelled researchers forward in

their search to understand productive and critical thinking, motivation and creativity" (p. 414). To take educational psychology "beyond symbolic processing" Derry puts forward the idea of situated cognition, a viewpoint in which "cognition must be viewed as an integral part of the physical, social and cultural context to which it belongs" (p. 416). Situated cognition stresses the role of apprenticeships in communities of practice, the negotiation of knowledge within a community, and sees motivation and self-concept as social phenomenon. She believes situated cognition "suggests an incredibly rich new set of metaphors that offer educational researchers and theoreticians a great deal" (p. 417).

Derry's call for educational psychology to focus on the social nature of learning as it actually occurs in the world is not an extreme position. Certainly constructivists like Vygotsky (1978, 1986) have brought much needed attention to the social aspects of learning. Certainly Mayer (1992), who shuns educational psychology's identification with "classical experimental psychology" (p. 411), would resonate with Derry's (1992) call for educational psychology to be relevant in "the world of work and every activity that occurs outside classrooms" (p. 414). Is it Derry's contention that theories of symbolic processing are relevant to the irrelevant process of schooling? No, she wants to focus attention on communities of practice, which "include the social, working, school, and family communities with which learners identify" (p. 416). Is her contention that if cognition is more than mere symbolic processing, then we should ignore symbolic processing? No, Derry shows herself as a proponent of balance rather than extremes when she concludes, "any theory of learning or instruction that focuses exclusively (emphasis mine) on the construction of symbolic knowledge by individuals is regarded as inadequate" (p. 416). Derry's challenge to educational theory is to place the learner's

symbolic processing in the proper social context to truly account for participation, enculturation, apprenticeship and motivation.

Both Mayer's and Derry's views of educational psychology's future may not be as irreconcilable as they at first seem. It is true that Mayer focuses on an individual's cognitive processes while Derry is more concerned with social processes. However a theory that attempted to unify our understanding of cognitive architecture as described by information processing and cognitive processes as described by constructivism and schema theory, would allow educational psychology to develop in individual and social contexts. A general or unified theory of learning would allow educational psychology to study various psychologies of subject matter as well as to study learning as a socially situated activity. Having seen the inadequacies of current cognitive theories and having received guidance on the future of cognitive theory, we are now ready to move toward what Kant called the "glorious ideal" of a unified theory of education.

How to Move Toward a Unified Theory of Cognition

This paper will take three broad steps to move towards a unified theory of cognition: 1) review the current literature of cognition 2) research the history of cognition in philosophy and psychology 3) apply key ideas from the history of cognition to clarify and unify current views of cognition.

The review of literature will briefly summarize current views of cognition. Topics reviewed will include information processing theory, constructivism, schema theory, procedural and declarative knowledge, and concept learning theory. This review of literature will help give an overview of these perspectives and set the boundaries for the research that follows.

The next step will be to research the history of cognition in philosophy and psychology. It will search for the historical answer to the question, "How do we learn?" The research will show that there are two extreme and competing schools of thought that have developed around this question. These schools are known in philosophy as empiricism and rationalism. The philosophy of Immanuel Kant will be presented as a balanced synthesis of these two views. These two philosophical schools of thought continued to influence the history of psychology, in which they have been labeled as experience centered and mind centered approaches (Reynolds, Sinatra & Jetton, 1996). Kant's thought will be shown to balance these psychological approaches just as it balanced philosophical approaches.

The third step will be to apply Kant's thought directly to the limitations of current cognitive theory as already described. Many of the vague and contradictory aspects of current cognitive theories will be clarified and unified by this Kantian analysis. Also, included in this chapter is a critique of Dual Coding Theory (DCT), as DCT presents itself as a challenge to Kantian schematism. Finally and importantly, the paper will explicitly describe the implications of this unified theory in K-12 classrooms.

Chapter II: Review of Literature

The review of literature will briefly summarize our current views of cognition. Topics reviewed will include information processing theory, constructivism, schema theory, procedural and declarative knowledge, and concept learning theory. This review of literature will help give an overview of the history and development of these perspectives. These perspectives form the theoretical foundations and set the boundaries for the research that follows. Occasionally some findings of the research may be mentioned in the course of this review to focus the reader's attention on the most salient aspects of the perspectives.

Information Processing Theory

Information processing achieved its status as educational psychology's "second metaphor" in reaction to the shortcomings of its first metaphor, behaviorism (Mayer, 1996). Influential psychologist E.L. Thorndike's (1911/1965) "law of effect" and "law of exercise" characterize the behaviorist view. The "law of effect" is that any behavioral response that brings pleasure will be repeated while a response that brings discomfort will not. The "law of exercise" is that the repetition of a response will lead to its further repetition. Thus the behaviorist view is that all learning is of one type, the passive association of stimulus and response.

The view that there is essentially one type of learning, learning by association, began to ring hollow with psychologists in the 1940's. Gagne et al. (1993) suggest that

the desire to understand more complex behavior, such as flying an airplane, learning to read, or composing a song, led educational psychologists to theorize about mental structures and processes (p. 6). Early information processing theorist George Katona (1940) sought to understand "the complicated learning process, which...appears to be described rather poorly as the establishment or a bond between a stimulus and a response" (p. 5). His work was inspired by Gestalt psychologists who were interested in the role of insight and the wholeness of experience, ideas anathema to behaviorists. Also challenging behaviorist conventions was the work of linguist Noam Chomsky (1972, 1976). His ideas, described as nativist, gave evidence that the mind was genetically predisposed to learn language, an argument that flew in the face of the behaviorist view of the mind as a "blank slate."

While information processing theory had its roots in Gestalt and nativist psychology, its flowering would coincide with development of computer science. Anderson (2000) states: "The direct influence of computer-based theories on cognitive psychology has always been minimal. The indirect influence, however, has been enormous" (p. 11). Rather than the direct application of computer science to cognitive psychology, computer science has indirectly influenced cognitive psychology through computer-based metaphors. Simply put, "Behaviorists used the switchboard and information processing theorists used the computer" as their driving metaphor (Reynolds et al., 1996, p. 102).

Computers have been regarded as productive metaphor for humans:

> Computers perform cognitive tasks by processing information – taking symbols as input, applying operators to input, and producing output – so it follows that perhaps humans are information processors. (Mayer, 1996, p. 153)

The metaphor of humans as information processors is significantly different from the behaviorist metaphor of humans as merely responders to stimuli because it seeks to identify and explain internal cognitive structures and processes. In this search to identify cognitive structure and processes, information processing theory has drawn specific metaphors from computer science. Mayer (1996) categorizes these metaphors according to their views of the mind, cognition and learning. I will consider each one in turn, highlighting the most important ideas associated with it.

1) The mind is an information processing system. Just as a computer has hardware, the mind has memory systems that store information. Atkinson and Shiffrin (1968) classically described the configuration of this cognitive architecture as sensory memory, short-term memory, and long-term memory.

Also called the sensory register, sensory memory is the first place stimuli enter the information processing system. Sensory memory is characterized by its rapid decay. Visual information decays in just 0.5 to 1.0 second; auditory information decays in 3.0 to 4.0 seconds - long enough for it to be selected for continued processing in working memory (Leahy & Harris, 1997).

Short-term memory is now most often referred to as working memory (WM). WM is analogous to awareness or consciousness (Gagne et al., 1993; Sweller, van Merrienboer, & Paas, 1998). WM has a limited capacity, holding 7±2 units of information (Miller, 1956), which decays within about 15 to 30 seconds (Brown, 1958; Peterson & Peterson, 1959). WM functions as a "mental workspace... an internal notepad or blackboard" (Gagne et al., 1993, p. 41). Information from sensory memory or retrieved

from long-term memory can be manipulated and/or altered on this "internal blackboard" and then stored in long-term memory for later use.

Long-term memory (LTM) is the final destination for information in the processing system. Unlike sensory memory and WM, LTM has a virtually unlimited capacity and durability. There seems to be no limit to the amount of information stored in LTM and information in LTM is very stable and may in fact remain there for an entire lifetime (Pashler & Carrier, 1996).

2) Cognition is the application of cognitive processes. Just as computers use software, humans use cognitive programs to process information. Three important types of cognitive processes identified by information processing are encoding, retrieval, and metacognition.

Encoding is the cognitive process of transferring information in WM to LTM (Bruning et al., 1999). There are several sub processes under the general term of encoding. One type of encoding is rehearsal. Rehearsal is the repetition of information in WM. One can rehearse a list of states and capitals to the point that it enters LTM, at least for a while. Rehearsal is an inefficient and unreliable method of encoding (McKeown & Curtis, 1987). Organization is a more efficient and effective method of encoding by "clustering related items of content into categories or patterns that illustrate relationships" (Eggen & Kauchak, 2001, p. 274). A student who rewrites her notes in a hierarchical outline to aid memorization is employing organization.

Elaboration is a method of encoding in which new knowledge is explicitly related to existing knowledge. Generally, elaboration is the encoding of new concepts on the foundation of existing concepts. For example, before teaching a new unit on pronouns, a

teacher would bring the existing concept of noun into WM and relate the new concept to it. This type of elaboration is referred to as schema activation (Pearson, 1984). More specifically, the art of mnemonics is elaborative because it relates new knowledge to existing images or ideas. A student can encode the definition "abstruse: difficult to understand" by relating it to an image of a man named Abe reading a truce to a man who doesn't understand it. A student might recall the names of the five Great Lakes by remembering the mnemonic acrostic HOMES. Notice that this is also a form of organization.

Retrieval is the pulling of information from LTM back into WM. Cognitive psychologists consider retrieval as a process of either recall or recognition. If students have learned some basic history of the Roman Empire they might be asked, "Was Nero emperor when Rome burned?" This question asks the students to recognize information stored in LTM. The question, "Who was emperor when Rome burned?" asks the students to recall the same information. In either case, this view of retrieval is directly analogous to computer processing systems - information is stored in one form in which it remains until it is brought again in the same form into WM.

However, retrieval can instead be considered as a reconstruction. Based on memories of voting in elections, people can construct false memories of voting in elections they did not (Loftus, 1993). Information incongruent with one's self-concept will be reconstructed in WM distorted or elaborated to be consistent with self-concept (Welch-Ross, 1995). The reconstructive nature of retrieval will be a key concept discussed in this paper.

Metacognition has been divided into two sub-areas, 1) one's awareness of cognitive processes and 2) one's control over those processes (Bruning et al., 1999). Two important types of metacognition are meta-attention and metamemory. An easily distracted student may choose to sit close to the front so he can only see the teacher and the chalkboard. This learner has an awareness and control over his process of attention and has developed and implemented strategies to direct his attention to a goal. A student with a lot of material to memorize might speak it aloud to herself or discuss it with a peer because she knows she remembers things she hears. This student is exhibiting metamemory, an awareness and control of her encoding processes.

3) Learning is knowledge acquisition. Just as computers rely on the input of transmission of data, human learning relies on the "transmission of symbols" (Mayer, 1996, p. 155). Because of this view of knowledge, information processing describes a moderately active learner. Information processing ascribes a host of activities to the learner, such as encoding, retrieval, meta-attention and metamemory. With its focus on these internal cognitive processes, one must conclude that information processing describes a learner more active than the purely passive response strengthening of behaviorism.

However, information processing still views the learner as the receiver of a transmission of symbols and this view places restraints on the learner's activities. The "rigid cognitive architecture" of information processing is not open to the influence of emotion, motivation, and the constructive and reconstructive view of learning and memory (Mayer, 1996 p. 157). To find the connections between cognitive structure and

processes of information processing and the constructivist view of knowledge will be the primary concern of this paper.

Information processing has had an enormous and beneficial influence on educational psychology. Primarily, it loosened the "strangle hold" of behaviorism (Mayer, 1996, p. 153), freeing educational psychologists to study cognitive structures and processes. Descriptions of memory stores have helped teachers and students overcome the limitations of working memory. Descriptions of cognitive processes such as encoding and retrieval have helped learners be more effective and efficient in their learning activities. Descriptions of metacognitive processes have especially emphasized the activities of learners and given them strategies to improve their activities.

However, information processing has important limitations, which need to be identified. Primarily the computer metaphor, which has been key to information processing's advances, has some serious drawbacks. After all, a computer is a machine and a human is not. Literally comparing learning with computing "is most consistent with the view of learning as a passive, atomistic, and mechanical process" (Mayer, 1996, p. 153). In this way information processing still shares limitations with the behaviorist metaphor it replaced.

Furthermore a computer may acquire new data or programs, but it cannot grow or develop in the manner that an organism does. "Machines neither can reflect on or reconceptualize past knowledge nor have passionate feelings about learning" (Reynolds et al., 1996, p. 102). Any machine-based metaphor is likely to neglect the important role of emotion and past experiences on learning. Finally, though computers can be networked to share data, this will never be an adequate metaphor for the complex social

relationships of humans. These social functions, at the very least, exert tremendous influence on learning as described by Vygotsky (1978, 1986) and social constructivists. Others, such as the advocates of situated cognition characterized by Derry (1992), suggest that learning can only be described as a social, rather than individual, phenomenon. These limitations of information processing will be a major focus of this paper.

Constructivism

Mayer (1996) describes constructivism as educational psychology's third metaphor (following behaviorism and information processing), which became widely accepted in the 1980's and 1990's, though it had early roots in philosophy and psychology, as this paper will describe. Constructivism is currently a "hot topic" in educational psychology with many distinct schools vying for ideological supremacy (Mayer, 1996, p. 151). Derry (1992) identifies three types of constructivism while Bruning et al. (1999) identifies three others. Steffe & Gale (1995) identify no less than six different types of constructivism. Despite the abundance of varieties, Eggen and Kauchak (2001, p. 294-95) list four characteristics common to most constructivist views:

1) Learners construct understanding. The earlier school of behaviorism viewed learners merely as recorders of knowledge (Mayer, 1996). According to influential behaviorist E.B Thorndike, after repeated exposure to a stimulus the associated response becomes, "stamped in." The later view of information processing theory accounted for the impact of cognitive constructs such as attention, metacognition, and working memory on the processing of stimuli. However, according to constructivist views, learners are not

recording or acquiring others' knowledge, but constructing their own knowledge (Phillips, 2000).

2) New learning depends on current understanding. The important role of background knowledge in knowledge construction has been most fully described by schema theorists working from the constructivist perspective (Anderson & Pearson, 1984; Bartlett, 1932; Bransford & Johnson, 1972; Rumelhart & Ortony, 1977). Their work is reviewed fully in the following chapter.

3) Learning is facilitated by social interaction. In the constructivist view, teachers are not response strengtheners or knowledge sources. Instead, according to Mayer (1996), teachers are "cognitive guides" who use more social methods such as discussion and guided discovery to help learners construct understanding (p. 154).

4) Meaningful learning occurs within authentic learning tasks. A writing lesson based on constructivist principles would relate realistically to the students' background and current experiences rather than focus on isolated drill and practice. For example students engaged in meaningful and authentic tasks have written to a major oil company regarding an oil leak in a local bay, interviewed adult family members about their childhood (Needles & Knapp, 1994) or had their work published in school newspaper or class journal (Hudson, 1988).

The Individual Construction of Knowledge

Knowledge construction as it occurs in the individual is primarily referred to as cognitive constructivism (Eggen & Kauchak, 2001). In this sense knowledge construction is seen as cognitive, or "in the head" of individual learners, rather than as a social phenomenon. Derry (1992) describes cognitive constructivism as primarily concerned

with the use of schemata in reading; however, in a broader sense described by Piaget (1952, 1959, 1970) cognitive constructivism concerns the experiences and development of the learner.

Cognitive constructivism's interest in the development of the learner has led to an alternative name of endogenous constructivism (Bruning et al., 1999). In this sense endogenous constructivism is a constructivism that originates and grows from within the individual. It couches constructivism in an organic or biological metaphor; hence the focus on development.

The most well known aspect of this endogenous approach is Piaget's description of the stages of development, which describe the qualitative changes in children's thinking as they develop into adults. A cognitive or endogenous constructivist approach would strive to make learning compatible with the learner's cognitive development. Also characteristic of the endogenous approach is Piaget's idea of cognitive equilibrium (1952, 1959). Piaget's concept of equilibrium suggests that individuals construct knowledge to maintain "internal coherence" (Bruning et al., 1999, p. 216). When new knowledge does not fit into existing schemes, equilibrium is disrupted driving the learner to assimilate new knowledge into existing schemes or accommodate schemes to fit the new knowledge. Here we see the organic nature of cognitive constructivism: the learner tries to maintain equilibrium in its knowledge systems just as any organism tries to maintain equilibrium in its physical systems.

The Social Construction of Knowledge

Russian psychologist Lev Vygotsky (1978, 1986) developed a more socially oriented constructivist perspective. He asserted that cognition is first a social and

secondly an individual phenomenon stating, "The social dimension of consciousness is primary in fact and time. The individual dimension is derivative and secondary" (Vygotsky, 1979, p. 30). He believed knowledge is primarily constructed in a social experience, typically that of adult to child or expert to novice. That experience is bound, not only by the individual differences between the expert and novice, but also by the language and culture in which they are immersed (Fowler, 1994; Rogoff, 1990). The knowledge acquired by the novice in that specific social experience is later applied in a broader context (Bredo, 1997). Thus Vygotsky's social constructivist perspective would lean more toward the experience centered perspective than Piaget's individual constructivist perspective, which tends to be more mind centered (Reynolds et al., 1996).

Interestingly, Bruning et al. (1999) describe this social constructivism as "dialectical constructivism" (p. 217). This term harkens back to the philosophy of G.W.F. Hegel (1770-1831), which can give insight into the social constructivist perspective. Hegel saw objective truth as a dialectic evolution of thesis, to antithesis, to synthesis. An idea, called a thesis, implies it opposite, called an antithesis. From this relation of opposites emerges a "higher unifying concept, the synthesis." This synthesis becomes the next thesis and the whole process continues indefinitely (Clark, 1957/2000, p. 344).

Consider the knowledge of the expert as the thesis, and the novice's lack of knowledge as the antithesis. When these interact in a social experience, the novice's new knowledge, the synthesis, is constructed. Notice it is not a passive transmission of knowledge of expert to novice like a behaviorist or information processing approach would imply; this Hegelian perspective helps us to the see the constructivist ingredient to Vygotsky's ideas. Another interesting point from this line of thought is that the expert

knowledge, the original thesis, is also swept up into the new synthesis. That leads us to question, how are experts, teachers and adults, changed by the social experience described by Vygotsky?

The most influential of Vygotsky's ideas has been the zone of proximal development (ZPD) and its implication of instructional scaffolding. The ZPD is the range of cognitive performance in which a novice can be successful only with the help of an expert. Cognitive tasks beneath the ZPD can be performed independently while tasks beyond the ZPD cannot be completed even with the help of an expert. The help that an expert gives a novice has been described as instructional scaffolding. Just as a physical scaffold consists of rungs stretched across empty space to a new destination, an instructional scaffold gives rungs of assistance so that learners can work themselves to a new place of cognitive development. The rungs must be the appropriate distance apart. If they are too close, if too much help is given, no growth can occur. If they are too far apart, if not enough help is given, likewise no growth will occur. The importance of the expert in Vygotsky's thinking gives a clearer and more prominent role to teachers than is typically seen from an individual constructivist view.

Schema Theory

It was F.C. Bartlett's book Remembering, (1932) which introduced the term "schema" into experimental psychology. (It should be noted and will be discussed later that Immanuel Kant actually coined the term in his philosophical writings nearly 150 years earlier.) Bartlett's idea of the schema is best characterized by his work with the story "The War of the Ghosts." In this experiment, he asked middleclass Englishmen to read a Native American folk tale. The tale is full of details of Native American life such

as place names, canoes, and bows and arrows. However, there is also a supernatural element. In the tale, a young Indian warrior accompanies a group of ghost warriors in an attack on other ghosts. Though initially unaware of his injury, the young warrior is mortally wounded. He returns to his home and dies after "something black" comes from his mouth. After reading the story twice, subjects were asked to reproduce the story following the original as closely as possible.

The reproductions exhibited many errors; but there was a pattern within the inconsistencies so that "the subjects were distorting the story to fit with their own cultural stereotypes" (Anderson, 1980, p. 153). For example, a subject changed "canoe" into "boat," or "paddling" to "rowing," terms more familiar to the subjects at the time. However, even more intriguing was the fact that the subjects sometimes changed the whole message or meaning of the story to fit their sensibilities. For example the subjects sometimes changed the mortal warrior into "more of a hero" and to be "the centre of interest at the end" (Bartlett, 1932, p. 69), rather than to portray him as the story did, as an incidental casualty in a supernatural battle. Perhaps this was in keeping with their more individualistic Western mindset. At any rate, the subjects' understanding was a combination of their background knowledge and the story. Bartlett described this through the operation of a schema, a term he immediately decried as "at once too definite and too sketchy" (p. 201). He would have preferred to describe the phenomenon as an "active developing pattern" or "organized setting" (p. 201).

Critics of schema theory explain that schemata have been "variously defined by comparison to stereotypes, prototypes, templates, scripts, plans, and grammars" (Sadoski et al., 1991, p. 466). All of these terms have a rigidity that Bartlett would not have

accepted. Scripts, plans and grammars are written down, codified, and can be placed in a filing cabinet or storehouse. Bartlett's (1932) schema "refers to an active organisation of past reactions" (p. 201) that are "living, constantly developing, affected by every incoming sensational experience of a given kind. The storehouse notion is as far removed from this as it well could be" (p. 200). Bartlett's worked helped educational psychology to understand "readers were not in the passive role of merely pulling information rotely from the printed page. Rather readers were active as they drew on their background knowledge...to determine the meaning of the text" (Hiebart & Raphael, 1996, p. 554).

Hiebart and Raphael (1996) explain that the constructivist perspective was the foundation of the two major lines of research in schema theory, one by R.C. Anderson and one by J.D. Bransford. Anderson's work (for summary see Anderson & Pearson, 1984) involved assigning perspectives to readers before they read a text. For example before reading a narrative description of the inside of a house, readers were assigned the perspective of a burglar or of a homebuyer. The assigned perspective greatly influenced what subjects perceived and remembered. Bransford's research (Bransford & Johnson, 1972) involved the use of ambiguous texts. For example a text might describe the process of washing clothes, without using words such as "clothes, washing machine" or "soap." The study revealed that if subjects did not invoke the appropriate schema, they had difficulty recalling and comprehending the text. From this constructivist perspective, schema theory has contributed to our understanding of the important role of background knowledge in the construction of new knowledge (Nuthall, 1999).

Though initially developed in opposition to the mechanistic tendencies of information processing theory (Reynolds et al., 1996) schema theory has been researched

from the information processing perspective. Research of schemata from this perspective has focused on topics such as model building, learning text information (Hiebart & Raphael, 1996) and problem solving. In these areas, particularly problem solving, "the term [schema] has been used in a far more restrictive sense" (Mayer, 1987, p. 329) by which their acquisition is described as "learning to categorize problems and apply particular rules" (Voss & Wiley, 1995, p.157). For example, when confronted with a math problem, "65-28=?," a student would categorize and solve it by using a schema for "borrowing" in a subtraction problem. The idea that schemata are procedures we develop and use to process symbols obviously has its origins in information processing theory.

Another interesting relationship between schema theory and information processing theory deals with cognitive architecture. Rumelhart and Ortony (1977) define schemata as "the generic concept of memory" that can "embed one within another" (p. 101). Gagne et al. (1993) describe how one's schema for "fast-food restaurant" could contain propositions such as "The food is cheap" or "The fries are good," images of menu boards and counters, and linear orderings such as "order, pay, eat, leave." One schema may actually bundle a large number of single elements. As described by cognitive load theory (Sweller et al., 1998), these schemata may bring many single elements into working memory as a single unit, thus freeing limited working memory resources for other tasks. For example a person in a fast food restaurant with a well-developed schema could devote attention to secondary matters such as food specials or contests, while someone without such as schema (one who has never been in a fast food restaurant) would have to devote working memory to grasp the basic order of this "dining experience."

Though often criticized for its vagueness and its lack of supporting empirical evidence (Sadoski et al., 1991; Reynolds et al., 1996) schema theory has interested educational psychologists for decades primarily because of its "extraordinary power in accounting for memory and other cognitive phenomena" (Bruning et al., 1999, p. 56). Schema theory has helped teachers to appreciate the importance of background knowledge in learning. Teachers know that students come to their lessons with a wide variety of background knowledge that affects perception and comprehension of new knowledge. Teachers also know the importance of building a common level of background knowledge that will facilitate the learning of new knowledge.

Declarative and Procedural Knowledge

Declarative knowledge is "knowledge of facts, definitions, procedures and rules" (Eggen & Kauchak, 2001, p. 263), whereas procedural knowledge is knowledge of how to perform tasks (Anderson, 2000). Declarative knowledge is of a purely cognitive, rather than physical, nature. In addition to verbal propositions, declarative knowledge can be represented in images and linear orderings (Gagne et al., 1993, p. 59). Declarative knowledge is static, quickly acquired, and easily modified (Gagne et al., 1993, p. 91). Declarative knowledge can be "easily manipulated in working memory, allowing for reflection" and can "facilitate the thinking of related ideas" (p. 110).

These thought processes occur because the basic representations of declarative knowledge are integrated into schemata (Eggen & Kauchak, 2001; Gagne et al., 1993). Gagne et al. (1993) describe how a schema for "fast-food restaurant" is composed of elemental propositions, images, and linear orderings. The schema contains propositions such as "The food is cheap" or "The fries are good," images of menu boards and

counters; linear orderings such as "order, pay, eat leave." As described by cognitive load theory (Sweller et al., 1998), limited working memory resources are freed for other tasks when declarative knowledge is integrated into schema, not isolated in disconnected bits.

Procedural knowledge is knowledge of how to perform tasks which may be cognitive, physical, or a blend of both (Anderson, 2000). Procedural knowledge provides "rapid execution of a set of actions under well-specified conditions" (Gagne et al., 1993, p. 110). In contrast to declarative knowledge, procedural knowledge is dynamic, acquired slowly, and difficult to modify once it reaches automaticity (p. 91). Automaticity is the third and final stage in the development of procedural knowledge as described below.

Procedural knowledge is developed in three stages: declarative, associative and automatic (Gagne et al., 1993). In the declarative stage, the learner acquires basic verbal or psychomotor knowledge of the procedure: "To operate a manual transmission, I simultaneously press the clutch to the floor and ease up on the gas pedal while I shift gears, then I release the clutch and reapply pressure to the gas pedal." In the associative stage, the learner can perform the task, but must concentrate on the procedure. In the associative stage the learner must pay attention (use working memory resources) to complete the task. For the safety of all involved, a driver of a manual transmission in this stage should not attempt to engage in conversation! Finally, procedural knowledge reaches a level of automaticity; little or no conscious effort is required to successfully complete the procedure. A driver in this stage can eat, drink, listen to the radio and talk while shifting gears.

Much procedural knowledge cannot be expressed verbally, such as how to ride a bike (Anderson, 2000). However, if possible, procedural knowledge can be verbally

represented as "if...then" contingency statements in which the "if" part of a statement signifies the condition and the "then" signifies the action to be taken (Gagne et al., 1993, p. 90). For example, when solving a two-digit subtraction problem, "If the top number is less than the bottom number, then I can 'borrow' from the number in the next column to the left." Describing procedural knowledge through "if...then" statements leads to an interesting point of confusion that this paper will attempt to clarify.

The distinction between declarative and procedural knowledge is very similar to the distinction between the information processing and constructivist perspective on schema theory as described in the preceding section. Constructivists have seen schemata as background knowledge, declarative knowledge, which affects the construction of meaning. Information processing theorists have seen schemata as rules we apply to perform tasks, or procedural knowledge. This view of schemata as rules has been described as a "far more restrictive sense" (Mayer, 1987, p. 329) than the constructivist view. Yet I will argue this "restricted" view actually encompasses the constructivist view, because, as this paper will show, all schemata are rule-based. In terms of knowledge, all knowledge, whether described as declarative or procedural, is ultimately procedural or rule-based.

Notice that procedural knowledge is developed in three stages: declarative, associative and automatic (Eggen & Kauchak, 2001). Declarative knowledge is the first stage of developing procedural knowledge. One must have declarative knowledge of the concept "noun" before one can complete the procedure: "Circle the nouns in the following sentence." One must have declarative knowledge of "borrowing" in a subtraction problem before one can complete the procedure: "65-28=?" Declarative

knowledge is simply a part of procedural knowledge. Furthermore, declarative knowledge is seen as static in that "it cannot be activated until a production fires" via procedural knowledge (Gagne et al., 1993, p. 110). In other words declarative knowledge only exists as it relates to some procedure or activity of the individual. One can only declare knowledge of "borrowing" if asked to do so or given a task which requires it. Procedure is the beginning and end of knowledge. Declarative knowledge is just a component of a procedure.

In other words, declarative knowledge only exists within the broader context of procedural knowledge. If this is true, then all knowledge is ultimately procedural or rule-based and can be "formally represented as IF-THEN contingency statements" (Gagne et al., 1993, p. 90). This is a claim that this paper will make. This paper will suggest that a schema can be linguistically expressed as an "if...then" statement, which I call a "hypothetical inference" following the American philosopher Charles Peirce (1839-1914). To describe all knowledge as hypothetical inference will bridge the gap between declarative and procedural knowledge and unify the information processing and constructivist perspectives on schema theory.

In summary, the ideas of declarative and procedural knowledge provide specific implications for instruction. It implies teachers should distinguish between lessons that attempt to merely build declarative knowledge and those that also seek to build procedural knowledge. If the goal is to build declarative knowledge, teachers should insure that this new knowledge is integrated into existing schemata or background knowledge. If the goal is to build procedural knowledge, it implies teachers should identify and teach the declarative knowledge that is the first step in the procedure. It also

implies that students need a lot of opportunity to practice new procedures so they can progress through the associative and to the automatic stage. But if all knowledge is ultimately procedural as this paper will argue, then teachers should teach all knowledge, whether it is considered declarative or procedural, through student activity.

Concept Theory

A concept can be quickly defined as a category. Examples of concepts are "dog, democracy, love, tool," etc. Concepts are hierarchical so that the concept "golden retriever" belongs under the concept "dog" which in turn could be placed under the concept "mammal" or "animal." The characteristics shared among all members of these concepts are the attributes. For example the attributes of the concept "mammal" are: animals that have hair or fur, give live birth, drink mother's milk etc. Obviously one can see that learning concepts is a large part of any student's education and therefore has been the subject of educational research early and often.

Two broad perspectives have vied for dominance in the literature on concept learning. The first of these perspectives is one based in logic and verbal knowledge; these can be categorized as rule-based theories. The other of these two perspectives is based on visual memory; these are categorized as prototype or exemplar theories. It will be a major focus of this paper to show that both perspectives are indeed valid. Concepts are learned both through logic and perception, but ultimately they are all formed based on rules, rules we apply to our words and our perceptions.

Educational psychology's first descriptions of concept learning were rule-based. The work of Bruner et al. (1956) was seminal in this regard. These psychologists were primarily interested in concept identification. The researchers had predetermined a novel

concept such as "red four sided figures." They would show the subjects a group of geometric shapes of various sizes and colors containing at least one example of the predetermined concept. The subjects would then make hypotheses about the concept and test their hypotheses by asking the researchers yes or no questions. In this way the researchers could determine how the subjects went about acquiring concepts. They found the subjects would quickly form rules such as, "If the object is not red then it is not an example" which they would apply and refine until arriving at all the essential attributes of the concept.

These concept learning tasks and the concepts themselves seem artificial. After all, who has learned a category of "red four sided figures" which is so clearly defined and has no gray or fuzzy boundaries? Who has sat in a laboratory asking questions to learn concepts? More typically we learn concepts in the normal course of our lives without an expert to confirm or refute our every hypothesis. Also the concepts we learn are not so easily and logically defined. Consider the concept "chair." Is a stool an example? What about the driver's seat in a car? These kinds of questions led to the development of the prototype and exemplar theories of concept learning.

Prototype theorists (Rosch & Mervis, 1975) suggest we identify examples of concepts, not by strict logical reasoning, but by a judgment of probability based on family resemblance. They would say rather than an abstract logical definition of chair, we have in our minds a prototype of chair, an analog mental construct based on and retaining characteristics of original sense experiences. This prototype is our "best instance" of the concept (Caelli & Moraglia, 1986). We probably recognize a stool as a chair because it has a family resemblance to our prototype of chair. After all it is a piece of furniture with

four legs used for sitting. Notice that a loveseat shares this logical list of attributes, but it would probably not be identified as an example of chair because it does not have a family resemblance. For prototype theorists this is evidence that we do not form and follow abstract logical rules but we make probability judgments based on sense experiences. One of the primary and important implications of prototypes is the exemplar theory of concept learning. Tenneyson and Cocchiarella (1986) have discussed how important it is for teachers to display concept exemplars and describe attributes or question students to discover attributes.

In reaction to the early development of prototype and exemplar theories, Bourne (1982) attempted to reestablish the validity of rule-based theories of concept learning. In his study he showed that when strictly rule-based concepts are artificially learned in a laboratory, it can still yield phenomena just like the "best instance" or typicality phenomena claimed as evidence of prototype theory. Perhaps, as this paper will suggest, all concept learning is ultimately rule-driven.

Prototype and exemplar theories make the most sense when discussing simple observable non-verbal concepts, such as "dog" or "bird." But it does not make as much sense to say we have prototypes of "love" or "democracy." Strictly rule-based theories better account for these verbal concepts. Immanuel Kant defined a concept as "a rule that allows you to unite separately given perceptual materials together under one label" (Kitcher, 1990, p. 195). For Kant a rule was an over-arching construct, it transcended the mere analog retention of images or prototypes. A typical prototype theory of concepts relies on recording of images. However, images are not merely passively recorded on the mind; they are actively constructed and reconstructed according to rules.

Therefore prototype and exemplar theories are just as rule-driven as an explicitly rule-driven theory. Here is why. The idea behind prototype or exemplar theories is that by observing a number of dogs, or even just one that makes an impression on us, we retain that image as a prototype. We then use this prototype to judge other animals we encounter so that we can classify them as dog or not dog by "family resemblance." If our prototype of dog looks like a golden retriever, then we would be quick to classify a yellow lab wearing a red bandana as dog because it closely matches our prototype, while we may be hesitant to classify a Chihuahua as a dog since it is so different. That is all very well and good. But we can't think that we will continue to use our prototype for a dog like this, like we were pulling a picture out of a file drawer. Our prototype is likely to change with new experience; the next time we use it, it may be a new combination of that first golden retriever wearing the red bandana of that second yellow lab. How can this be?

The prototype was not really the image, it was the rule we followed to construct the image. Recorded images are not subject change (it was not possible to record the golden retriever wearing the bandana because it never existed), but the rules we follow to construct images are evolving. Our prototypes, like any memories or imaginations, are not static recordings (or "analogs" as suggested by Rosch & Mervis, 1975), but constructions and reconstructions. The prototype image does not sit in our mind like a picture waiting to be pulled from a file drawer. What sits in our mind is the schema, the directions, the blueprint, the rule for constructing the image. Kant described the schema as "the part of the concept that permits perceptual recognition... or the rule for constructing images of concept instances" (Kitcher, 1990, p. 196). In summary, rule-driven, prototypical, and exemplar theories of concepts are all ultimately rule-driven.

This paper will show that Kant's idea of concept and schema give us the common ground of a rule-driven theory while still allowing for differences in verbal and non-verbal concepts.

Summary

This existing literature of cognition has extended educational psychology's ability to describe and prescribe learning experiences. The various perspectives share important ideas that have greatly impacted educational practices. Chief among these is the idea that students are not merely passive responders to stimuli, but they are active processors and constructors of knowledge. The literature of cognition is an attempt to describe these internal cognitive activities in a way that can lead to improved educational practice. Though largely successful, the literature still exhibits vagueness and lack of cohesion as described in the first chapter of this paper.

This second chapter further demonstrated the incompatibility within and among these views. One can refer to the debate between individual and social constructivism, rule-based and prototype theories of concept learning, or schemata as declarative or procedural knowledge as evidence of this incompatibility. The research that follows will demonstrate that many of these incompatibilities stem from a single core issue: is learning experience centered or mind centered? (Reynolds et al., 1996). The next chapter of this paper will attempt to research this question, tracing it from ancient to modern philosophy and from early to contemporary psychology. The research will show that some key ideas of philosopher Immanuel Kant can answer this question and alleviate the vagueness and lack of cohesion in the literature of cognition.

Chapter III: Research

Introduction

A paper describing an experimental or empirical study would at this point describe the study's subjects, materials, methods, etc. This paper describes a study that is theoretical rather than experimental or empirical. Because of this difference, the research will differ as well. This paper looks backward to the origins of psychology, to see if the great minds of the past can help clarify and unify current cognitive theory. This study's subjects will be those great minds of philosophy and psychology. This study's methods, though not experimental or empirical, are hopefully no less rigorous. The methods employed are more historical than scientific, unearthing the origins and tracing the lineage of ideas that have been foundational for educational psychology.

This research will define empiricism and rationalism and trace their development through the history of philosophy and psychology. Like the very measures of time and space that implicitly guide our science (though we consider them only a tool in our hands), the foundational ideas of empiricism and rationalism guide our educational psychology. Particular attention will be paid to how these two schools of thought established oppositional views of the mind, learning, and the possibility of knowledge. The philosophy of Immanuel Kant will be presented as a reconciliation of these two schools of thought. In Chapter 4, titled "Results," Kant's philosophy will help psychology reconcile these two views in a unified theory of cognition.

Empiricism and Rationalism in Philosophy

Consider Raphael's (1483-1520) famous painting, "The School Athens" (1509-1510). It portrays some of the greatest thinkers of Western civilization standing in a colonnade of Athens. In the spirit of the Renaissance, Raphael wished to depict Western civilization's outgrowth from its Greek roots. Most expressions of Western culture can find its origin in the Greeks, and psychology is no exception. In the very center of the painting stand two figures. One, the older, is raising a solitary finger toward the sky; the younger is extending his splayed fingers out toward the viewer. The older is Plato; the younger is his student, Aristotle. Here, symbolized by these two men and their almost incidental gestures, lays the central question of knowledge: "How do we learn?" This question is central to philosophy and psychology alike. It is a question that has fascinated many great minds for thousands of years.

	Empiricism	Rationalism
View of Mind	Passive mind Mind is a blank slate	Active mind Mind has innate knowledge
View of Learning	Involuntary association Based on sense experience alone	Voluntary act of will Based on logical thought alone
View of Possibility of Knowledge	Skeptical Nothing is knowable	Dogmatic Everything is knowable

Table 1: Empiricist and Rationalist Views of the Mind, Learning and the Possibility of Knowledge.

Whose hand holds the answer? Is it Plato's one finger pointing upward or Aristotle's several fingers pointing out? Let Aristotle fingers represent empiricism. They are several fingers pointing out to the world because empiricism claims knowledge is based only in the accumulation of sense experiences. Let Plato's finger represent the

philosophy of rationalism. It is one finger pointing toward the heavens because rationalism claims knowledge is based only on the unity of logical thought. Table 1 depicts some contrasting characteristics of empiricism and rationalism as they view the mind, learning, and the possibility of knowledge.

Teachers may feel this question of knowledge is antiquated or at the very least impractical. However, the answer to this question will determine how teachers plan lessons, organize classrooms, and write tests. To simply follow a textbook series is to simply suspend judgment and endorse the judgment of the textbook authors by default. It is better to decide that a philosophy of knowing, an epistemology, is so central to teaching it is worth the trouble of a little study. In other words, if one is to know how to teach, one must first know how to know.

It is unfortunate that Aristotle represents empiricism in Raphael's painting because he was really the first one to try and synthesize empiricism and rationalism. Actually empiricism can trace its roots a few decades before Aristotle to the Greek philosopher Democritus. Science textbooks credit Democritus for developing the idea of the atom, but more importantly Democritus developed the idea of materialism – the idea that all reality is material. Think again about Aristotle's hand, it shows us the fingers and the space between them. That is the essence of materialism; there is matter and space, but nothing else.

For Democritus there is one type of matter, the atom. For Thales there were four: fire, water, earth and air. For Mendeleyev there were ninety-four elements on a periodic table. "Whether there are four types or ninety-four is theoretically immaterial... All the great variety of common experience is to be derived from combination of these elements

[emphasis mine]" (Clark, 1957/2000, p. 37). The number does not matter (no pun intended), in the end a materialist agrees with Democritus. All reality is either matter or space; therefore, the qualitative differences we see can ultimately be reduced to quantity. Our knowledge can only come from sense experiences of matter, because matter is all that exists; this is the essence of empiricism.

In "The School of Athens," Plato is pointing toward the heavens in an effort to direct our attention away from the material world of sense experiences, and towards the unified world of ideas. Plato developed his philosophy in direct opposition to empiricism and materialism. To Plato, the idea that matter was the ultimate reality was absurd. If reality was only matter, then it is true that we could only know things that are based on sense experiences. But, Plato argued, we have knowledge apart from sense experiences. For example, by reason we know that a circle is a two-dimensional figure in which all points are equidistant from the center. We know what a circle is only by reason and logic; we have never experienced a circle with our senses. We have sense experiences of things that are like circles or spheres such as a plate, the sun, or a ball. But these are not truly perfect (the plate has an imperfection) and unchanging (the ball may deflate), while our idea of circle is perfect and unchanging. Plato's philosophy thus makes our ideas more real than our sense experiences. We recognize a plate as circular because we already have an innate idea of circle. Likewise all sense experience is based on logical thought. Plato's ideas are the basis of rationalism.

Very early in philosophy we have the beginnings of the conflict of empiricism and rationalism. As illustrated in Table 1 we have seen the conflict between pluralism and monism, between sense experience and logic. Reynolds et al. (1996) describe this conflict

as between experience centered and mind centered approaches. They place Democritus at the extreme pole of experience centered approaches and Plato at the extreme end of mind centered approaches. As stated earlier it was Aristotle who first tried to reconcile these disparate views of reality, the mind and learning. The middle path he developed was widely accepted and developed throughout the Middle Ages. However, to make Aristotle's, and later Kant's, synthesis more clear, I will continue to trace the development of empirical and rational extremes into the modern period.

Empiricism was fully developed and popularized in England by men such as John Locke (1632-1704), George Berkeley (1685-1753), and David Hume (1711-1776) who became collectively known as the British empiricists. They championed the idea that the mind has no innate ideas and that all thought is based on sense experience alone. In the words of John Locke (1690/1995):

> Let us then suppose the mind to be, as we say, white paper, void of all characters, without any ideas. How comes it to be furnished? Whence comes it by that vast store which the busy and boundless fancy of man has painted on it with an almost endless variety? Whence has it all the materials of reason and knowledge? To this I answer in one word, from experience. In that all our knowledge is founded, and from that, ultimately derives itself. (p. 59)

Here we see the empiricist view of the mind and learning. The mind is "white paper," the "blank slate" known as the "tabula rasa," anything written on it (learned) is a unity derived from particular sense experiences. "According to the empiricist view, the mind grows through the progressive accumulation of sensory experiences" (Schultz & Schultz, 1987, p. 29). This "progressive accumulation" is learning by association; we associate the sense experiences of red, juicy, and sweet over and over again and form the idea of apple.

These empiricist views are seductively simple, especially to educators. If children come to us as blank slates that passively learn by association, all we need to do is carefully craft experiences to shape student behavior. We see here the origins of behaviorism, which is the most extreme psychological expression of empiricism (Clark, 1957/2000, p. 341; Reynolds et al., 1996). We will examine this more carefully as we trace empiricism in psychology.

The British empiricists developed their views in opposition to the rationalism propagated on the European continent by men such as Descartes (1596-1650), Spinoza (1632-1677), and Leibniz (1646-1716). Descartes was determined to find an absolutely objective foundation for thought. He dismissed the idea that sense experience or divine revelation could be this foundation since either could be later found in error. Like Plato, he decided that pure logic and reason alone could provide such a foundation. What could he know absolutely for certain without basing it on sense experience or divine revelation?

Descartes proved, by logic alone, he could know that he exists. He doubted everything, except that he doubts. If he doubts, then he thinks. If he thinks, then he exists. This is his famous "cogito, ergo sum," translated, "I think, therefore I am." Prior to any sense experience (a priori) and apart from any divine revelation, he knew that he existed. From this foundation Descartes used logic alone to prove the existence of "God, geometric axioms, perfection and infinity" (Schultz & Schultz, 1987, p. 27). No doubt Descartes' views can be labeled as extremely mind centered. If empiricism leads to behaviorism, then the rationalistic philosophy of Descartes "culminates in the nativistic theory of perception and the Gestalt school of psychology" (p. 27).

Without exploring every intricacy of early modern philosophy, we can see that by Kant's time both empiricism and rationalism had reached dead ends. Rationalism may have found knowledge of abstract principles, but how could we gain knowledge of concrete individuals and history by reason alone? Empiricism may have found knowledge of sense experiences, but how can we gain knowledge of self, mathematics or science by sense experience alone? Are we to join with the rationalists and have absolute and perfect knowledge of abstract ideas that are utterly divorced from the material world? This would be like knowing calculus and never being able to use it. Or perhaps we should join the empiricists and gain perfect knowledge of our sense experiences but never be able to have any absolute or probable knowledge of them whatsoever? This would be like having the ability to count to a million but never being sure if 2+2=4. This was the choice that Immanuel Kant faced as described by Cornelius Van Til:

> Kant himself says that on the basis of empiricism we can have only brute facts and more brute facts but no systematic relation between them. He adds that on the basis of rationalism we would have only order, but it would be merely the idea of order without any ordering of facts. (Bahnsen, 1998, p. 344)

Instead of merely choosing a side, Kant strove to synthesize these two views. What he did he labeled the "Copernican revolution" of philosophy.

Kant's Synthesis of Empiricism and Rationalism

Both the empiricists and rationalists had the idea that objective reality was something outside of us. The nature of learning was to understand how our mind could conform to something outside of it. Think of objective reality like an apple and think of the mind as of those thin sheets of caramel one can wrap around the apple to make a caramel apple. The sheet of caramel conforms to the apple in the same way the empiricists and rationalists assumed the mind conforms to experience; they just differed as to how our

minds could conform to objective reality. The empiricists believed it could happen through sense experience, the rationalists through logic.

Kant did not pick one of these sides, he turned the whole issue inside out, or perhaps it is best to say "outside in." The mind does not conform to experience, Kant said, but experience conforms to the mind. The mind is the apple of objective reality; experience is the sheet of caramel. Our minds shape experience. This is Kant's self-described "Copernican revolution" in philosophy. Copernicus revolutionized astronomy when he demonstrated that the sun, not the earth, was the center of the solar system. Kant revolutionized philosophy and psychology, when he demonstrated that our mind, not experience, is the center or foundation of knowledge.

A further analogy may help explain the point. G. Haddon Clark (1957/2000) explains Kant's revolution with an analogy of jelly and a jelly jar. Think of a jelly jar sitting on a pantry shelf year after year. One year it experiences a sweet soupy sauce with chunks of red fruit floating in it; the next year it experiences a firmer dark purple substance with no fruit, the next year a bitter concoction with slices of peel. While each year the experience changes, one thing remains constant. The substance, no matter what color or texture or flavor, always has the same cylindrical shape and size. How could that be? Imagine the amazement of the jelly jar when it realizes that it, the jar itself, is the reason the substance always has the same size and shape (p. 313). The jelly (experience) conformed to the jar (mind). Experiences come and go, but the innate structure of the mind remains constant. Thus, Kant suggests, we can use experience to determine the innate structure of the mind. That innate structure of the mind can then be the firm foundation of knowledge, whereas experience and logic alone have failed.

All of this discussion about finding a firm basis of knowledge is of ultimate importance to philosophy and psychology. Table 2 depicts Kant's synthesis of empiricism's and rationalism's views of the mind, learning and the possibility of knowledge.

	Empiricism	Kant	Rationalism
View of Mind	Passive mind Mind is a blank slate	Interactive mind Mind has innate structures that shape experience	Active mind Mind has innate knowledge
View of Learning	Involuntary association Based on sense experience alone	Construction Based on application of thought to experience	Voluntary act of will Based on logical thought alone
View of Possibility of Knowledge	Skeptical Nothing is knowable	Evolving Some things are knowable	Dogmatic Everything is knowable

Table 2: Empiricist, Rationalist and Kantian Views of the Mind, Learning and the Possibility of Knowledge

Kant and Mind

While an empirical mind is passive and a rational mind is active, a Kantian mind is interactive. An active mind of the rationalist claims innate knowledge of everything apart from experience, but, like the jelly jar could only learn of its shape by its experience of the jelly, a Kantian mind must have experience to gain knowledge of itself. A passive mind of the empiricist has only experience; it is a blank slate with no innate structure to mold experience. But jelly without a jar would simply spill all over the shelf and onto the floor. This difficulty forced the empiricists to at least allow the mind the innate structure of habit or association, but once one ascribes to the mind a structure of association, it is not really a "blank slate" anymore, is it? Nevertheless Kant proved there must be a structure that exists even before the structure of association. Before a mind can learn by

habit to associate two things, it must already know that they are two things and not just one. Before I can associate the movement of one billiard ball with the movement of another that strikes it, I must first know that they are two balls separated by space. Therefore, space is an innate structure of the mind that exists before experience that we can only gain knowledge of with experience. A Kantian mind is interactive in that it is acted upon and acts upon experience. In Van Til's opinion, Kant's view of the mind was revolutionary in that, "no one had ever conceived the idea that the mind itself was doing the ordering [of experience] even as it was doing the observing [of experience]" (Bahnsen, 1998 p. 344).

Kant and Learning

While empiricism views learning as involuntary association and rationalism views learning as a voluntary act of will through logic, "Kantian schematism implies… constructivism" (Eco, 1997, p.89). What sits on the pantry shelf is the jelly jar and the jelly, there is no knowledge in either one alone but only in the relationship of the two. From a Kantian perspective, learning occurs, not from experience or mind alone, but from the relationship between the two. To use a "meatier" analogy from Cornelius Van Til, "Like a sausage-grinder, the mind of man form things into molds as it receives them. We never see pork or beef; we see only sausages that, according to the butcher's word, contain both. Thus we always make facts as much as we find them (emphasis mine)" (Bahnsen, 1998, p. 346). We cannot see the raw "pork and beef" of experience as the empiricists had hoped, nor are we free to prove facts apart from experience as the rationalists had hoped.

For Kant learning is constructed, in the sense that Beers (1987) explains that to see knowledge as constructed is to see knowledge as individually designed using common raw materials. When a house is constructed, the resulting structure depends on the background knowledge and activities of the builder and the nature of the materials provided. In the same way when knowledge is constructed, the resulting edifice depends on the background knowledge and activities of the mind and the provided experience. The link between Kant and constructivism and schema theory will be discussed more thoroughly when we examine how Kant's thought can unify and clarify cognitive learning theory.

Kant and the Possibility of Knowledge

While an empiricist view is skeptical and a rationalist view is dogmatic, Kant views knowledge as evolving. Kant validates the scientific method, yet allows the findings of the method to be revised. This is no easy task, for the empiricist view finds no firm basis for science. If the empiricists were right and we only have knowledge of fallible sense experiences, then science has no absolute knowledge of the material world. As Clark (1957/2000) paraphrases Locke's An Essay Concerning Human Understanding, "the indubitable experience we have of bodies never rises to the level of science; that is there are no general and unquestionable truths concerning bodies" (p. 289). Empiricism leads to skepticism. While a rationalistic view would allow us to know for certain that 2+2=4, it could never allow our knowledge, based on the unchanging laws of logic, to be revised by new experiences. If the rationalists are right and we can only know through logic and reason, we can reason to absolutes of God and geometry but never have any experience of them. Rationalism leads to dogmatism.

If empiricism says we can know nothing and rationalism says we can know everything, then Kant's view is that we can know some things. In Kant's view, science is not something outside of us we discover, nor is it something only inside of us we realize. Science is experience arranged by the mind of man. Scientific knowledge is based on a firm foundation (the innate structure of human thought) yet it is open to revision by new experiences. After Columbus, the world did not change shape from flat to spherical. After Copernicus, the earth and sun did not physically change places. Any scientific "discovery" is in fact just a new way of thinking about what was there all along. In this way science, like all learning, is constructive; it exists in the relationship of the mind applied to experience. Van Til explains this relationship:

> Facts cannot be observed, argues Kant, except that they are observed as being incorporated into systematic arrangement. So it is the mind itself that imposes it categories of substance and causality upon nature even as it observes nature. Nature means causally related facts. And causally related facts are brute facts observed and arranged by the mind of man. (Bahnsen, 1998, p. 344)

Empiricism and Rationalism in Psychology

To see the influences of empiricism and rationalism in psychology it might seem helpful to first answer the question, what is psychology? But this is not the most helpful starting point because any definition of psychology is likely to assume the dominance of one of these two views. One can see the influence of empiricism in British psychologist William McDougall's1908 definition of psychology as the "science of behavior" (Schultz & Schultz, 1987, p. 3). Does a strictly etymological definition of psychology as the "study of the mind" defer to a rationalistic view? After all, a study does not have to be a science and the mind is not directly observable through sense experience like a kidney or a flower.

"The distinction between modern psychology and its antecedents has less to do with the kinds of questions asked about human nature than with the methods used to seek the answers" (Schultz & Schultz, 1987, p. 1). So both philosophy and psychology are concerned with the nature of the mind, learning and the possibility of knowledge, but they use different methods to reach those answers. What are these different methods? Schultz and Schultz (1987) suggest philosophy uses "speculation, intuition, and generalization" while psychology uses the "the tools and methods of science" specifically, "controlled observation and experimentation" (p. 1). If it really is that simple a division, we could describe philosophy as rationalistic and psychology as empiricist.

But it is not that simple. We need to differentiate between empirical and empiricist, between rational and rationalistic. As we have seen, empiricism is a philosophical viewpoint, adopted by those we call empiricists, which states experience is the only firm foundation of knowledge. Rationalism is a contrasting philosophical viewpoint, adopted by those we call rationalists, which states logic is the only firm foundation of knowledge. By basing knowledge only in experience or logic, empiricism and rationalism are extreme views. Contrast that with the idea of empirical as "consistent with observation" and rational as "consistent with logic."

Therefore, science in general, and psychology specifically, is not empiricist or rationalistic, but it is empirical and rational. It is empirical because it stresses the observation of sense experience and it is rational because it assumes a logical order exists in that experience. The extreme views of empiricism and rationalism cannot operate in this blend of empirical and rational. They don't lead to good science, so they don't lead to

good psychology either. Table 3 restates the empiricist and rationalist views of mind, learning and knowledge and adds their views of psychology's focus.

	Empiricism	Rationalism
View of Mind	Passive mind Mind is a blank slate	Active mind Mind has innate knowledge
View of Learning	Involuntary association Based on sense experience	Voluntary act of will Based on logical thought
View of Possibility of Knowledge	Skeptical Nothing is knowable	Dogmatic Everything is knowable
View of Focus of Psychology	Sensation* Conscious Processes View conscious experience as the association of simple elements	Perception/ Reason Non-conscious processes View conscious experience as continuous stream of wholes

Table 3: Empiricist and Rationalist Views of the Mind, Learning, the Possibility of Knowledge and Focus of Psychology. *Influences of empiricism on psychology adapted from Schultz and Schultz (1987, p. 37).

The story of psychology can be viewed as a constant struggle between empiricism and rationalism to pull psychology toward one of these extremes. In this next section we will briefly survey the evidences of this struggle. We will review the history of psychology under four basic headings, structuralism, functionalism, behaviorism, and current cognitive theory. The following section will look to the ideas of Immanuel Kant to synthesize these influences in psychology as we have already seen him synthesize these influences in psychology.

Structuralism

As described by influential psychologist E.B Titchener (1867-1927), structuralism focused on the "elemental sensations and images that, in his view, composed the structure

of consciousness" (Schultz & Schultz 1987, p. 90). In Titchener's view, psychology should study the sensations of shape and color people experience when they observe an apple, not why they describe those experiences as an apple (p. 89). Obviously Titchener's structuralism, focused on raw uninterpreted sense experience, is heavily influenced by empiricism. Titchener was a student of Wilhelm Wundt, founder of the first psychological laboratory in Leipzig, Germany, an achievement which has led to his title of the father of psychology. Titchener claimed that he was bringing the ideas of Wundt to American soil. As an influential psychologist and sole translator of Wundt into English, this claim went unchallenged. However, more recent scholarship suggests that Titchener "altered Wundt's system dramatically while claiming to be a loyal follower" (p. 85). I would argue that structuralism, as developed by Wundt and other early German psychologists exhibited a balance of empirical and rational influence, not the radical empiricism one might see by reading Titchener alone.

The work of Wilhelm Wundt (1832-1920) exhibited a balance of empirical and rational views. The empirical influence is displayed by Wundt's insistence on the elements of experience. Wundt wrote, "the first step in the investigation of a fact must therefore be a description of the individual elements ...of which it consists" (Diamond, 1980, p. 85). Perhaps inspired by the thought of chemist Mendeleyev, Wundt hoped to develop a "periodic table of the mind" (Marx & Hillix, 1979, p. 67). However empirical his science, Wundt was no empiricist. He showed an appreciation of the wholeness of human thought when he wrote, "Every psychic compound has characteristics which are by no means the mere sum of the characteristics of the elements" (1896, p. 375). This wholeness or unity of experience, Wundt labeled "apperception", which is an "active

process...The mind is not merely acted upon by the experienced elements; rather, it acts on them in the creative synthesis of the parts to make up the whole" (Schultz & Schultz, 1987, p. 67). For example, "we see a tree as a unity, not the many and varied sensations of brightness, hue or shape" (p. 67). Wundt's apperception is at odds with British empiricism and the view that Wundt's student E.B. Titchener ascribed to Wundt and promoted so heavily in the United States.

Other early German psychologists seemed to lean towards empiricism or rationalism, but when looked upon as a whole, this early German school exhibits a balance of these views. Hermann Ebbinghaus (1850-1909) was markedly empiricist as he focused on how the association of simple elements leads to complex thought. Georg Elias Muller (1850-1934) exhibited rational influences as he rejected learning by association alone and included more active "mental phenomena, such as readiness, hesitation, and doubt...that actively influence learning (emphasis mine)" (Schultz & Schultz, 1987, p. 75). Carl Stumpf (1848-1936) believed Wundt's empirical focus on the elements of experience was wrong; he thought the reduction of experience to elements rendered it "artificial and abstract, no longer natural" (p. 78). Stumpf's more rational appreciation of the wholeness of experience directly influenced Gestalt psychology. Oswald Kulpe (1862-1915) founded the Wurzburg school of thought in opposition to Wundt's empirical elementalism. The Wurzburg school suggested the idea of imageless thought, which is a direct blow to the sense-based knowledge of empiricism. Kulpe showed that mental states such as "hesitation, doubt, confidence, searching, or waiting for an answer" (p. 81) are not produced by a passive association of sense-based images. Importantly, Kulpe reacted against empiricist focus on consciousness to investigate non-conscious influences on

consciousness. Kulpe's work helped pave the way for Freud's psychological theory (p. 82).

In conclusion, the empiricist structuralism that Titchener brought to and disseminated in America, was not representative of the original more balanced structuralism of Germany. German scholarship displayed a balance of empirical and rational influences that served psychology well. "German thought was spared the eighty or ninety years of British experience [with empiricism] and passed directly from rationalism to Kant's reconstruction of philosophy" (Clark, 1957/2000, p. 309). Germany had an interest in all new science and the discipline to carry out the empirical and experimental work (Schultz & Schultz, 1987, p. 43) yet it remained open to more rational influences. These rational influences can be seen very early in German psychology and later developed into schools of thought, such as those of Freud or the Gestalt psychologists, which were distinct from the American schools. We will now trace the influence of empiricism and rationalism on the first distinctly American school of psychological thought, functionalism.

Functionalism

As its name suggests, functionalism was a school more concerned with the function rather than the structure of the mind. Functionalism would not be content with describing the elements of consciousness, a "periodic table of the mind." It focused on perception and purpose; it searched for the "ways and means of the mind." It was a psychological expression of evolutionary biology. Functional psychology "came to be more concerned with the adaptation of the organism to its environment" while structuralism's "detailed investigation of mental elements began to lose its appeal" (Schultz & Schultz, 1987, p. 115). It was more philosophical and less experimental than the balanced German

structuralism. In fact, functional psychology's two main founders, William James and John Dewey, are perhaps more widely known as philosophers than psychologists. A brief description of these two philosopher/psychologists will provide an idea of the struggle between empiricism and rationalism in functionalism. In the end we will see functionalism was a school that blended empiricism and rationalism in a way that ultimately led to the development of an extreme form of psychological empiricism, behaviorism.

William James was not a disciple of empiricism or rationalism. In Pragmatism (1907), James derides the "serpent of rationalism, or intellectualism" (p. 19). He viewed logic, not as an innate idea, but as the result of evolution. Logic does not exist objectively in the outside world as a rationalist would argue, or innately in the human mind as Kant would argue; logic exists through evolution because it was pragmatic (useful) to the species. He agreed with the empiricists that knowledge must come through experience, yet "not experience consisting of discrete, atomic simple ideas, but experience as an ever-flowing stream of consciousness" (Clark, 2000, p. 389). We see in Berliner's (2001) description of James the rejection of empiricist and rationalist extremes for a more balanced approach: "He would have found nothing wrong with a scientific and strongly behavioral psychology...but such a psychology would not provide a complete picture of humans" (p. 6).

James' thought led to a more balanced view of functionalism, the study of the whole mind as it adapts to its environment. In James' thinking, the mind is not purely passive or active. Though James believed the environment conditions the mind to operate passively in "habit systems," he also "emphasized the human capacity to exercise initiative and to

introduce novelty into the evolutionary process" (Rippa, 1997, p. 181). If, as we have described above, Kant's view was of an interactive mind that constructed knowledge in an ongoing evolving process, we can see some similarity between Kant and James. Of course Kant believed the foundation of this process is the innate and objective structure of the human mind, while James viewed the mind as the product of evolution. It is important to note this issue raises critical ethical issues (Are our morals part of our innate, God-given essence, or are they just rules that have evolved and that we can change to further our species?), but those issues need not concern us here. What will concern us is that James' view of mind as the result of evolution reduces the mind to a physical phenomenon and opens the door for extreme empiricism, behaviorism

John Dewey (1859-1952) was an "American giant" who formally founded the functionalist school of psychology. Like James, Dewey developed a functionalism wth both empiricist and rationalist views that ultimately paved the way for the extreme empiricism of behaviorism. Dewey was initially interested in rational philosophy (his doctoral thesis was on Kant, in fact) but it was James' Principles of Psychology that most deeply influenced Dewey (Rippa, 1997, p. 164). Like James, Dewey stood "against elementalism and in defense of a more holistic view" (Berliner, 2001, p. 11). Berliner (2001) sees in Dewey's functionalism the seeds of the contemporary cognitive approach: Dewey believed the "individual's internal processes must be understood" (p. 12) and "what held together stimuli and their responses were the interpretations given to both, thus putting consciousness, attribution, and constructivist views squarely before [historically speaking] the emerging stimulus-response (S-R) psychologists of that time" (p. 11).

Yet Dewey's psychology is not rationalist or mind centered. Dewey is "definite in his repudiation of both innate ideas and a blank mind" (Clark, 1957/2000, p. 401) as the foundation of psychology. He considers the "starting point, then, is the compound of men and things, and this compound may be called Experience" (p. 404). However, once Dewey compounded or fused men and things, mind and experience, knowledge and learning soon become purely physical. In Democracy and Education (1944), Dewey wrote that teachers should, "give pupils something to do, not something to learn; and the doing is of such a nature as to demand thinking, or the intentional noting of connection; learning naturally results" (quoted in Rippa, 1997, p. 171). We see in this prescription a leaning towards behaviorism. Let's contrast Kant's blend of empiricism and rationalism, which led to a more cognitive approach, with James' and Dewey's blend which led to a more behaviorist approach.

Kant's synthesis of empiricism and rationalism led him to an interactive view; knowledge is a construction of mind and experience. Yet, ultimately it was more of a mind centered approach, because he viewed experience as a necessary component to discover how our mind is the objective basis of knowledge. Think back to the analogy of the jelly and the jar. The jar learns of its own innate and objective qualities through the experience of the jelly. For example, through experience in the material world we learn of our objective and innate ideas of space, time, language, etc. Any philosophy or psychology pursued from this perspective is bound to be more mind centered, more cognitive. Gestalt psychology, Freudian psychoanalysis, nativist theory, constructivism and schema theory can find their origins more directly in Kant.

On the other hand, pragmatism's blend of empiricism and rationalism led to a compound or fused view of mind and experience. Mind and experience are not two things interacting to form knowledge constructions; mind and experience are really one thing. There is no separate "jelly" or "jar," there is one thing "jellyandjar." However, once you fuse mind and experience, mind soon disappears. "Mind..." in Dewey's view, "is the complex of bodily habits, and knowledge lives in the muscles" (Clark, 1957/2000, p. 408). In James' 1904 article, "Does Consciousness Exist?" he concluded, "the stream of thinking...consists chiefly of the stream of breathing" (p. 403). Functionalism may have exhibited some rational and cognitive characteristics, "beliefs the nascent behaviorists chose ultimately to ignore" (Berliner, 2001, p. 6), but it also exhibited some extreme empiricist traits. It was men like E.L. Thorndike who picked up on functional psychology's empiricist traits and developed a behaviorist approach that dominated American psychology for decades.

Behaviorism

E. L. Thorndike (1874-1949) was a student of James' at Harvard, yet he was no disciple: "Thorndike's version of science and his vision of educational psychology has led us to a narrower conception of our field than would have been true had the views of these three other ancestors [James, Dewey and G.S. Hall] gained prominence" (Berliner, 2001, p. 5). James and Dewey developed a more balanced approach, but it was the radical empiricist views of Thorndike that "promoted and directed our field [educational psychology] for half a century" (p. 16). James' and Dewey's functional psychology explained the mind in Darwinian evolutionary terms. Since Darwin had blurred, if not erased, the line between man and animal, animal psychology as developed by Thorndike

gained acceptance. Through his study of animal behavior Thorndike developed his ideas of "connectionism, an experimental approach to associationism" (Schultz & Schultz, 1987, p. 181). This is an associationism that could make even the British empiricists blush: "Instead of talking about associations or connections between ideas, Thorndike talked about connections between situations and responses" (p. 182). Thorndike's connectionism led to a decreased role of the mind and directly to an extreme from of empiricism, behaviorism.

Behaviorism is the modern voice of empiricism (DiVesta, 1987; Kratochwill & Bijou, 1987; Reynolds et al., 1996). Behaviorism has been described as a revolution against both structuralism and functionalism: "It was truly a revolt, an open break, a total war... sudden, traumatic, and dramatic, no modification of the past, no compromise, but a complete change" (Schultz & Schultz, 1987, p. 173). However, as we have noted, functionalism's view of the mind as the result of evolution opened the door for the view that mind is purely a physical entity and then the behaviorist view that mind does not exist. Behaviorism's founder, J.B. Watson (1878-1958) "rejected the classic distinction between mind and body" (Rippa, 1997, p. 198) and was left with only body. From his behaviorist perspective, "there is no room for any organizing or framing function of the mind in this approach; indeed, there is no room for a mentalistic concept such as 'mind'" (Reynolds et al., 1996, p. 95). Watson's directive for psychologists was to "start work on psychology, making behavior, not consciousness the objective point of our attack" (Watson, 1913). Others took up his directive, notably B.F. Skinner, who most influentially applied the behaviorist school of thought in his system of operant conditioning.

Current Cognitive Theories

For the first half of the 20th century, behaviorism held American educational psychology in a "strangle hold" that was "successfully challenged" by cognitive psychology (Mayer, 1996, p. 153). Some examples of these challengers are information processing theory, schema theory, and constructivism. Each of these cognitive perspectives is by default more rational or mind centered than the radically empiricist and experience centered behaviorist view. Yet each one still leans towards rationalism or empiricism.

The rational influence in current cognitive theory is seen most clearly in schema theory and individual constructivism. Schema theory contributes to our understanding of cognition by describing the role of background knowledge in the process of knowledge construction (Nuthall, 1999). Thus schema theory leans more toward a "top-down" or rational approach. Reynolds et al. (1996) identify schema theory as the only current cognitive theory that leans more toward a mind centered approach. Constructivism, more a principle than a theory of learning, argues that understanding is constructed rather than recorded (Phillips, 2000). Piaget (1952, 1959, 1970), who stressed the development of individual's knowledge construction, came from a distinctly mind centered or rational approach. Schultz and Schultz (1987) explain, "Gestalt psychologists as well as Piaget argued that the tendency to organize conscious experience (sensations and perceptions) into meaningful wholes is innate. Thus the mind gives form and coherence to mental experience" (p. 375).

The empirical influence in current cognitive theory is seen most clearly in information processing theory and social constructivist perspectives. The information

processing metaphor "enabled the rebirth of cognitive psychology by providing an alternative to the behaviorist view of learning" (Mayer, 1996, p. 157). Information processing contributes to our understanding of cognition by describing our cognitive architecture, metacognitive abilities and, as elaborated by cognitive load theory (Sweller, van Merrienboer, & Paas, 1998), the limitations of working memory. Yet, despite its use of cognitive terms, information processing still is recognized by its empiricist leanings. It may have substituted a computer metaphor for the switchboard metaphor of behaviorism (Reynolds et al., 1996), yet information processing still shows cognition as progressing in a "bottom-up" manner in which discrete stimuli are processed into more complex forms of knowledge, one of the defining traits of empiricism. Vygotsky (1978, 1986) developed a more socially oriented constructivist perspective, stressing the role of culture, social interaction, and language in learning (Fowler, 1994; Rogoff, 1990). His social constructivist perspective would lean more toward the experience centered perspective than Piaget's individual constructivist perspective (Reynolds et al., 1996).

In summary, current cognitive theory needs to unify and clarify its empirical and rational influences. We have seen how in the history of philosophy, cognitive theory has exemplified the struggle between empiricism and rationalism, between experience-centered and mind-centered approaches We have seen how this struggle continued in the early history of psychology as structuralism and functionalism tried to define and maintain a balance. In Europe this balance ultimately titled toward a more rational approach, yet, "Historically, American psychology has had a decidedly experience-oriented, mechanistic attitude... [which] was likely first established by the British

Empricists. The cognitive revolution did not really change this attitude" (Reynolds et al., 1996, p. 102).

As described earlier, current cognitive theory is in need of a more balanced and unified approach. The thought of Immanuel Kant can help provide such a unified theory. In an attempt to unify philosophy, Immanuel Kant developed his ideas of the interactive mind that constructed knowledge in an evolving manner. The next chapter will show how Kant's ideas can lead to a theory of cognition which unifies the more empirical information processing theory with the more rational schema theory in light of the constructivist framework that underlies them both.

Chapter IV: Results

Immanuel Kant (1724-1804), recognized as one of the world's great philosophers (Ozmon & Craver, 2003), was born, lived, and died all in the seaside town of Königsburg, Prussia. To any observer, his life was entirely unremarkable. His social status was decidedly middle class; his religion was strictly Lutheran; his education was typically rigorous. All this prepared him to take a position on the faculty at the local university where he lectured in mathematics, physics, geography (astounding in that he never left his own town) and, of course, philosophy.

Kant devoted himself to philosophy rather late in life, being appointed professor of metaphysics and logic when he was 46, and arguably founding modern philosophy and psychology when he was 57, when he published his Critique of Pure Reason. It is unnecessary to describe every detail of Kant's philosophy in this paper, if it is even possible, for, "It is not clear that every aspect of his thought has been intelligible to anyone, even to Kant" (Scruton, 2001, i).

However Kant's ideas of what schemata are and how they are formed can help extend the limitations of cognitive learning theory. Let us join what linguist Umberto Eco (1997) calls, "the return to Kant discernible in many contemporary cognitive sciences" (p. 89) and see how Kant can help unify cognitive learning theory. To proceed, we will see how Kant can help answer the difficult questions posed above to constructivism,

schema theory, and information processing theory. Let's first consider Kant's system from the perspective of knowledge construction.

Kant and Constructivism

- What exactly is constructivism?

Suppose two students are briefly shown the sentence, "The cowboy rode tall tall in the saddle." Suppose that after the sentence was removed from the students' vision, the students were instructed, "Remember what you saw and describe it." It is likely that one student might recall it exactly as written including "tall tall," while another student might recall it as, "The cowboy rode tall in the saddle." Both are certain they are right. How could this happen?

Any theory that says knowledge is recorded in the mind, could not explain how this could happen. A recording must be an exact reproduction. A photocopy of "The cowboy rode tall tall in the saddle" will not read, "The cowboy rode tall in the saddle." An audio recording of "The cowboy rode tall tall in the saddle" will not playback, "The cowboy rode tall in the saddle." Yet many philosophers and psychologists have suggested knowledge is indeed recorded by the mind. This is the view of learning supported by empirical philosophers such as Berkeley, Locke and Hume, and behaviorist psychologists. They say the mind is like a passive lump of clay while sense experience is like an active hand. Like a thumb leaves a thumbprint on a piece of clay, sense experience impresses itself on the mind. The thumbprint cannot change; the imprint of the sense experience cannot change. Yet the student's memory of "The cowboy rode tall tall in the saddle" changed to "The cowboy rode tall in the saddle." That is why the idea

of recorded knowledge cannot explain these kinds of changes. Our perceptions and thoughts are too different, too unique, to be the result of mere recording.

Then is it more accurate to say that we individually create knowledge? Do we authoritatively decide what we will think? A theory that suggests that knowledge is created would see the mind like the active hand, not the passive piece of clay. This view of learning has also been supported philosophers and psychologists. To use a broad brush, this is the view of learning supported by rational philosophers such as Leibniz and Spinoza and radical constructivists. They suggest the mind is so active that it actually creates knowledge, as if by magic. It snaps it fingers and a 747 jet appears; it crosses it fingers and knows what love is; it wiggles its fingers and remembers, "The cowboy rode tall tall in the saddle" or "The cowboy rode tall in the saddle." It doesn't matter what knowledge the mind creates, as long as it is useful to or approved by its creator. This may be an interesting self-help philosophy, but it is not a description of learning that can help teachers. The student who restated the sentence "The cowboy rode tall in the saddle" only changed one word, he did not say, "The rain in Spain falls mainly on the plain." He did not leap from his seat and start doing jumping jacks. It may be possible for one person to point to an object and say, "book" and for another to say, "dictionary," but it is unlikely that someone will say "polka-dotted democracy." People do not create knowledge. Our perceptions and thoughts have too much in common to be the result of creation.

There must be a middle way between these two extremes. Educational psychology is searching for this middle way between these extremes of behaviorism and radical constructivism. Almost two hundred years ago, the Prussian philosopher Immanuel Kant searched for a middle way between the similar extremes of empirical and rational

philosophy. The middle way he described essentially founded modern philosophy and psychology. Kant was the first to describe the active mind in a way that contemporary cognitive psychology can identify. Kant suggested that knowledge is, not recorded or created, but constructed.

Kant saw the mind as both the hand and the piece of clay. Let the hand represent the structure and function of the human mind. A hand has a normal structure of five fingers and one thumb; a hand has normal functions of fingers grasping, poking, pushing while the thumb can move in opposition to the fingers. Kant considered that the mind has normal structures (imagination, for example) and functions (inference, for example) too. Consider that the piece of clay represents all sense perceptions, all experiences. The clay is not reality, but our perception of it. Here is how it works: we see a 747 airplane and the hand shapes the clay into a representation of the airplane. The plane did not strike our minds and leave an exact impression or recording. The hand did not create a plane out of thin air. The hand has constructed a representation of the plane from the clay. Beers (1987) explains that to see knowledge as constructed is to see knowledge as individually designed using common raw materials.

To illustrate, imagine we give two people two identical stacks of building materials and ask them to build a doghouse. The resulting constructions may be very unique, one may have a window, one may have a raised floor, etc. However, the doghouses will have just as much in common since they will be made of identical materials and (hopefully for the dog's sake) exist in compliance with the laws of physics. Knowledge is constructed in much the same way. It is not merely recorded or processed; it is too unique for that. Yet our knowledge has too much in common to be pure creation.

It is remarkable to think that Kant described knowledge construction in this way almost two hundred years before the "cognitive revolution." This Kantian analysis is consistent with the principles of constructivism mentioned previously:

1) knowledge is constructed, not merely recorded or processed, by individuals, (Phillips, 2000);
2) knowledge construction is affected by the experiences and development of the learner (Piaget,1952, 1959, 1970);
3) knowledge construction occurs in a social context (Vygotsky, 1978, 1986).

Now we will see what Kant can bring to schema theory. If Kant can be described as a founder of constructivism, he can certainly be described as a founder of schema theory since "schema" is a term he actually coined.

Kant and Schema Theory

- What exactly is a schema?

Linguist Umberto Eco (1997) states, schematism "suffers from insufficient historical background" (p. 7). A reading of educational psychology texts supports this view. This is a typical description: "The historical roots of the concept of schema in psychology can be traced to Bartlett's (1932) classic book on prose memory, Remembering, as well as Piaget's (1954) classic discussion of intellectual development" (Mayer, 1987, p. 329). This is true in a technical sense; however, the concept of schema was birthed in philosophy by Immanuel Kant, more than 150 before Bartlett's "classic book". In its first definition, the Oxford English Dictionary recognizes Kant's primacy in developing the term "schema":

> 1. In Kant: Any one of certain forms or rules of the 'productive imagination' through which the understanding is able to apply its 'categories' to the manifold of sense-perception in the process of realizing knowledge or experience.

In more direct language, a schema is a rule the imagination follows to construct images. Consider this in terms of the analogy of the hand and the lump of clay. The hand represents the imagination; the lump of clay represents an image. How hand shapes the clay, the rule that it follows in shaping the clay, is the schema. Think of all the ways we use images. We construct images when we use our eyes to perceive, when we imagine something we have never seen, or when we remember something we have seen. Schemata are the rules we follow when we construct these images. Let's consider schemata as the rules we follow as we construct the images we perceive, imagine or remember.

Schemata are rules that guide visual perception. Think again about the two students confronted with the sentence, "The cowboy rode tall tall in the saddle." The first student perceived it exactly as written. From this student alone, we could not determine if this perception was the result of passive recording or active construction. But when the second student actually perceived, "The cowboy rode tall in the saddle," it proved his perception was constructed, not recorded. But we don't only construct our misperceptions; we construct all our perceptions.

All our perceptions are composites of what is really there and what we expect to be there. Think about it - why did the student perceive the sentence with only one "tall?" He perceived it with one "tall" because he expected it to have only one "tall." His expectation guided the construction of the image. His expectation was the rule he followed. The schema was part of the rule that specifically guided his construction of the

image. When confronted with the sentence, his schema followed the rule about not doubling words and guided him to construct the perception, "The cowboy rode tall in the saddle." The first student had a similar schema, but his imagination did not follow it. In fact he may have noticed and remembered the sentence precisely because it did not follow the schema. Schemata are not determinative laws, they are rules or guidelines we sometimes follow and sometimes do not.

In much the same way, schemata guide the images we imagine. Like a perceived image, an imagined image is constructed. Beers (1987) explains how constructed knowledge is individually designed using common raw materials. How are we able to imagine a pink polar bear? How are we able to imagine a flexible triangle that can assume any possible combination of angles and side-lengths? We can imagine these things because our mind can combine the schema for "pink" and for "polar bear" to construct an image of a pink polar bear. Our mind can combine our schema for "flexible" and "triangle" and construct an image of a flexible triangle. Pink polar bears and flexible triangles do not exist; they could not have been passively recorded in our minds.

A supporter of the passive mind might say, "Well the mind has previously recorded images of "pink" and of "polar bear," and the mind combines these recordings to construct the imagination." The inconsistency is clear – combining recorded knowledge and constructing images are activities. At some point the supporter of the passive mind must turn to the active mind to explain human thought. But Kant shows us how our imagined images of "pink polar bears" are constructions based on perceived images of "polar bears" and "pink" which were also constructions. Images, whether imagined or perceived, are constructed. This view is consistent and adequate in a way a

passive view cannot be. Schemata are rules that guide the construction of perceived and imagined images, but do schemata also guide the construction of images that are remembered?

If our perceptions are constructed, then our remembrance of our perceptions is a reconstruction. Therefore our constructed perceptions can be different than reality and our reconstructed memories can be different than our perceptions. In the words of Loftus and Loftus (1980): "Not only might the original acquired memory have departed from reality in some systematic way, but the memory may have been continually subject to change after it was initially stored" (p. 419). These memories, these reconstructed images, are also guided by schemata.

If two people witness the same traffic accident, or if two siblings experience the same childhood event, they may later visualize different images. This vivid visual memory is not a recording, but it is a reconstruction. The memories are similar because they are reconstructed from a common experience. Yet they are unique because the schemata, the rules that guided the imagination in its reconstruction, are unique. Why do we sometimes alter our memories? Remember that Loftus (1993) describes how people can remember voting when they had not and suggests: "One interpretation of these findings is that people fill in gaps in their memory with socially desirable constructions, thus creating for themselves a false memory of voting" (p. 532). People have a self-concept that includes civic responsibility. In this case we see the self-concept guiding the schema. The self-concept is serving as a rule that guides the schema as it guides the construction of images. Fascinatingly, this is exactly how Kant described the relationship between concepts and schemata. Kant saw the schema as a part of a concept. The concept

is the broader rule to construct meaning while the schema is the part of the concept that specifically constructs images.

- How are schemata related to concepts?

Like a schema, a concept can be described as an expectation or rule. The Kantian concept can be identified with understanding, which Kant described as the "faculty of concepts" or the "faculty of rules" (Kitcher, 1990, p. 200). A concept is simply broader than a schema. A concept is a rule for constructing understanding; a schema is "the part of the concept that permits perceptual recognition... or the rule for constructing images of concept instances" (p. 196). Schemata are related specifically to images while concepts are related to more general understanding. Kant defined the concept as "a rule that allows you to unite separately given perceptual materials together under one label" (p. 195).

Take the concept "dog," for example. We have united all our separate experiences of dogs, all the dogs we have seen, read and heard about, under the label "dog." The concept "dog" contains all our knowledge and our feelings about dogs. The part of the concept that is image-based (what dogs generally look like, what particular species look like, or what a childhood pet looked like, etc.) is the schema. The schema for the concept *dog* guides our construction of images of dogs, the images of dogs we perceive, imagine or remember. The rest of the concept "dog" is language-based (that dogs are mammals, that dogs hear better than we do, that dogs pant when they are hot, etc.). We have discussed how schemata guide the construction of images which are perceived, imagined or visually remembered, following this line of thought we can see how concepts guide the construction of understanding that is recognized, possible, or generally remembered.

Concepts are rules that guide recognition. Just as we saw schemata at work when the student made a mistake in perception, we can see concepts at work when someone makes a mistake in recognition. Umberto Eco (1997) relays the amusing story about explorer Marco Polo's first encounter with a rhinoceros. Polo "recognized" a unicorn. He had never before seen a rhinoceros nor a unicorn, but he did possess the concept of unicorn from reading Greek mythology. He had constructed a rule for unicorn, something about a fantastical white horse with a single horn on its muzzle. When he received the sense stimulus of seeing the rhinoceros, his understanding followed his rule for unicorn. He "recognized" a unicorn (p. 57-58).

Again, like with perception, just because we can easily see the use of rules when we make mistakes, does not mean we use them only when we make mistakes. Any time we recognize or name something, we are using our rules to construct meaning. If two people who have never formed a rule for platypus suddenly encounter one, one is likely to name it "bird" while another is likely to name it "mammal." It depends on what concepts and schema are followed. The same process happens when we hear or read about something. If someone describes to us the political system of ancient Athens, we are likely to recognize it correctly as "democracy," or more accurately as a "pure democracy," or mistakenly as a "republic." It all depends on what rules we have formed in the past and how we apply them in the present. Whether it is an image we perceive and recognize as unicorn, or a government we read about and recognize as a democracy, we are applying rules to construct meaning.

Just as we use schema to construct images we imagine, we use concepts to conceive possibilities. We can imagine a pink polar bear, because we have formed

schemas for "pink" and "polar bear." We can conceive of a despotic democracy because we have formed concepts for "despotic" and "democracy." We cannot conceive of or form an image of a "dinkled diam," because we have not formed rules for "dinkled" or "diam" (which are of course invented words). Interestingly we can see that they were invented using rules of how vowels and consonants are combined to make English words. We can conceive of them as possible English words because they follow these rules. Our existing concepts guide, even determine, our possible new concepts. This is a powerful statement about the importance of discovering and activating students' background knowledge. Students can only perceive and understand new knowledge through the lens of background knowledge. Concepts do guide the construction of possibilities, but do concepts also guide the construction of memories, of meaning that is remembered?

Concepts do guide remembered meaning, or meaning that is *re*constructed. Consider again our two students confronted with "The cowboy rode tall tall in the saddle." As discussed earlier it is likely that one student actually perceived, "The cowboy rode tall in the saddle" because his concepts and schemata about English guided his perception. I actually made this very misperception in an educational psychology class. However, is it possible that a student would perceive it as written, but when later asked to remember it, would then alter the sentence to contain only one "tall?" In other words, is perception and meaning frozen in memory or is it subject to change?

Common experience and controlled experiments tell us that our memories do indeed change over time. I recently told a professor about an article on how Kant influenced Maslow's [sic] hierarchy of ethical reasoning. My professor suggested that I must have actually been referring to Kohlberg's hierarchy. I deliberately paused to check

my memory of the article. I actually visualized the page with the reference, and clearly saw Maslow's name in the upper left hand of the page. My professor was shocked to think such a mistake actually made it to print. When I actually checked the article, I found the mistake was mine. When I looked at the page in question, there was Kohlberg's name in the lower right hand of the page. We were amazed to see how my self-concept had guided my imagination to create a false visual memory. My embarrassment at making this mistake unconsciously guided me to create a false visual memory.

This is the same phenomenon experienced by people who create a false memory of voting described by Loftus (1993). These people's self-concept includes being a responsible voting citizen; this self-concept leads them to create a false memory of voting. Our concepts do not just guide our reconstruction of images, but of meaning in general. Remember the experiment conducted by Conway & Ross (1984) in which students who were given instruction in study skills were asked to remember their initial study skills and the subsequent improvement in their grades. The students exaggerated the weakness of their initial study skills and the improvement in their grades, even though there was no real change. They had formed a concept of an expectation of change that guided their reconstruction of meaning.

Consider again our two students who see, "The cowboy rode tall tall in the saddle." It is very possible that the student would initially perceive it with two "talls," but later reconstruct the image with only one "tall," from fear of remembering something that "couldn't be right." We have seen how concepts guide the construction of meaning that is recognized, possible, or remembered, and how a schema is the part of the concept that

guides the construction of images. Now we will discuss the benefits of describing concepts and schemas specifically as rules.

- Are concepts and schemata rules or prototypes?

Two contemporary theories of concept learning are rule-based theories and prototype theories (Eggen & Kauchak, 2001). Obviously, a Kantian theory of concepts is a rule-based theory. However, a Kantian theory of concepts is a rule-based theory that encompasses the image-based orientation of prototype or exemplar theories. That is because a Kantian concept encompasses the image-based schema. A Kantian concept is constructed from both visual and non-visual experience, so it is a combination of rules and prototypes. Consider again our triangle. Whether we are seeing examples of triangles, hearing triangles described in language, or seeing triangles described with language (reading) we are still constructing rules from sense experience. Our rules, our concepts and the schemas associated with them, are our construction of meaning.

It is beneficial to think of concepts and schemas as rules rather than as definitions or laws. A rule can be continually modified while a definition or law has the air of fixed objectivity. The words "definition" or "law" give the sense of something unchanging that we discover, like the law of gravity. But Kant uses the word "rule" in the sense of "guideline, principle, rule of thumb," not in the sense of "definition" or "law." Kitcher (1990) quotes Kant: "Since the synthesis of empirical concepts is not arbitrary but empirical and as such can never be complete (for in experience ever new characteristics of the concept can be discovered), empirical concepts cannot be defined" (p. 197). So for Kant our concepts are rules continually available for revision.

Thinking of concepts as rules that can be followed or revised can help us to describe Piaget's ideas of assimilation and accommodation. When we follow our rules, we are assimilating new sense experience. When we revise our rules, we are accommodating new sense experience. Consider again Marco Polo's experience with the rhinoceros. When he saw the rhinoceros, his concept "unicorn" assimilated this new sense experience. He followed his rule for "unicorn;" his concept and schema for "unicorn" guided what he perceived and recognized. If he had a concept "elephant," he might have assimilated the rhinoceros into that just as easily. After all, they are both big and gray with a protuberance on their snout.

However, interestingly, he also had to accommodate his concept "unicorn" in light of this new experience. He wrote in his journal, that a unicorn is "quite the contrary to that which we believe that it was" (Eco, 1997, p. 58). He revised his rule for unicorn. Polo revised his rule for unicorn by changing descriptors such as "white and beautiful" to "black and ugly." One wonders, why did Polo revise his rule for unicorn like this rather than revise his rule for animal by admitting a new species? Is this evidence of a hierarchy of concepts? Do we hold to some concepts more tightly than others? The rule for animal is more general than the rule for unicorn. Is that why Polo did not want to change it? Would it have caused too much overall change to his belief system? Would it have caused a greater amount of disequilibration?

We see how thinking of concepts as rules can avoid Derry's (1992) criticism of focusing "exclusively on the construction of symbolic knowledge by individuals" (p. 416) while neglecting "the world of work and every activity that occurs outside classrooms" (p. 414). As we have seen, our concepts can be rules about symbolic

knowledge, or rules about self-concept, or rules about social relationships. To describe learning as the construction of concepts, and to describe concepts as rules constructed from experience, is to describe learning in and out of the classroom. While we can distinguish cognitive, affective and psychomotor domains for the sake of discussion, there is no real division.

When the teacher smiles and hands the student a sheet of math problems, every response, what the student thinks, what the student does, what the student feels, is the result of applying his rules to experience. We see that the goal of education is to help students construct rules that are as accurate and helpful as possible. If we can find a good way to linguistically represent these rules, then teachers can have a good way to state lesson objectives and structure learning experiences.

- How can we linguistically describe concepts and schemata?

Can we linguistically describe these concepts and schemata? Rumelhart and Ortony (1977) tell us, "schemata are not linguistic entities but abstract symbolic representations of knowledge which we express and describe in language" (p. 111). If so, then *how* can we linguistically represent such complex rules? We can linguistically represent a concept in the form of an "if...then" statement:

- "If a polygon has 3 sides, then it is a triangle."
- "If a government forms its laws based on a majority vote of its populace, then it is a democracy."
- "If the top number in the ones column of a subtraction number is smaller than the lower number, then you must 'borrow' from the tens column."

Any one example of a concept expressed as an "if...then" statement may seem counterfeit, simplistic, and yet cumbersome. It is. That is because we are using language to express it. If concepts are not linguistic entities, but rules that can be expressed in language, then expressing them in language will make them into something they are not, it will counterfeit them. Using language to express concepts always simplifies, isolates, limits and counterfeits human thought, yet it must be done for the sake of communication.

An "if...then" statement can be named a hypothetical inference. A hypothetical inference is our best guess at meaning using the clues we have. This is exactly what we do when we form and apply our concepts and schemata. The student who mistakenly perceived "The cowboy rode tall in the saddle," Marco Polo who mistakenly recognized a unicorn, the students who mistakenly remembered an improvement in their grades after instruction in study skills - all these people made their best guesses at meaning. These particular guesses were just not as accurate as most. Usually our guesses, our hypothetical inferences, are pretty accurate and helpful to us.

To consider the hypothetical inference as the foundation of all human cognition is a line of thought developed by the American philosopher Charles Peirce (1839-1914). Peirce was a prominent developer of semiotics, the study of how humans infer from signs and symbols. Eco (1997) describes Peirce's position that human thought and even perception is based on inference. He writes about Peirce's conception of inference:

> Like the post-Kantian he was on his way to becoming, Peirce was later to say that this process of conceptualization proceeds only by hypothetical inferences therefore: it happens not only in the process of conceptualization but even in the recognition of sensations. (p. 61)

Say that we point to an object and label it "pretty yellow cup." Peirce would say we infer, we guess, that it is a "cup" not a "glass" or "mug," just as we guess that it is "yellow" not "cream" or "lemon," just as we guess it is "pretty," not "beautiful" or "elegant." Peirce views our thoughts and sense perceptions as sequential guesses of meaning in a symbolic environment; they are hypothetical inferences.

Eco (1997) describes Peirce as "post-Kantian" (p. 61), because Kant did not consider concepts as formed by inference, but Peirce did. For Kant, inference was an ability of the faculty of reason, not of the faculty of understanding (which was the faculty of concepts or rules). For Kant, inference was conscious reasoning such as when we infer "Socrates is mortal," from the premises, "Socrates is a man" and, "All men are mortal." But Peirce helps us to see that inference is much more automatic and foundational. If we perceive a rather unattractive old man questioning young men in the streets of Athens, we infer that it is Socrates. If we hear the word "men" in this context we infer that it refers to mankind, not just male humans.

At this point we must agree with Kitcher (1990) who stated, "We cannot turn to Kant and expect to discover that the true theory of concepts has been lying undetected in our midst for almost two hundred years" (p. 198). However to adopt the view that concepts are the products of this kind of automatic and foundational inference does not refute or significantly alter his theory of concepts, but his view of inference.

Summary of Kant and Constructivism and Schema Theory

A Kantian analysis of cognition tells us that we can describe knowledge as rules and express those rules in the form of "if...then" statements. This analysis has clarified and unified constructivism and schema theory. It has helped to clarify and under gird

constructivism as a set of principles rather than a distinct learning theory. A Kantian analysis of cognition is consistent with the constructivist principles:

1) knowledge is constructed, not merely recorded or processed, by individuals, (Phillips, 2000);
2) knowledge construction is affected by the experiences and development of the learner (Piaget,1952, 1959, 1970);
3) knowledge construction occurs in a social context (Vygotsky, 1978, 1986).

A Kantian analysis of cognition has also alleviated the definitional vagueness of schema theory. Schemata and concepts can be described as rules rather than by comparison to scripts, plans, frameworks, slots, etc. Because of this, a Kantian analysis gives teachers a clearer description of the product of learning. Teachers can view their goal, not as the somewhat vague construction of knowledge or poorly defined schemata, but as the construction of rules. Furthermore, we have described those rules as "if...then" statements, which gives teachers a functional way to consider objectives and structure learning experiences. This benefit will be fully explored in Chapter 5, titled "Discussion." Finally, because we see that concepts and schemas are rules that are constructed from experience, a Kantian analysis has helped to unify constructivism and schema theory. What remains is to examine how the construction of these rules is related to our cognitive architecture as described by information processing theory.

Kant and Information Processing Theory

To understand how the ideas of Kant can extend the limitations of information processing theory, it is important to understand a Kantian view of cognitive structure or architecture. Kant advocated a "two-tiered theory of belief" aptly described by Kitcher

(1990). Kant described two separate cognitive faculties, "understanding" and "reason." The understanding forms concepts like "Socrates, mortal, man" and reason infers, "If Socrates is a man, and if all men are mortal, then Socrates is a mortal." The faculty of understanding forms concepts while the faculty of reason infers knowledge from concepts supplied by the understanding. We have already noted how Charles Peirce showed that inference is at the heart of all mental operations, so we need not correct Kant again on this point. With regards to information processing theory, the important thing is that Kant viewed understanding as unconscious and reason as conscious.

If we take Kant's two faculties of unconscious understanding and conscious reason and superimpose them on information processing, what would be the result? Working memory (WM) can be identified with Kant's faculty of reason and long-term memory (LTM) can be identified with Kant's faculty of understanding. If "working memory can be equated with consciousness" (Sweller et al., 1998, p. 252) and if WM is limited as described by cognitive load theory (Sweller et al., 1998) then we can identify WM with Kant's faculty of reason.

Kant viewed the faculty reason as "conscious and under (some) direct control" (Kitcher, 1990, p. 201) and as beset with the same limitations as WM. Kant described reason's purpose is "to reduce the varied and manifold knowledge obtained in the understanding to the smallest number of principles... and thereby achieve the highest possible unity of knowledge" (p. 201). This is very consistent with the limits of WM as described by cognitive load theory. If WM is consciousness then LTM is the unconscious and can be identified with Kant's faculty of understanding. Kant viewed the understanding, the forming of concepts/schemas, as "virtually unconscious and under no

voluntary control" (p. 200). The important difference is that LTM is typically considered passive, while Kant's faculty of concepts is extremely active. Kant's view of the active unconscious will help extend the limitations of information processing and unify it with constructivism and schema theory.

The role of the unconscious is an important current topic in cognitive psychology, with many experts investigating the question, "Is the unconscious smart or dumb?" (Loftus & Klinger, 1992). Even Jerome Bruner (1992), who is reluctant to assign a major role to the unconscious, which he describes as "not very" smart, states, "it now seems downright barmy to assume that everything that affects any mental process, perceptual or otherwise, has to be accessible to consciousness" (p. 782). On the other hand, advocates of a smart unconscious have stated, "Although it might appear to some to be somewhat surprising, the ability of the human cognitive system to non-consciously acquire information is a general metatheoretical assumption of almost all of contemporary cognitive psychology" (Lewicki, Hill & Czyzewska, 1992, p. 796). This statement is supported by the very first paragraph of John Dewey's, "My Pedagogic Creed", first published in 1897:

> I believe that all education proceeds by the participation of the individual in the social consciousness of the race. This process begins unconsciously almost at birth, and is continually shaping the individual's powers, saturating his consciousness, forming his habits, training his ideas, and arousing his feelings and emotions. Through this unconscious education the individual gradually comes to share in the intellectual and moral resources which humanity has succeeded in getting together. He becomes an inheritor of the funded capital of civilization. The most formal and technical education cannot safely depart from this general process. It can only organize it or differentiate it in some particular direction. (p. 77)

Let's see how Kant's idea of the active unconscious can better define this "general process," and how it can help extend the limitations of information processing and unify it with constructivism and schema theory.

- How are memories unconsciously elaborated in LTM?

The passive LTM of information processing cannot explain how memories are elaborated unconsciously. Information processing theory describes LTM as a storehouse, like a bookshelf on which passive schemata rest. Schemata have been described passively as, "stereotypes, prototypes, templates, scripts, plans, and grammars" or "as 'frameworks' with 'slots' to be filled, or 'packets' of knowledge contained within larger 'packets' of knowledge" (Sadoski et al., 1991, p.466). But Kant considers schemata as rules, as the ways our mind actively relates to sense experience. If this is accurate, then the place where they are stored, the LTM, is active as well. This active LTM can explain the unconscious elaboration of memories.

We have thoroughly discussed how concepts and schemas guide the reconstruction of memories. We are "revisionist historians" (Johnson & Sherman, 1990, p. 497) and our concepts and schemata are the rules that guide how we edit and create memories. A person's self-concept may guide them to create a false memory of voting, or mistakenly visualize a page in a book with an error it did not contain. A person's expectations may cause them to remember a sentence with only one "tall" when it had two or to exaggerate academic improvement after instruction in study skills. A Kantian analysis of concepts and schemata has adequately explained all these elaborations of memories. Now we can see that these elaborations happened unconsciously in LTM, the place where concepts and schemata are formed.

In each case the memory had been stored in LTM. There were several minutes or even days between the experience and the memory of the experience. Yet when the memory was recollected it had been elaborated. None of these elaborations were lies; no person consciously constructed a false memory. These elaborations were made unconsciously, outside the person's awareness. This is evidence that "the memory may have been continually subject to change after it was initially stored" (Loftus & Loftus, 1980, p. 419). This is evidence of an unconscious and active LTM.

- How does background knowledge affect information processing?

The LTM described by information processing is a passive storehouse at the end of the processing line. It is part of the "rigid architecture of the mind" (Mayer, 1996, p. 157) that "typically glosses over questions concerning the nature and origin of the information process" (Beers, 1987, p. 374). However, considering LTM as the active constructor of concepts explains how background knowledge affects information processing.

The LTM that constructs concepts and schemata is constantly guiding perception and WM. Specifically, we have thoroughly discussed how concepts and schemata affect perception, recognition, imagination, possible conception, and retrieval. We discussed how they can guide a student to perceive a sentence with only one "tall" when it had two, how they can guide Marco Polo to recognize a unicorn when he saw a rhinoceros, how they can guide someone to conceive of or imagine a "pink polar bear" or a "despotic democracy," but not a "dinkled diam," and how they can guide someone to falsely reconstruct the past. We can describe our background knowledge as our pre-existing concepts and schemata. Though we easily see how the pre-existing concepts and

schemata affect information processing in the case of errors, they always do affect it. And they always affect it unconsciously as the active LTM affects information processing.

- How does information "pop" into one's consciousness?

The passive LTM of information processing cannot exert influence on WM, or consciousness. Yet experience tells us that unconscious concepts and schemata are continually flooding our consciousness with their rules, trying to apply them to experience to make meaning even as they are being formed with experience. In other words, our background knowledge is shaping our new experiences, even as our new experiences are shaping our background knowledge. Information is rapidly and uncontrollably flowing back and forth from consciousness to unconsciousness. Johnson & Sherman (1990) describe this in terms of time:

> Past, present and future fold backward and forward like Japanese origami. They collapse onto each other, emerge from each other, and constantly determine each other, as we construct and reconstruct both [sic] past, present and future in the present, and the past and future construct the present. (p. 482)

This is not explained by the "rigid architecture of the mind" (Mayer 1996, p. 157) described by information processing theory in which information flows from sensory memory to working memory to passive long-term memory. However an active LTM, that is constantly shaping perception and WM, even while it is being shaped by perception and WM, is consistent with experience. An active LTM explains this fluid movement of information among our senses, our conscious present and our unconscious experiences and expectations. Where classic information fails to explain the role of beliefs and expectations in learning (Mayer, 1996), a Kantian analysis of cognition can succeed.

- How does information enter LTM without ever being in WM?

Information processing suggests all information passes through WM before being encoded in LTM. Pashler and Carrier (1996) suggest this is the typical path, yet they affirm, "being in STM [short-term memory] may be neither necessary nor sufficient for copying into LTM" (p. 18). There is evidence that information enters directly into LTM. Kelly & Lindsay (1996) relay an anecdote about the French neurophysiologist Clarapede:

> who concealed a pin in his hand and pricked the hand of an amnesic woman while shaking hands with her. She quickly forgot the incident, but on a subsequent occasion when he moved his hand toward hers, she withdrew hers reflexively. "When I asked her for the reason, she said in a hurry, 'Doesn't one have the right to withdraw the hand?' and when I insisted, she said, 'Is there perhaps a pin hidden in your hand?'" (Clarapede, 1911/1951, p. 69). (p. 31-32.)

The experience of the prick directly entered her unconscious LTM and later entered her conscious WM in an altered form. Not only can information directly enter LTM, it can be actively processed in LTM alone. The language acquisition device, suggested by Noam Chomsky (1972, 1976) is evidence of the active unconscious. The language acquisition device describes how children unconsciously form and follow syntactical rules. A child will say, "This one is gooder [sic]," even though he has never heard that mistake. The child has unconsciously formed and followed a syntactical rule. The language acquisition device is consistent with Kant's description of the understanding – the unconscious faculty that takes in experience and forms and follows rules. These rules are concepts and schemata. A child unconsciously forms and follows a syntactical rule, "If I add '–er' to a word, then it means 'more'." An anterograde amnesic unconsciously forms and follows a rule, "If this man extends his hand, then there might be a pin in it." Classic information processing cannot explain these things, but a Kantian analysis of cognition can.

- How do constructivism and schema theory relate to our cognitive architecture?

In a simplified form, information processing theory has typically depicted the relationships among memory stores as depicted in Figure 1.

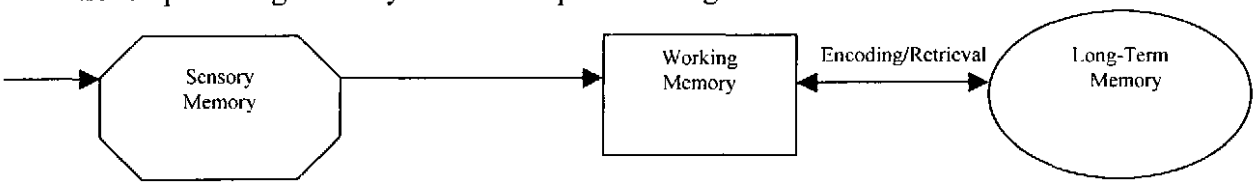

Figure 1. Classic information processing with one-way flow of information.

The problems of classic information processing theory stem from its view of LTM as a passive storehouse of knowledge and the WM as the only active constructor of knowledge. A more accurate model arises from superimposing the Kantian two-tiered system of belief on the classic view of information processing. This model is depicted in Figure 2.

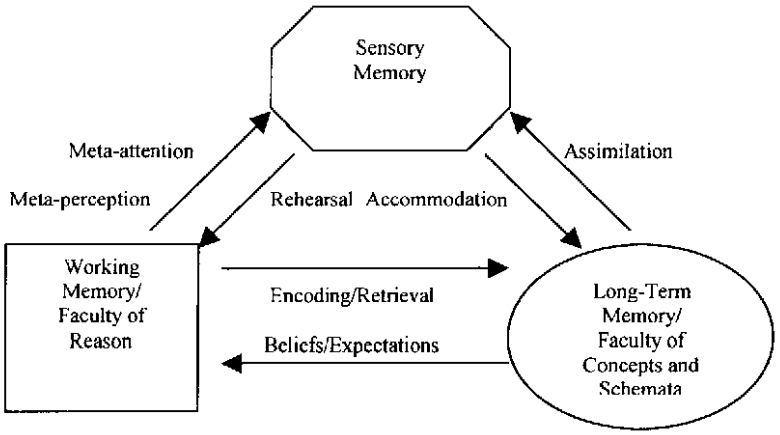

Figure 2. A unified view of information processing with fluid flow of information.

- How do schemata relate to our cognitive architecture?

Neither information processing theory nor schema theory has answered important questions. Let's answer them from a unified theory developed from a Kantian analysis:

- Where are schemata formed?

They are formed in the unconscious and active LTM.

- Where are they stored?

  They are stored in the unconscious and active LTM.

- Where do they operate?

  Concepts and schemata are beliefs and expectations that exert influence on WM and perception.

This new model represents a unified theory of cognition. It relates the construction of schemata to cognitive architecture as described by information processing theory. The LTM is identified as the place where concepts and schemas are constructed. Importantly they are formed unconsciously directly from experience. The revising of these concepts and schemata in light of new knowledge is accommodation.

This model also shows how concepts and schemata influence perception and WM. When concepts and schemata influence perception it can be described as assimilation. Assimilation occurs when existing concepts and schemata determine perceptions. Concepts and schemata affect WM as beliefs and expectations. These beliefs and expectations introduce information, assumptions, motivations, and biases into the reasoning process. All of these statements about how concepts and schemata affect various cognitive processes have been fully explained and exemplified in the preceding chapters.

Essentially schema theory provides a "top-down" point of view to information processing because it stresses how background knowledge guides attention and perception. It has suffered from vagueness about exactly what schemata are and how they are formed. Classic information processing theory provides a "bottom-up" point of view to information processing because it stresses how knowledge is built up from sensory

perceptions. It suffers from an overly mechanistic and "rigid architecture of the mind" (Mayer 1996, p. 157), which can't explain the role of beliefs and expectations in learning (Mayer, 1996).

Although it is commonly held that, "Processing is both bottom-up and top-down" (Andre, 1987, p. 270), educational psychology does not have one theory that supports this view. A unified cognitive theory would encompass both top-down and bottom-up processing. This model represents this kind of theory. Concepts and schemata are unconsciously formed in a bottom-up fashion directly from experience. This clarifies the vagueness of schema theory and constructivism. It is also true that concepts and schemata guide perception and reasoning in a top-down fashion. This provides a more fluid architecture that can explain the role of beliefs and expectations in learning. A Kantian analysis of concepts and schema superimposed on information processing theory has provided a more unified cognitive theory. It is time to offer a critique of Dual Coding Theory (DCT), as DCT presents itself as a challenge to Kantian schematism.

A Rebuttal of Dual Coding Theory (DCT)

As its name indicates, Dual Coding Theory (DCT) suggests that our knowledge exists in one of two codes, verbal and non-verbal. The verbal code includes the written and spoken word, while the non-verbal code includes images, tastes, smells, sounds, and haptic input. However, DCT's prime interest in the non-verbal code is the image; hence the name of a recent book on DCT, Imagery and Text (Sadoski & Paivio, 2001).

Before describing the details of DCT, it is very important to note that the unified theory presented in this paper also suggests that knowledge exists in two similar codes. A Kantian schema constructs images, while a concept constructs non-imaged meaning. On

this very basic and important proposition, DCT and the unified theory presented in this paper agree. Furthermore, the primary implication of DCT is the use of the "concrete example;" knowledge presented in both the verbal and non-verbal form will be more easily and meaningfully encoded. This is also the primary implication of this unified theory; people construct knowledge from examples so concepts should be first concretely exemplified and then abstractly described.

If DCT and a unified theory both agree that knowledge is in two codes, imaged and non-imaged, and that teachers should use concrete examples that can be encoded in both codes as much as possible, is there a need to distinguish or choose between the two theories? Yes, because DCT theorists claim an "empiricist and pragmatic" approach as the basis of DCT, specifically disdaining rationalism and "Kantean idealism" (Sadoski & Paivio, 2001, p. 6-7). This explicitly empiricist viewpoint ultimately leads to the same roadblocks hit by British empiricists and behaviorists: the mind is passive, not active or interactive, and learning is an involuntary association, not an act of will or construction.

It is important that educational psychology avoids reverting to empiricist views in a "cognitive counter-revolution." It is my belief that DCT theorists have embraced empiricist ideas because of a misunderstanding of Kant's philosophy in general and his schema in particular, which I hope to clarify. Ultimately, we agree on the existence of distinct verbal and non-verbal meaning and the importance of the use of experience and example to learning. I hope to establish similar agreement on Kant's view of an interactive mind that constructs knowledge.

DCT's and Kant's Philosophy

DCT theorists view themselves "empiricist and pragmatic" (Sadoski & Paivio, 2001, p. 6) and specifically disdain rationalism and "Kantean idealism" (p. 7). DCT theorists find their philosophical origins in Aristotle, whose "psychology was based in empiricism" (p. 15). They place Aristotle decidedly in the empiricist camp, though other educational psychologists correctly place him at the philosophical midpoint between experience-centered and mind-centered approaches (Reynolds et al., 1996). DCT theorists claim Aristotle "held that all knowledge comes from sense experience" (Sadoski & Paivio, 2001, p. 15), but this is not empiricism. An empiricist like John Locke would say, "all knowledge comes from sense experience alone." Aristotle would not say that; he knew that our minds actively bring something to experience "to allow higher-order knowledge to emerge" although "he did not say exactly how the mind accomplishes this task" (Reynolds et al., 1996, p. 94).

What we do know is that Aristotle suggested "there must be an active intellect...this [the working of the active intellect] is like light shining on colors and making them visible" (Clark, 1957/2000, p. 115). Our intellect actualizes sense experience, so our thought is always a composite of the two. What Aristotle grasped at while he tried to synthesize empiricism and rationalism, Kant clarifies and extends. As corroborated by Van Til: "The relation of Aristotle to his predecessors is therefore very similar to that of Kant to the empiricist, Hume, and the rationalist, Leibniz" (Bahnsen, 1999, p. 331).

This philosophical confusion shows up later when Sadoski and Paivio (2001) discuss Pestalozzi's object lesson, "the use of real objects for observation, verbal

description and verbal definition" (p. 30). Importantly, the object lesson is consistent with the implication of both DCT and a unified cognitive theory in that it stresses the importance of beginning instruction with concrete experiences and examples. Sadoski and Paivio (2001) conclude, "For Pestalozzi, as for Aristotle, concrete sense impression was the foundation of all knowledge" (p. 30). Yet they also state that Pestalozzi was influenced by Kant and Rousseau, stating Rousseau emphasized "extensive sensory experience" (p.29). The line of thought extends from Aristotle to Rousseau to Kant to Pestalozzi. They fail to see that Aristotle and Kant similarly balanced empirical and rational influences in a way that led to Pestalozzi's emphasis on concrete experience as the beginning of instruction. The point of all this is to say that DCT theorists wish to embrace Aristotle's views and reject Kant's; but their views are very similar.

DCT and Kant's Schema

The proponents of DCT suggest Kant's schemata are an example of reification, the attribution of "actual existence to something that is only a name or abstraction" (Sadoski et al., 1991, p. 467). In other words, schemata do not exist. They go on to ask, "schemata are, by most accounts, abstractions derived from experience that exist in a potential, nonspecific state, awaiting input. The epistemological question is how conceptual or schematic knowledge can exist in the abstract, isolated from any of the examples that gave rise to it" (p. 467).

Is it true that a Kantian concept/schema is isolated from the examples that gave rise to it? No. For Kant, knowledge is a combination of us and the world around us. Just because we must have experience to gain knowledge does not mean that *all* our knowledge comes from experience; we humans bring something to experience to

construct knowledge. Just as we bring our eyes to experience to perceive an image, we bring our minds to experience to form knowledge. Just as the nature of our eyes (they can see some types of light, but not infrared or ultraviolet light) and our experience combine to determine what images we perceive, so the nature of our mind and experience combine to determine what knowledge we acquire.

Knowledge comes from sense experience, but not from sense experience *alone* (despite the assertions of Locke, Hume, 20th century behaviorists, and DCT theorists). A Kantian schema is no more a reification than the idea of memory. Based on all the examples described earlier in this chapter, we can infer that people construct rules from experience. These rules are concepts and schemata and they do indeed exist.

Ironically, while trying to distance themselves from schema theory, DCT theorists describe two hypothetical constructs, which are essentially the same as a Kantian concept and schema. DCT theorists suggest the existence of the logogen and imagen. Sadoski and Paivio (2001) describe logogens and imagens as DCT's "building blocks" of cognition, the "basic representational units". Logogens can also be described as "verbal representations, verbal encodings, mental language and inner speech; imagens are alternatively called nonverbal representations, nonverbal encodings, mental images and imagery" (p. 46). Importantly, "the morpheme '–gen' means that which generates. Hence, logogens are language generators and imagens are image generators; both are also useful in recognition" (p. 47). At this point one can see that the logogen corresponds directly to a Kantian concept while an imagen corresponds directly to a Kantian schema. They are hypothetical constructs that describe how we recognize and generate non-imaged and imaged meaning. What is the difference?

Dual coding theorists describe schemata as "abstract and amodal structures" (Sadoski & Paivio, 2001, p. 43) while logogens and imagens are modal and concrete. By "amodal" they mean schemata are separate from the modes of the five senses. While this criticism may be true of schemata as vaguely defined by current schema theorists, Kant's description of schemata avoids this criticism. Kant's concept/schemata does make a distinction between language and image, with the schema as the rule that guides the construction of images perceived, imagined or remembered. So Kant's schema is not amodal, it is linked to the visual mode. Kant's concept is linked to non-visual meaning.

DCT also tries to distance itself from the "abstract" schemata by supposing that logogens and imagens "retain some of the original concrete qualities of the external experiences from which they derive...This implies that our mental encodings themselves are concrete rather then abstract" (p. 44). If a "concrete" representation has "a basis in sense experience" then Kantian concepts and schema are just as concrete as a logogen and imagen. If a "concrete" representation "retains some elements of sense perception," then Kantian concepts and schemata are just as concrete as a logogen and imagen. But if a "concrete" representation is a "recording of sense experience," then neither logogens, imagens, concepts nor schemata are concrete, because perception and knowledge is constructed, not recorded.

But DCT theorists also suggest that logogens and imagens are concrete because they are "assumed to have physical form" (p. 46) and describe them as "neuronal structures" (p.71). Is there empirical basis for this assumption? If so, it is just as strong an empirical basis for the "concreteness" of a Kantian concept and schema, which they describe as a

"reification," the attribution of "actual existence to something that is only a name or abstraction" (Sadoski et al., 1991, p. 467).

DCT and Associative Learning

DCT theorists admit "current views of meaning and comprehension in literacy have evolved away from extracting meaning from stimuli and toward the view of an active comprehender" (p. 68). Yet DCT leaves few activities to the learner. Ultimately, DCT claims that knowledge structures are built through associative learning as "repeated and invariant associative experience results in integrated higher order structures" (p. 61). Associative learning is the foundation of British empiricism and behaviorism, not the more balanced view of Aristotle (Reynolds et al., 1996) or of Kant. DCT theorists embrace extreme empiricism when stating "all meaning may ultimately lie on a foundation of direct nonverbal experience" (p. 85).

Describing learning as associative leads to the idea of a passive mind as described by empiricist philosopher J.S. Mill "the direct forefather of modern behaviorism" (Reynolds et al., 1996, p. 95) who believed that "the mind has no creative function because association is a passive process" (Schultz & Schultz, 1987, p. 37). The idea of learning as response strengthening which DCT calls the "repeated and invariant associative experience" held American psychology in a "strangle-hold" for decades, until successfully challenged by the cognitive revolution in the mid-twentieth century (Mayer, 1996). We do not need to return to the idea of associative learning, as DCT would encourage us. Instead we need to clarify an approach balanced between empiricist (experience-centered) and rationalist (mind-centered) extremes. The next chapter will explicitly state the implications of a unified cognitive theory for K-12 classrooms.

Chapter V: Discussion

Teachers in K-12 classrooms "do not routinely locate and translate research-based knowledge to inform their efforts" (Hiebert, Gallimore, & Stigler, 2002, p. 3). The understanding required to interpret the information in a range of theories often overwhelms teachers and detracts from their abilities to use these theories to inform their practice. Any unified theory of learning, must therefore explicitly state and demonstrate its implications for effective classroom use.

The present literature of cognition does not give clear implications for classrooms. Information processing theory, schema theory and constructivism exhibit limitations and lack cohesion. Each theory is limited by vagueness and an inability to describe common phenomena. They also lack cohesion in their explanation of learning. These limitations and lack of cohesion make their application in teaching-learning environments difficult.

Not only has a Kantian analysis clarified the vagueness, extended the limitations and generally unified current cognitive theories, but it has important implications for teachers' thinking. Since, according to Kant, the unconscious formation of concepts depends on the combination of innate cognitive structures and sense experiences, carefully crafting experiences for students is essential. These crafted experiences aid natural learning by providing approximations of the authentic experiences people encounter in day-to-day living, while simultaneously helping students reach important learning goals.

Teachers' thinking should then focus on their goals and ways to most effectively exemplify topics that will aid this unconscious concept formation and help students reach the goals. This suggestion is corroborated by additional research (Cassady, 1999; Spiro, Feldovich, Jacobson & Coulson, 1992); it is consistent with thinking about the creation of productive learning environments (Bransford, Brown, & Cocking, 2000); it is grounded in current views of the processes involved in learning to teach (Borko & Putnam, 1996); it begins to answer the question about the teacher's role in learners' construction of understanding, as well as the question about learner background differences.

High quality examples accommodate differences in learner background knowledge, lead to the formation of concepts, and provide frameworks for problem solving and other higher-order cognitive processes. The contributions of existing theories then guide teachers' actions, such as guiding learners through social interaction (Wink & Putney, 2002) and accommodating the limitations of learners working memories (Sweller, et al., 1998). In summary, viewing concepts/schemata as rules unconsciously formed implies:

1. Teachers should describe the concept to be taught as a rule.
2. Teachers should introduce the concept rule by experience or by example.
3. Teachers should use the concept rule as a framework for effective questioning.
4. Teachers should describe the rule with abstract language only after students have understood the rule.

As noted above, after a thorough study of information processing, constructivism and schema theory, a classroom teacher would still be left with important unanswered

questions. Let's restate these questions and answer them based on the implications of a unified theory:

- If students construct their own understanding, what is my role?

The role of the teacher is to identify concepts to be taught, to assemble a wide variety of examples of the concept, and help students construct rules about the concept so that they can recognize and create examples of the concept.

- How can I help students construct schemata if I am not sure what they are?

Schemata are rules or guidelines students use to recognize or create examples of concepts. For example, if a student has constructed a rule such as, If an animal is warm-blooded, has hair or fur, gives live birth, and drinks mother's milk, then it is a mammal, then that student can recognize, supply or create examples of mammals. When teachers help students construct such rules, they are helping them construct schemata.

- How do I accommodate learner background differences and the influences these differences have on the processes involved in knowledge construction?

Ask questions to determine background knowledge and build it as necessary. A teacher won't be able to effectively teach about mammals unless his students have already formed concepts of warm-blooded, hair, fur, live birth, and mother's milk. The way to find out if students have the requisite background knowledge is to ask questions, "What do you notice about this animal? Why do think this polar bear has so much hair and is so fat? How do the babies get food?" If the students do not already possess an understanding of and language to describe

background concepts, the teacher must go back and lay this foundation before continuing.

- How can I help students adapt to the limitations of working memory?

Use examples of the concept; do not use abstract descriptions of the concept. Abstract descriptions place a large load on working memory. A high school English teacher should not begin a lesson on effective introductions by saying, "If an introduction persuades the reader to be attentive, interested and well-disposed to the text, then it is an effective introduction. An introduction can get the attention of the reader by being unique…etc." The teacher should have the students read effective introductions and then help them perceive their characteristics. Once they have understood from the examples, then the teacher may abstractly name and describe the concepts.

Let's take a more detailed look at how each of these four implications should affect classroom practice.

1. Teachers should describe the concept to be taught as a rule.

Effective teachers set goals for instruction. Some goals teachers may set are:

- If a closed two-dimensional figure has three-sides of any length and three-angles of any degree, then it is a triangle
- If an introduction persuades the reader to be attentive, interested and well-disposed to the text, then it is an effective introduction
- If an animal is warm-blooded, has hair or fur, gives live birth, and drinks mother's milk, then it is a mammal.

Teachers can use "if...then" statements to clarify goals as represented above. The "if...then" statement is preferable to a typical concept definition because the characteristics precede the concept name. This helps to remind teachers that student must perceive and understand these characteristics before the concept can be known. These characteristics are the background knowledge students must possess before they can learn the concept. Once a student has constructed these rules so that he or she can recognize and create examples of the concept, a learning goal has been met.

2. Teachers should introduce the concept rule by experience or by example.

A middle school English is in the middle of a unit on critical thinking. Currently she is teaching her students about informal fallacies, common errors in reasoning. One of today's concepts is chronological snobbery. She considers her objective, "I want the students to recognize that if someone likes or dislikes something simply because of how old it is, they are committing the fallacy of chronological snobbery." She has assembled some examples of this concept. The teacher places a transparency on the overhead and says, "Johnny, read aloud the sentence on the overhead." Johnny reads, "I can't believe you still support trickle-down economic policy. That was formulated way back in the 1980's. It is so out of touch with today's economic realities." The teacher asks, "Is there a problem with this reasoning? What is it...Sarah?" Sarah responds, "The speaker does not define his term. We don't know what he means by trickle-down economics." "That's right," the teacher affirms, "but is there another problem? ... What do you think Rick?" Rick stops to search for the right words and begins, "Well, the speaker doesn't give a valid reason for not supporting trickle-down economic policy. He just doesn't like it because it is old." The teacher smiles, "That's right, just because something is old is no

reason to dislike something… Hank, read the next example." Hank snaps up in his seat and reads, "Courtship is the proper way for young people to pursue romantic interest. Courtship was working centuries before dating was even developed." "What is the problem here?" asks the teacher. Gretchen raises her hand and says, "It's the same problem." "Exactly the same, Gretchen?" the teacher probes. Gretchen responds, "Well, this person thinks we should like something because it is old when the other said we should not like something because it is old." The teacher nods, "Exactly. Is this a fallacy?" Hank says, "Well a fallacy is an error in reasoning, and these are not good reasons." The teacher raises her hands palms up, "So what is the fallacy or error in reasoning in these examples… Jenny?" Jenny says confidently, "That we should like or not like something just because of how old it is." The teacher claps her hands together, "You're right, Jenny, that is exactly right. If we suggest that someone should like or dislike something just because of how old it is, then we have committed a fallacy."

The very first act of teaching is to represent the concept with high quality examples. This way, students can apply their background knowledge, their current concepts and schemata, to the example. Through questioning, the teacher can evaluate the level of background knowledge. This allows the LTM to construct the new concepts/schemata.

3. Teachers should use the concept rule as a framework for effective questioning.

A Kindergarten teacher wants to teach her students about triangles. She knows she wants the students to recognize and create examples of triangles, but how does she get them to do this accurately and consistently? She thinks about how we know what a triangle is, "If a shape is flat and has three connected sides, then it's a triangle." She

knows she must help her students perceive and understand all these characteristics of triangles: shape, flat, three sides, connected. Using examples of triangles, she focuses her questions on each of these characteristics. Standing in front of her class, she points to several triangles drawn on the board. She smiles, "What do you notice about these shapes...Hunter?" "There all the same," answers Hunter. "How are they the same?" she asks. "They're all pointy," says Hunter, "They all have three points." "Aha!" the teacher exclaims while she wonders to herself why she didn't think of that characteristic, "What else... Latisha?" Latisha beams, "They all have three sides." "What else?" she queries, "How are they different... Mackenzie?" "Well, some are big and some are small," Mackenzie suggests. "That's right," affirms the teacher, "but they are still the same shape even if they are different sizes, aren't they?" The teacher points to a square, "What is different about this shape?" Mackenzie blurts out, "It has four sides!" "That's right," then she corrects the eager student, "but remember to raise your hand, OK?" The teacher then points to three lines that are not connected and asks, "What about this one... Vonda?" "The side is not connected, right?" "Yes, that is different from these shapes, isn't it?" the teacher affirms as she points to the triangles. The teacher then holds up a piece of wood in the shape of a pyramid, "What about this one? How is it different from these on the board...Kellie?" Kellie wonders, "It's not flat?" "No it's certainly not," agrees the teacher while she pretends to struggle to press the pyramid flat on the desk. The class giggles. The teacher points again to the triangles on the board, "Now, what do all the shapes on the board have in common?" Madeline says, "They are flat and have three sides." Logan clarifies, "And the sides are connected." The teacher summarizes, "Yes, if a shape is flat and has three connected sides, then we call it a triangle. Everyone say

'triangle'" The class responds in chorus as they watch the teacher write 'triangle' on the board. The teacher instructs, "Now draw a triangle on your paper."

The characteristics of a concept that follow the "if" in the hypothetical inference should be the focus of teacher questioning. It is important that the students actively perceive and conceptualize these characteristics. This is how students form concepts and schemata. After students construct their understanding the teacher labels concepts and evaluates students' mastery.

4. Teachers should describe the concept with abstract language only after students have understood the concept.

Let's rejoin our lesson on fallacies right after the students have formed the rule, "If we suggest that someone like or dislike something just because of how old it is, then we have committed a fallacy." The teacher repeats, "That's right. If someone wants us to like or dislike something just because of how old it is, then they have committed the fallacy of chronological snobbery." She writes 'chronological snobbery' on the board and asks, "Why do you think this fallacy is called 'chronological snobbery'...Danielle?" "Well, a snob is ... Hank!" she jokes, "I mean a snob is someone who thinks they are better than someone else". The lesson continues...

After the essential characteristics of the concept have been perceived, then the teacher can label the concept. This teacher has avoided overloading working memory with abstract information. The teacher would have ineffectively overloaded the working memory if she had begun the lesson, "Chronological snobbery is the fallacy of liking something or disliking something just because of how old it is. Can someone give me an example...anyone?"

Conclusion

Though Kant is remembered for his world-changing philosophy, we should not forget that he was a university professor renowned for his lectures. He revealed his passion for education when he proclaimed, "the greatest and most difficult problem to which man can devote himself is the problem of education" (Kant, 1804/1966, p. 11). He did in fact write one treatise of education, Lecture Notes on Pedagogy, which showed the deep influence of Rousseau; it focuses almost exclusively on moral and physical education. The terms "concept" or "schema" never appear. Buchner (1904) notes, "The reader of the Lecture Notes on Pedagogy will doubtless be struck by the apparent absence of the former [Kant's psychological theory] upon the latter [Kant's educational theory]" (p. 52). But is the unified theory presented in this paper consistent with the little that Kant wrote concerning education?

We do find such a consistency. In one of the few passages relevant to this topic Kant advises, "The understanding may at first be cultivated, in a certain way, passively also, either by quoting examples which prove the rules, or, on the contrary, by discovering rules for particular cases" (Kant, 1804/1966, p. 79). Here Kant describes the understanding as rules and suggests they can be cultivated or discovered passively (constructed unconsciously) from examples. This is clearly consistent with the unified theory presented in this paper. Kant also advises about sequence of instruction:

> Here the question arises whether the rules shall be first studied 'in abstracto,' and whether they ought to be studied after they have been applied, or whether the rule and application should be studied side by side. This last is the only advisable course; otherwise the application of the rule is very uncertain till the rule itself is learned. (p. 76)

This is consistent with the four implications of the unified theory described above. In each lesson the rule is first learned from example, then named and described 'in abstracto,' and then applied by recognizing or creating other examples. Kant gives this advice without specifically basing it on his psychological theory. However it is clear that this advice is consistent with Kant's psychological theory and both Piaget's (1952, 1959, 1970) and Vygotsky's (1978, 1986) views of development.

An analysis of the philosophy of Immanuel Kant has clarified and unified the current cognitive theories of information processing, schema theory, and constructivism. This unified theory has provided clear implications to classroom teachers to improve practice. Principal among them is that teachers should introduce and design instruction around high-quality examples of concepts.

References

Abelson, R., Loftus. E., & Greenwald, A. (1992). Attempts to improve the accuracy of self-reports of voting. In J. Tanur (Ed.), Questions about survey questions: Meaning, memory, expression, and social interaction surveys (pp. 138-153). New York: Russell Sage Foundation.

Anderson, J. (1980). Cognitive psychology and its implications for instruction. San Francisco: W.H. Freeman and Company.

Anderson, J. (2000). Cognitive psychology and its implications for instruction (5th ed.). New York: Worth Publishers

Anderson, R., & Pearson, P. (1984). A schema-theoretic view of basic processes in reading comprehension. In P. Pearson, R. Barr, M. Kamil, & P. Mosenthal (Eds.), Handbook of reading research (Vol. 1, pp. 255-293). New York: Longman.

Andre, T. (1987). Process in reading comprehension and the teaching of comprehension. In J. Glover, & R. Ronning (Eds.), Historical foundations of educational psychology (pp. 259-296). New York: Plenum Press.

Atkinson. R., & Shifrin, R. (1968). Human memory: A proposed system and its control processes. In K. Spence & J. Spence (Eds.), The psychology of learning and motivation: Advances in research and theory (Vol. 2). San Diego: Academic Press.

Bahnsen, G. (1998). Van Til's apologetic: Readings and analysis. Phillipsburg, NJ: Presbyterian and Reformed Publishing Company.

Bartlett, F. (1932). Remembering. London: Cambridge University Press.

Beers, T. (1987). Schema-theoretic models of reading: Humanizing the machine. Reading Research Quarterly, 22 (3), 369-377.

Berliner, D. (2001). The 100-year journey of educational psychology: From interest, to disdain, to respect for practice. Retrieved May 26, 2003 from the World Wide Web: http://courses.ed.asu.edu/berliner/readings/journey.htm

Borko, H., & Putnam, R. (1996). Learning to teach. In D. Berliner & R. Calfee (Eds.), Handbook of educational psychology (pp. 673–708). New York: Simon & Schuster.

Bourne, L. (1982). Typicality effects in logically defined categories. Memory & Cognition, 10, 3-9.

Bransford, J., Brown, A., & Cocking, R. (2000). How people learn: Brain, mind,

experience, and school. Washington, DC: National Research Council.

Bransford, J., & Johnson, M. (1972). Contextual prerequisites for understanding: Some investigations of comprehension and recall. Journal of Verbal Learning and Verbal Behavior, 11, 717-726.

Brown, A. (1979). Theories of memory and problems of development: Activity, growth, and knowledge. In L. Cermak & F. Craik (Eds.), Levels of processing in human memory (pp. 225-258). Hillsdale, NJ: Erlbaum.

Brown, J. (1958). Some tests of the decay theory of immediate memory. Quarterly Journal of Experimental Psychology, 10, 12-21.

Bruner, J. (1992). Another look at new look 1. American Psychologist, 47 (6), 780-783.

Bruner, J., Goodenow, J., & Austin, G. (1956). A study of thinking. New York: John Wiley.

Bruning, J., Schraw, G., & Ronning, R. (1999). Cognitive psychology and *instruction* (3rd ed.). Upper Saddle River, NJ: Prentice Hall.

Buchner, E. (1904). The educational theory of Immanuel Kant. Philadelphia: J.B. Lippincott.

Caelli, T., & Moraglia, G. (1986). On the detection of signals embedded in natural scenes. Perception & psychophysics, 39, 87-95.

Cassady, J. (1999, April). The effects of examples as elaboration in text on memory and learning. Paper presented at the annual meeting of the American Educational Research Association, Montreal.

Chomsky, N. (1972). Language and Mind (2nd ed.). Orlando, FL: Harcourt Brace.

Chomsky, N. (1976). Reflections on Language. London: Temple Smith.

Clarapede, E. (1951). Recognition and "me-ness." In D. Rappaport (Ed.), Organization and pathology of thought (pp. 58-75). New York: Columbia University Press. (Reprinted from Archives de Psychologie (1911) 11, 79-90)

Clark, G. (1957/2000). Thales to Dewey: A history of philosophy (4th ed.). The Trinity Foundation.

Cobb, P. (1994). Where is the mind? Constructivist and sociocultural perspectives on mathematical development. Educational Researcher, 23 (7), 13-20.

Conway, M., & Ross, M. (1984). Getting what you want by revising what you had. Journal of Personality and Social Psychology, 47, 738-748.

Derry, S. (1992). Beyond symbolic processing: Expanding horizons for educational psychology. Journal of Educational Psychology, 84 (4), 413-418.

Dewey, J. (1897). My pedagogic creed. The School Journal, 54 (3), 77-80.

Diamond, S. (1980). A plea for historical accuracy [Letter to the Editor]. Contemporary Psychology, 25, 84-85.

Di Vesta, F. (1987). The cognitive movement and education. In J. Glover, & R. Ronning (Eds.), Historical foundations of educational psychology (pp. 203-233). New York: Plenum Press.

Eco, U. (1997). Kant and the platypus: Essays on language and cognition (A. McEwen, Trans.). New York: Harcourt Brace.

Eggen, P., & Kauchak, D. (2001). Educational psychology: Windows on classrooms (5th ed.). Upper Saddle River, NJ: Prentice-Hall.

Fowler, R. (1994, April). Piagetian versus Vygotskian perspectives on development and education. Paper presented at the annual meeting of the American Educational Research Association, New Orleans.

Greeno, J. (1989a). A perspective on thinking. American Psychologist, 44, 34-141.

Greeno, J. (1989b). Situations, mental models, and generative knowledge. In D. Klahr & K. Kotovsky (Eds.), Complex information processing: The impact of Herbert A. Simon (pp. 285-318). Hillsdale, NJ: Erlbaum.

Hiebart, E., & Raphael, T. (1996). Psychological perspectives on literacy and extensions to educational practice. In D. Berliner & R. Calfee (Eds.), Handbook of educational psychology (pp. 550-602). New York: Macmillan.

Hiebert, J., Gallimore, R., & Stigler, J. (2002). A knowledge base for the teaching profession: What would it look like and how do we get one? Educational Researcher, 31, 3-15.

Hudson, S. (1988). Children's perceptions of classroom writing. In B. Rafoth & D. Rubin (Eds.), The social construction of written communication (pp.37-69). Norwood, NJ: Ablex.

James, W. (1907). Pragmatism. New York: Longmans Green.

Johnson, M., & Sherman, S. (1990). Constructing and reconstructing the past in the

future and the present. In E. Higgins & R. Sorrentino (Eds.), Handbook of motivation and social cognition: Foundations of social behavior (pp. 482-526). New York: Guilford Press.

Kant, I. (1804/1960). Education. Ann Arbor, MI: University of Michigan Press.

Katona, G. (1940). Organizing and memorizing; studies in the psychology of learning and teaching. New York: Hafner.

Kelley, C., & Lindsay, D. (1996). Conscious and unconscious forms of memory. In E. Bjork & R. Bjork (Eds.), Memory (pp. 31-63). San Diego: Academic Press.

Kitcher, P. (1990). Kant's dedicated cognitivist system. In J. Smith, (Ed.), Historical foundations of cognitive science (pp. 189-209). Boston: Kluwer Academic Publishers.

Koenke, K. (1984). ERIC/RCS report: An examination of the construct of reader-text relationship. English Education, 16 (2), 115-20.

Kratochwill, T., & Bijou, S. (1987). The impact of behaviorism on educational psychology. In J. Glover, & R. Ronning, (Eds.), Historical foundations of educational psychology (pp. 131-157). New York: Plenum Press.

Leahy, T., & Harris, R. (1997). Learning and Cognition (4th ed.). Upper Saddle River, NJ: Prentice Hall.

Lewicki, P., Hill, T., & Czyzewska, M. (1992). Nonconscious acquisition of information, American Psychologist, 47 (6), 796-801.

Locke, J. (1995). An essay concerning human understanding. New York: Prometheus. (Original work published 1690).

Loftus, E. (1993). The reality of repressed memories. American Psychologist, 47 (6), 518-537.

Loftus, E., & Klinger, M. (1992). Is the unconscious smart or dumb?, American Psychologist, 47 (6), 761-765.

Loftus, E., & Loftus, G. (1980). On the permanence of stored information in the human brain. American Psychologist, 35 (5), 409-420.

Marx, M., & Hillix, W. (1979). Systems and theories in psychology (3rd ed.). New York: McGraw-Hill.

Mayer, R. (1987). The elusive search for teachable aspects of problem solving. In J.

Glover, & R. Ronning (Eds.), Historical foundations of educational psychology (pp. 327-347). New York: Plenum Press.

Mayer, R. (1992). Cognition and instruction: Their historic meeting within educational psychology. Journal of Educational Psychology, 84 (4), 405-412.

Mayer, R. (1996). Learners as informational processors: legacies and limitations of educational psychology's second metaphor. Educational Psychologist, 31 (4), 151-161.

McKeown, M., & Curtis, M. (1987). The nature of vocabulary acquisition. Mahwah, NJ: Erlbaum.

Miller, G. (1956). Human memory and the storage of information. IRE Transactions of Information Theory, 2-3, 129-137.

Needels, M., & Knapp, M. (1994). Teaching writing to children who are underserved. Journal of Educational Psychology, 86 (3), 339-349.

Nuthall, G. (1999). The way students learn: Acquiring knowledge from an integrated science and social studies unit. Elementary School Journal, 99 (4), 303-342.

Ozmon, H., & Craver, S. (2003). Philosophical foundations of education (7th ed.). Upper Saddle River, NJ: Merrill.

Pashler, H., & Carrier, M. (1996). Structures, processes, and the flow of information. In E. Bjork & R. Bjork (Eds.), Memory (pp. 3-29). San Diego: Academic Press.

Pearson, P. (1984). Guided reading: A response to Isabel Beck. In R. Anderson, J. Osborn, & R. Tierney (Eds.), Learning to read in American schools (pp. 21-28). Mahwah, NJ: Erlbaum.

Peterson, L., & Peterson, M. (1959). Short-term retention of individual items. Journal of Experimental Psychology, 58, 193-198.

Phillips, D. (2000). An opinionated account of the constructivist landscape. In D. Phillips (Ed.), Constructivism in education: Opinions and second opinions on controversial issues (pp. 1-16). Chicago: National Society for the Study of Education.

Piaget, J. (1952). Origins of intelligence in children. New York: International Universities Press.

Piaget, J. (1954). The constructional reality in the child. New York: Basic Books.

Piaget, J. (1959). Language and thought of the child (M. Grabain, Trans.). New York:

Humanities Press.

Piaget, J. (1970). The science of education and the psychology of the child. New York: Orion Press.

Reynolds, R., Jetton, T., & Sinatra, G. (1996). Views of knowledge acquisition: A continuum from experience centered to mind centered. Educational Psychologist, 31 (2), 93-104.

Rippa, A. (1997). Education in a free society: An American history (8th ed.). White Plains, NY: Longman.

Rogoff, B. (1990). Apprenticeship in thinking: Cognitive development in social context. New York: Oxford University Press.

Rosch, E., & Mervis, C. (1975). Family resemblance: Studies in the internal structures of categories. Cognitive Psychology, 7, 573-605.

Rumelhart, D., & Ortony, A. (1977). The representation of knowledge in memory. In R. Anderson, R. Spiro, & W. Montague (Eds.), Schooling and the acquisition of knowledge (pp. 99-135). Hillsdale, NJ: Erlbaum.

Sadoski, M., & Paivio, A. (2001). Imagery and text. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Sadoski, M., Pavio, A., & Goetz, E. (1991). A critique of schema theory in reading and a dual coding alternative. Reading Research Quarterly, 26 (4), 463-84.

Schultz, D., & Schultz, S. (1987). A history of modern psychology. New York: Harcourt Brace Jovanovich.

Scruton, R. (2001). Kant: A very short introduction. New York: Oxford University Press.

Shallice, T., & Washington, E. (1970). Independent functioning of verbal memory stores: A neuropsychological study. Quarterly Journal of Experimental Psychology, 22, 261-273.

Shaw, R., & Bransford, J. (1977). Psychological approaches to the problem of knowledge. In R. Shaw & J. Bransford (Eds.) Perceiving, acting, and knowing: Toward an ecological psychology (pp. 1-39). Hillsdale, NJ: Erlbaum.

Spiro, R., Feltovich, P., Jacobson, M., & Coulson, R. (1992). Knowledge representation, content specification, and the development of skill in situation-specific knowledge assembly: Some constructivist issues as they relate to cognitive flexibility theory and hypertext. In T. Duffy & D. Jonassen (Eds.), Constructivism and the technology of instruction: A conversation (pp. 121–127). Hillsdale, NJ: Erlbaum.

Steffe, L., & Gale, J. (Eds.). (1995). Constructivism in education. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Sweller, J., van Merrienboer, J., & Paas, F. (1998). Cognitive architecture and instructional design. Educational Psychology Review, 10, 251-196.

Tenneyson, R., & Cocchiarella, M. (1986). An empirically based instructional design theory for teaching concepts. Review of educational research, 56, 40-71.

Thorndike, E. (1965). Animal intelligence. New York: Hafner. (Original work published 1911)

Viadero, D. (2000). Larger teacher presence at AERA meeting may mark change. Education Week, XIX (34), 6.

Vygotsky, L. (1978). Mind in society: The development of higher psychological processes (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, Eds. & Trans.). Cambridge, MA: Harvard University Press.

Vygotsky, L. (1979). Consciousness as a problem in the psychology of behavior. Soviet Psychology, 17 (4), 3-35.

Vygotsky, L. (1986). Thought and language. Cambridge: MIT Press.

Voss, J., & Wiley, J. (1995) Acquiring intellectual skills. Annual Review of Psychology, 46, 155-181.

Watson, J. (1913). Psychology as the behaviorist views it, Psychological Review, 20, 175-176.

Welch-Ross, M. (1995). An integrative model of the development of autobiographical memory. Developmental review, 15, 338-365.

Wink, J., & Putney, J. (2002). A vision of Vygotsky. Boston: Allyn and Bacon.

Wundt, W. (1896). Outline of psychology. Leipzig: Engelmann.

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