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ABSTRACT

One strategy to prevent confusion as new paradigms emerge is to have professionals in the area develop and use a standard model of the phenomenon in question. The development and use of standard models in physics, genetics, archaeology, and cosmology have been very productive. The cognitive revolution in psychology and education has produced a plethora of information processing models of learning and learning processes. All of the proliferation and contradictory models are beginning to produce paradigm blight and anomalies in the experimental literature. It would seem that a Standard Information Processing (Cognitive) Model of learning and learning processes is needed, with a commitment to develop a consensus version for all professionals working in this area to use. An initial attempt at formulating such a model is presented based on an analysis of the model proposed and the literature in the field for the past 25 years. Each component of the model is defined and discussed, and its etiology and logical necessity are established. The importance of developing standard models for organizing the literature and research of a field or discipline is also discussed. A flowchart illustrates the information processing view of cognition and cognitive processing. (SLD)

Needed: A Standard Information Processing Model of Learning and Learning Processes

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Abstract

It has been pointed out by Kuhn (1965) and others that when a major paradigm shift is occuring in a particular scientific area, there tends to be a large number of new and competing models and variations of competing models generated of the "new science" or "new view" of "old" phenomenona. The overgeneration of (competing) models leads to several major problems which are discussed in this paper. These major problems cause great confusion and then stagnate the emerging paradigm so that it never achieves its initial potential. One strategy to prevent emerging paradigm blight is to have professionals in an area develop and employ a Standard Model of the phenomenon in question (Hawkings, 1991). The development and use of Standard Models in physics, genetics, archeology, and cosmology have been very productive on the past fifty years.

The "cognitive revolution" in psychology and education in the seventies and eighties produced an incredible plethora of information processing models of learning and learning processes. Many of these models are logically incorrect and many are contradictory. Many others are not cognitive at all and are repackaged behaviorism and neobehaviorism. Many reserachers using these later models, moreover, do not seen to be aware of the repackaged character of these models. All of this proliferation and contradictory models is beginning to produce paradigm blight and numerous anomalies in the experimental literature. It would seem, therefore, that what is needed now is a Standard Information Processing (Cognitive) Model of learning and learning processes and a commitment to develop a consensus version of such a model for all professionals working this these areas to use.

This paper presents an initial attempt at formulating a Standard Information Processing (Cognitive) Model of learning and learning processes based on an analysis of the models proposed and literature in this area for the past 25 years. Each component of the model is defined and discussed and it's etiology and logical neccessity established. The importance of standard models for organizing the literature and research of a field or discipline is also discussed.

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It has been pointed out by Kuhn (1965) and others that when a major paradigm shift is occuring in a particular scientific area, there tends to be a large number of new and competing models and variations of competing models generated of the "new science" or "new view" of "old" phenomenona. This burst of creativity, somewhat akin to speciation after natural disasters in the evolutionary record, or the inflationary period in modern big bang cosmology, tends to create intellectual and scholarly confusion and retard progress in several different ways (Lakatos, 1970).

With McKieche's (1979) famous essay on the "decline and fall of the (behaviorist) laws of learning," Behaviorism's hold on American psychology education and educational research efforts was officially and publically on the wane and cognitive psychology and the cognitive revolution was in full swing and beginning to be considered in educational circles. The seventies had been a period of rapid model proliferation within cognitive psychology and the cognitive sciences. Many of the proposed new models not only contradicted each other, but they also contracted well establsihed experimental fact (see Neisser, 1976 and 1982). Another problem was that many of the models were logically impossible such as those that advocated template (rather than feature) theories of perception (see Norman, 1981), which require storage of an infinite number of templates in long term memory which is logically and phsyically impossible.

Another problem was the the model proposed was only "repackaged" behaviorism or asscoiationism (see Anderson, 1983 and 1991) or neobehaviorism (see Gagne, Briggs, and Wagner, 1988), or even worse an "apple-oranges" eclecticism (see Linn, 1986; and Beieiter, 1991). These "repackaged" models and approaches created a great deal of confusion and a belief by many reseachers that they were investigating cogntive models and views of phenonena when in fact they were only investigating repackaged and revamped behaviorist models that in several instances were eighties variants of Ryle's (1949) philospohical model of learning.

These repackaged neo-behaviorist models in particular did not include key model components and rejected the key principles and assumptions of the cognitive and information processing view of learning such as the proposition as the fundamental unit of learning rather than the association (see Norman, 1980 and 1981), and the existance of mutiple and qualitatively different types of long term memory (see Tulving, 1985 and 1986) that were and became structured with learning and development (see Smith, 1978; Ausubel, 1976; and Ashcraft, 1989). But most importantly was the concept and absolute necessity of working memory (see Baddeley, 1986) and the executive controller and metacognitive skills (see Best, 1989 and Lohman, 1991). An only by including a response generation component can the differences between competence and performance (Chomsky, 1959) be accomodated in all of it wide and varied ramification as well as concepts of automationization of processes and behaviors (see Sternberg, 1985; Minsky, 1986; and Montgomery, 1991).

The next problem that model proliferation has caused (which is getting worse yearly) is that each model and its numerous variants generates experimental data and lines of research that are not easilt comparable or synthezied even by meta-analytical techniques (see Peverly, 1991 for details). The empirical knowledge-base, therefore, is not only becoming extremely cluttered and factional in character, but it is also being filled with an increasing number of "anomalies" that seem to be very puzzling to literature reviewers. As has been reasonably well documented, both specious and abberant data are very difficult to eliminate from discourse that is inherently factional, oppositional and contentious in character (Suppes, 1976).

Standard Models

The above phenomena and problems are not only the results of researchers and theorists working in isolation and/or ignoring the work and data of others (or/and refusing to modify their "core theoretical beliefs), but they are also the result of having a basic intellectual and professional commitment to developing a Standard Model of a phenonenon (see Bohr, 1934; and Hawkings, 1990) that is logically coherent, coherent with the body of experimental evidence (see in particular Martinez and Kesner, 1991), and accepted by the majority of professionals working in a given area. This basic commitment to developing Standard Models of phenomena is now commonplace and standard practice in physics, chemistry, archeology, genetics, and cosmology. Commitment to hte Standard Model approach is also considered to be one of the major reasons why each of these areas has developed so extensively and so rapidly in the past fifty years to the point where each is currently experiencing a "mini-rennaissance" of some kind (see Penrose, 1989).

The Standard Model approach has never been an approached employed by any of the social sciences, but most particularly psychology (as well as education). In psychology, there have been some periodic attempts to utilize soemthing life the Standard Model approach (e.g., theories of hypnosis, types of conditioning, or transfer). However, these attempts have always been confiend to micro-phenomenon and confined to small subgroups of professionals, who tend to be somewhat insular as professionals, operating in "special interest" research groups. Part of the difficulty and tensions both researchers and reformers (as well as the general public) are currently experiencing is due to the lack of a "standard model philosophy and commitment" in psychology and education, and the lack of a standard information processing (cognitive) model of learning and learning processes. Part of the reason why the research on learning (in natural contexts) and instruction currently is in such a mess and held in low regard is the lack of a standard models to sort out and organize the experimental literature and guide new studies and the intrerpretation of issues, findings, proposed innovations and change. The "excessive individualism" and lack of (scientific) community and common value system and perspective have in great part put psychology and the educational research community in the very "pickle" that is the current "experience."

Purpose

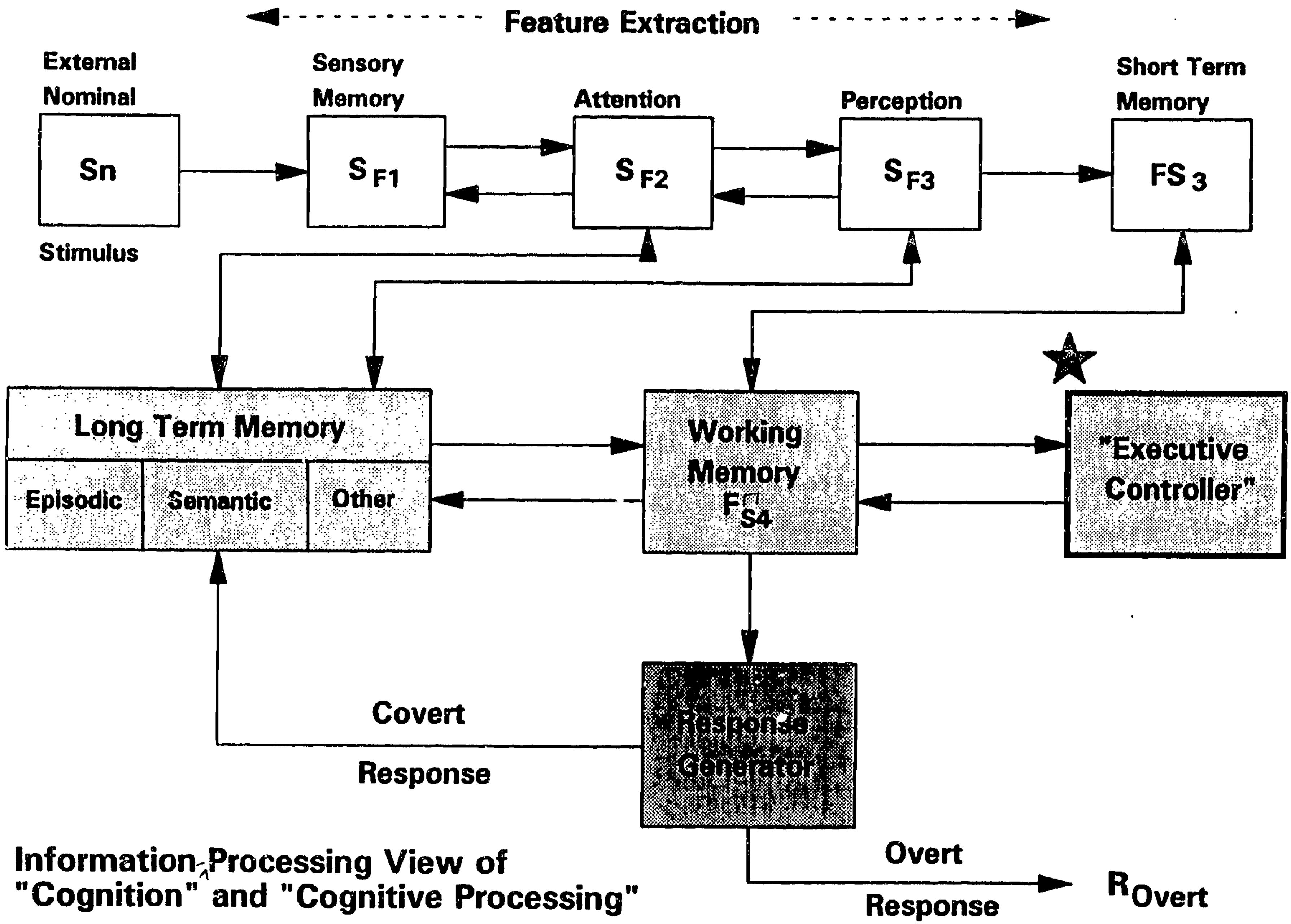
The purpose of this paper is to outline an initial attempt at formulating a Standard Information Processing (Cognitive) Model of learning and learning processes based on an analysis of the models proposed and literature in this area for the past 25 years. Once this Standard Model is outlined, the operations of its components will be discussed as well as the etiology of the components in the models and the chief principles and assumptions of the model. Where appropriate key supporting experimental data will be cited and the logical problems with the chief alternative views will be cited. The Standard Model proposed here is based primarily of the work of Bartlett, Selfridge, Neisser, Ausubel, Tulving, Piaget, Norman, Minsky, Loftus, and McClelland, and is primarily constructivist in character. Outlining an intial Standard Information Processing Model should provide a stimulus and first step hopefully towards professionals in psychology and education developing and adopting a consensus standard model.

The importance of having standard models of phenonema is becoming more widely recognized in all areas (see Thompson, 1985 and Reed, 1992). It is difficult to get coherent research programs without a standard model of the phenomena being investigated (Hawkings, 1991). Standard models are ways of organizing knowledge, researching phenomena systematically and coherently, and for eliminating destructive and unproductive competition in vital areas. Standard models also have many teaching and instructional benefits for an area and discipline and their pedagogical value should not be underestimate or undervalued (see Deutchl, 1990).

The Standard Model (Mark I).

Figure I outlines an intitial attempt at a Standard Information Processing (Cognitive) Model of learning and learning processes. Each of the components of this standard model is elucidated below. Key to this model is the distinction between the nominal and the functional stimulus, schema theory, propositional representation of information in perception and memory, parallel processing, fuzzy neural networks, a family of different types of processors and memories, language, and the view that all cognitive components are severely limited and that limiations are transcended by conceptualization, abstraction, thinking, elaboration (fantasy) and on-going dynamic fuzzy constructions all of which reduce cognitive and information load so that it may be handled reasonably quickly in real time by the very limited physical hardware that implements the model described.

Figure



Information Processing View of "Cognition" and "Cognitive Processing"

The Standard (Information Processing) Model

The Nominal (external) Stimulus: the "complex of features and their relationships" which arouse and excite the senses and activate attention, perception, sensory to long term memory, and various decoding, encoding, enhancement, manipulation and production processes, all of which result in responses (either overt, covert, or both).

Sensory Memory: the neurons of the sense organs (both external and internal) which are excited and activated by the nomial stimulus. Sensory memory "captures and transforms information" from the nominal stimulus into neural impulses (encodings and encoded respresentations) which is transmitted to the brain for further processing. This memory is extremely brief and captures only a very small subset of features from the nominal stimulus (NS); what is captured is called the functional (internal) stimulus (FS1) that is processed further. The nature and character of the functional stimulus changes with each stage of process.

Attention: the process of focusing on a subset (FS2) of the subset of features (i.e., specific "key" features) extracted by sensory memory. Attention is driven and guided by schemas (prior knowledges and learnings) from long term memory; attention is highly selective and very limited; certain features are focal and key ("the figure"), while others are less focal and background ("the ground"); thus the concept of figure/ground relationships and "dominant (key) and latent" features. Schemas influence what a person attends to and does not attent to; attentional behaviors, therefore, are mostly learned (and consequently, unlearned).

Perception: construal and interpretation of the functional stimulus (FS2); enhancing, enriching, and adding information to it obtained from schemas (prior knowledges and learnings) stored in long term memory which are aroused and activated by cues (the features) of FS2; creation of FS3. Perception is both conscious and unsconscious (or subliminal); it is "giving meaning to what is attended to and processed".

Short-Term Memory: very limited temporary holder of "perceptually encoded" information (FS3 and FS3 updates); limited storage capacity: 7+/-2 chunks; info must be "rehearsed" (refreshed) to be kept and not "obliterated" (lost/forgotten).

Working Memory: where info from short-term memory is processed and worked on (analyzed, elaborated, "felt", inferences and deductions made and so on) utilizing information from episodic and semantic long term memory and "strategies" and "programs" from the "executive controller" which governs the processing system. Results of processing here (FS4) is some "product" or "production" that is "executed" (acted upon) by the response generator component. The product may be an overt response (or sequence of responses or procedure), an alteration of long term memory (covert action/behavior) or both, or neither (discard FS4, go to next FS3 and continue).

Response (or production) Generator: the component of the system that takes the results from working memory and converts them into an "appropriate" responses; e.g., your understanding of a question (competence) into a sentence (performance) that is an answer which you write, say, or mime. Thus the competence/performace distinction relative to "knowing/understanding" versus "doing". Note, "alterations" of long term memory schemas is covert responding. FS4 results, therefore, may be assimilated into existing schemas (expansions and elaborations), or they may cause a reorganization and "overhauling" of an existing schema (new conceptual units added and new relationships) which is accomodation. Long term schemas, therefore, change in at least two qualitatively different ways.

Executive Controller: the component that oversees and controls all processing and processing activities; the "intelligence" and "reasoning/thinking/feeling" or "operations" component; performs "mental operations" on information being processed in the Piagetian sense of "operations"; employs algorithms, strategies, heuristics, "logics", programs, processing stvles (preoperational, concrete, abstract, bottoms-up, top down, induction, metaphoric. Often called meta-cognition or metacognitive activities, skills and knowledges (strategies, savy, "smarts", cleverness etc.).

Long term Memory: relatively permanent storage of prior learning and knowledge in an organized, propositional and structured fashion (scema) of some kind. Long term memory is conceptualized as being differentiated into different specialized type of long term memory. This differentiation of long term memory types is based on research data (human performances) and neurological evidence and data. The two major types of long term memory are:

Episodic (or Procedural) Long Term Memory: specializes in the storage of personally dated autobiographical information and experiences including emotions and feeling information. Specializes in storing "events" (episodes) information and groups of events and sequences of episodes ("procedures" and motor behaviors) information. Thus sometimes called procedural or motor memory. Information tends to be stored in "action-based, doing, procedural, or "story" schematas or "scripts" that are "chronologically" organized and operate via associations and chains and sequences of associations and responses. Not very abstract or general in character; tends to be very specific, concrete and oriented towards particulars. Only semi-logical in its operations; often operates in "rote" fashion; very automatic. Forgetting most often results from "breaks in the cnains" of cues and associations that make up an episodic schema. Most basic type of long term memory; present in animals as well as people.

Semantic (or Abstract) Long Term Memory: sometimes called conceptual, symbolic, declarative, or generalized (as opposed to personal or episodic) long term memory. Specializes in the storage of abstract and general knowledge such as specific subject-matter areas which are characterized as being structured networks of concepts, principals, facts and associated information and their inter-relationships. In "experts" such knowledge structures are hierarchically organized schemas of concepts, principals, facts and associated information and their (logical) inter-relationships. The schemas of "experts" tend to be the same and are called "highly developed and logically constrained" schemas. In novices, such knowledge structures tends not be be hierarchically organized, many of the key concepts and principals are not present, and the relationships between elements in the schemas are not logical and are often contradictory (unconstrained), all of which influences the processing of information and performance by the "novice". Cognitive development is often characterized as the development of highly constrained semantic (abstract) long term memory schemas and reasoning skills which is essentially Piaget's view. Semantic long term memory information tends not to "personally dated or autobiographic" but rather "general and timeless". Forgetting is a "bottoms-up" process in sematic long terms memory (from details to the general).

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