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Mark Sadoski
Texas A&M University

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Mark Sadoski
Texas A&M University

Allan Paivio
University of Western Ontario

Despite nearly 40 years of scientific theorizing about reading, the field remains fragmented with little progress toward unification. In this article, we (a) emphasize the privileged position of unified theories in all science, (b) compare the growth of theory in cognitive science and reading, (c) identify the phenomenal domain of a unified scientific theory of cognition in reading, (d) propose five general principles for evaluating such theories, and (e) discuss selected influential theories and their potential for contributing to a unified theory of cognition in reading. Our purpose is to extol reading theory and encourage increased attention to developing powerful, unified theories.

This article examines the current disunified state of reading theory and offers a rationale for its possible unification and future development. We define the term *theory* as a scientific theory in contrast to other uses of the term such as literary theory, critical theory, postmodern theory, and so on. These schools of thought are primarily ideological, not scientific. The definition implied here is consistent with the one widely cited in Kerlinger (1986): "A theory is a set of interrelated constructs (concepts), definitions, and propositions that present a systematic view of phenomena by specifying relations among variables, with the purpose of explaining and predicting the phenomena" (p. 10). To this we would add that a meaningful scientific theory typically includes (a) abstract terms that generalize about a domain of phenomena; (b) concrete, observational terms that represent or refer to those phenomena; and (c) some picture, image, or process that serves as a model. Historical examples include Darwin's theory of natural selection with its tree diagrams of

Correspondence should be sent to Mark Sadoski, Department of TLAC, Texas A&M University, 4232 TAMU, College Station, TX 77834-4232. E-mail: msadoski@tamu.edu

specific species, the DNA double helix in genetics, atomic theory, and so on. Scientific theories of reading have typically conformed to this general description.

We review influential scientific theories of reading and argue that they are all incomplete, including the theory we have advanced. Furthermore, we contend that they have made insufficient scientific progress mainly because of the lack of a viable overall architecture to unify them and provide heuristic growth directions. We review several possible alternatives. We begin with a reminder of the privileged role of theory in science.

THE CENTRALITY OF THEORY IN SCIENCE

Many articles and books on the conduct of science overlook its primary objective: to get the best possible theory (Maleske, 1995). Kerlinger (1986) stated it most simply: "The basic aim of science is theory" (p. 9). Science that is directly applicable to human problems is also aimed at improving life (e.g., education, medicine), but from a strictly scientific point of view, application is secondary. Application is best served by developing the best possible theory.

Moreover, science aims at the progressive unifications of its theories. The physical sciences again provide a seminal example. Before Newton, Galileo formulated his law of falling bodies, which explained terrestrial motion. About the same time Kepler formulated his laws of celestial motion. Newton later formulated a general theory that applied to the motion of all massive bodies, whether terrestrial or celestial. Einstein's theory of general relativity reinterpreted mass in still more expansive terms, and so on. Of course, the social sciences differ in complexity, measurability, and replicability from the physical sciences, but both share the common scientific goal of progress toward powerful, unified theories (Van Dalen, 1979).

At its best, scientific theory is not merely a logical account of the world in a closed system of axioms and mathematical formulae (Bronowski, 1978; Norris, 2005). Whereas one goal of theory is to define constructs and find systematic relations among them to explain and predict, another goal is the heuristic goal, the goal of prompting new growth and discovery. It is the heuristic aspect of science that mainly distinguishes it from engineering and technology. All scientific theories are tentative, imaginatively exploring and advancing toward better, more precise, and more inclusive theories in an ongoing, asymptotic approach to understanding.

This view is particularly appropriate to literacy, an area where theory is young and many puzzles remain. One of our earliest reading theorists recently commented,

> The job of the scientist is not to find simple causal relationships in reduced and controlled contexts. It is to build a theory of the underlying structures and processes of

> the reality being studied and then to test that theory against reality again. In doing so, the theory changes and improves but there are always new layers of reality revealed. The more we know, the more we realize how much more there is to be known. (Goodman, 2005, p. 13)

Major advancements in reading theory await, but insufficient attention seems to have been paid to theory development recently. The reasons for this include increased attention to putting existing theory into practice and the relative youth of reading as a science. The professional and political motivations for the first reason are complex, and we do not deal with them here. We briefly discuss the relative youth of reading theory and one of its parent fields, cognitive science.

THE GROWTH OF COGNITIVE SCIENCE AND READING THEORY

The oldest theories in any branch of science that are based on systematic, controlled observations date back to the 15th and 16th centuries (e.g., physics). Those sciences have gained considerable maturity and unification although new revelations continue and they remain dynamic. In contrast, the social sciences are much more immature.

Modern cognitive psychology took shape in the 1950s and 1960s, and ever since it has primarily adopted a piecemeal strategy toward research and theory. That is, research and theory have been directed toward carefully limited aspects of cognition. The assumption behind this strategy was that one could understand all the pieces of cognition separately and forge them together into a single unified theory (J. R. Anderson & Lebiere, 1998).

In a famous paper, Newell (1973) questioned the wisdom of the piecemeal strategy because, rather than advancing toward unification, the field was becoming bogged down in an increasing array of smaller issues that never seemed to get settled. Newell felt that progress would best be made by working on unified theories that addressed all aspects of cognition, reasoning that the pieces could be more productively studied by understanding how they were constrained to fit into the whole. However, few such unified theories have been yet advanced, and cognitive psychology remains a largely fragmented science (cf. Newell, 1990).

Scientific theories of the reading process (i.e., theories based on substantial amounts of empirical data) can be traced to the 1960s and 1970s. The first volume dedicated explicitly to models and theories of reading was published less than 40 years ago (Singer & Ruddell, 1970). Consensus rapidly emerged that the moment-by-moment reading process was interactive, a psycholinguistic fusion of bottom-up and top-down cognitive processes. Gough (1985) acknowledged the deficiency of his purely bottom-up theory, and Samuels (1977) modified the purely bottom-up theory of LaBerge and Samuels (1974) to allow for top-down feedback, making it interactive, its current form (Samuels, 2004, 2007). Rumelhart (1977) reviewed the limitations of the theories of both Gough and LaBerge and Samuels and proposed a theory where competing or confirming hypotheses could be simultaneously generated at levels ranging from visual feature detection to semantic integration. These and similar theories are still well represented in books and journals and form much of the basis of contemporary reading theory.

However, these theories mainly addressed the moment-by-moment aspects of the reading process and paid insufficient attention to the contributions of prior knowledge and memory to meaning and integrated comprehension. Comprehension in these process theories was often treated as the "semantic level," "word meaning codes," "the place where sentences go when they are understood," or similarly imprecise constructs. Few theories even mentioned nonverbal aspects of reading such as mental imagery or affect (but for one early example, see Ruddell, 1970).

Cognitive Theories of Comprehension and Memory

Theories of reading comprehension based on cognitive theories of the structure of knowledge in memory emerged in the late 1970s and 1980s. Prominent examples were schema theory (e.g., R. C. Anderson, 1984; Rumelhart & Ortony, 1977), and the discourse comprehension theory of Kintsch and van Dijk (1978). Schema theory enjoyed considerable popularity and prompted much research, but it has not evolved well due to various limitations we discuss later (Alba & Hasher, 1983; Sadoski, Paivio, & Goetz, 1991). The Kintsch and van Dijk theory has evolved through several iterations (e.g., van Dijk & Kintsch, 1983) and now is termed construction-integration theory (Kintsch, 1988, 1998, 2004). Kintsch has posed construction-integration theory in reading as a paradigm for all cognition. Dual coding theory was originally designed to account for both verbal and nonverbal cognition (Paivio, 1971), and developed as a general theory of cognition (Paivio, 1986, 1991, 2007). It subsequently developed into a general theory of literacy (Sadoski & Paivio, 2001, 2004) and an account of the evolution of mind (Paivio, 2007). We later return to more discussion of these theories.

With a few exceptions, candidates for a unified theory of cognition in reading seem absent, and little momentum toward a unified theory is apparent in the recent literature. What theoretical momentum has been shown, we later argue, has been mostly toward limited aspects of reading and computational formalisms of artificial intelligence (AI). Whether these developments can ultimately lead to a unified theory of all aspects of reading is uncertain.

THE SCOPE OF A UNIFIED THEORY OF READING

What phenomena should be addressed by a unified theory of cognition in reading? An architecture to systematically define and explain all phenomena relevant to reading must be broad, but that is the ultimate goal of a unified theory. The scope of that theory depends on how the concept of *reading* is defined. *The literacy dictionary* (Harris & Hodges, 1995) provides 25 definitions of the word *read* and 20 definitions of the word *reading*, although many definitions are variations on a few themes.

Aspects of a Unified Theory of Reading

At least three major aspects or subdivisions of reading can be identified: *decoding* or *recoding*, *comprehension*, and *response*. The definition and rationale for these three subdivisions is detailed in Sadoski (2004). These subdivisions include most but not all of the types of reading defined in Harris and Hodges (1995). Reading acts such as proofreading or skimming that only marginally involve the comprehension of meaning are ancillary to our present purpose.

1. *Decoding* or *recoding* involves converting printed language to spoken language whether it is understood or not and whether it is done overtly as oral language or covertly as inner language.
2. *Comprehension* involves the construction of a meaningful interpretation or mental model of the text and is typically seen as occurring at levels such as literal, inferential, and interpretive/critical.
3. *Response* overlaps with comprehension at the interpretive/critical level but also involves affect, appreciation, and/or application. This may occur during reading as well as afterward.

These aspects of reading interact. They can be arrayed on a continuum with one pole being input from the written language and the other pole being input from the reader (Sadoski, 2004, Figure 4.1). When input from the writing is primary and input from the reader is secondary, reading becomes most like decoding. Alphabetic writing maps the speech of its respective language, and some degree of speech recoding is involved in reading even if subconsciously. Comprehension is central to reading, and it occupies the central place on the continuum where input from the writing and input from the reader are in relative balance. The writing is important in retaining the particulars of the message, but the reader's interpretation of it is equally important. Response occurs toward the other end of the continuum where input from the reader becomes more important than input from the writing, where the message encoded in the writing serves merely as a springboard for our own mental critique, application, or appreciation.

It is still tempting to think of these as serial stages, but such theories have been abandoned. For example, correct phonological recoding is frequently dependent on context, and comprehension can be affected by our attitude toward the text; that is, reading is interactive in all its aspects.

The articulation of these basic concepts does not constitute a theory in itself. Rather, we see these basic constructs or concepts as the minimal domains of phenomena requiring explanation to some degree in any comprehensive, unified theory of cognition in reading. We would further include both the verbal, linguistic aspects of reading and the nonverbal cognitive and affective aspects of reading at all levels.

Ultimately, a unified theory of reading should also offer an explanation of the acquisition and development of decoding, comprehension, and response. No general theories of reading have yet elaborated on the development of all these aspects of reading or aligned themselves with established general theories of development (e.g., Piaget's stages). A general model of reading stages that dealt with decoding, comprehension, and response was proposed by Chall (1996), but this model is largely conceptual and has not been subjected to extensive empirical test. Several empirically based theories of the acquisition of word decoding have been advanced (e.g., Ehri & McCormick, 2004; Frith, 1985; Goswami, 1988; Stuart & Coltheart, 1988). Stanovich (1986) discussed the complex reciprocal relationship between reading, organism–environment interaction, and developmental change in explaining individual differences in reading (i.e., the Matthew effect). Paivio (1986, 2007) theorized that language and literacy development builds on an initial substrate of nonverbal imagery derived from a child's observations and behaviors with concrete objects and events and that language builds on this foundation and remains interlocked with it. However, a full program of empirical research into the acquisition and development of all aspects of reading based on any cognitive theory is currently lacking.

CRITERIA FOR EVALUATING THEORY

For a comprehensive set of criteria that have evolved for evaluating theories, we have drawn on recent discussion by Utall (2005), who in turn interpreted discussions by Kuhn (1977), Popper (1959), and other philosophers of science. Along with the definition of theory we presented at the beginning of this article, we propose a summary set of five general principles:

1. *The Conservation Principle.* A theory should "conserve" a large body of research observations. That is, a theory should be broad in the body of research it interprets, it should not contravene other well-established theories (although it might reinterpret them), and it should be largely free of

contradictions in its interpretations. A theory therefore generalizes across a broad and defined domain of phenomena in a consistent way.

2. *The Accuracy Principle*. A theory's explanations and predictions should agree with valid empirical findings. This directly implies that a theory must be empirically testable and capable of refutation or falsification at some level. This further directly implies that a theory's constructs should be capable of reasonably clear and unambiguous definition and operationalization.
3. *The Parsimony Principle*. The simplest explanation that conserves the most observations is likely to be the correct one (i.e., Occam's razor). A theory should bring order to its domain with the fewest possible statements, the simplest possible structure of constructs, and the reduction or elimination of all features of the theory that cannot be observed. A tension exists between parsimony and conservation; a unified theory can only be made as simple as the largest relevant body of research allows.
4. *The Heuristic Principle*. A theory should be expansive and promote growth in fruitful new directions. It should help to predict and explain new, relevant phenomena that extend the limits of our knowledge. This implies that a theory should be open-ended to the extent that new observations can fit in somewhere. The converse is the closed axiomatic system with perfect internal consistency that cannot even be achieved in mathematics (Gödel, 1931).
5. *The Plausibility Principle*. In the end, theories must be accepted by critical evaluation and objective debate among scholars in the field. Theories that lack persuasiveness because of their inability to address a body of relevant research, their complexity or vagueness, lack of testability, perceived bias, or appeals to entities that transcend science and its methods (e.g., transcendental idealism) are unlikely to endure.

The acceptance and application of these principles varies among researchers and theorists, and no final, absolute definition of theory or set of criteria for theory is intended here. However, these principles in one stated form or another have evolved over many years and can be applied widely in science including current cognitive neuroscience (Utall, 2005).

Accordingly, some theories that have been applied to reading are largely untenable. One is the cognitive theory of Vygotsky (1962) as applied to reading. Vygotsky maintained that thought was inner speech even at very young ages, a view quite similar to that of the radical behaviorists of the early 20th century. However useful Vygotskian ideas of social child development and education might be (e.g., Forman & Cazden, 2004), a radical behaviorist view of cognition is untenable because it does not acknowledge evidence of any nonverbal cognitive constructs (e. g., Kosslyn, 1980, 1994; Paivio, 1971, 1986, 2007). That is, it does not include or "conserve" that body of evidence.

Other reading theories have been proposed that are primarily statistical models. Familiar examples of these are rauding theory (Carver, 1978b, 2000) and the simple view of reading (Hoover & Gough, 1990). Deriving from Holmes's (1970) factor-analytic model of reading, Carver empirically developed a set of statistical equations to precisely predict reading efficiency. However, the constructs advanced in the theory were entirely positivistic. For example, reading efficiency was defined as "what is measured by tests of reading achievement, or traditional standardized reading tests" (Carver, 2000, p. 58). Similarly, the simple view of reading is a single equation (reading = decoding × linguistic comprehension) that operationally defines these constructs as standardized tests. Beyond this, "the task remains to define components underlying decoding and linguistic comprehension" (Hoover & Gough, 1990, p. 151). Hence, theoretical constructs are not sufficiently explicated in these models, limiting their defining status as "true" theories (Hill, 1978, but see Carver, 1978).

As noted earlier, schema theory has not evolved well due to various limitations including its definitional ambiguity, idealist epistemology, and limited empirical accuracy (see critiques by Alba & Hasher, 1983; Paivio, 2007; Sadoski et al., 1991). All scientific, testable versions of schema theory rely heavily on some form of computational "mentalese" (e.g., propositions)—abstract, amodal representations that are analogous to computer languages (e.g., Britton & Graesser, 1996). The plausibility of a computational account of human cognition is questionable from philosophical and psychological perspectives (e.g., Norris, 2005; Paivio, 2007; Searle, 1987; Utall, 2005). The general argument is that computer models are closed systems of internally consistent rules that are related only to each other and not the world; any experience that does not fit the system must be ignored or accounted for post hoc. Recently, attempts to link schema theory with embodied views of cognition have been proposed (McVee, Dunsmore, & Gavelek, 2005), but such approaches contradict the philosophical and theoretical history of schema theory and are post hoc themselves (Krasny, Sadoski, & Paivio, 2007).

So far, we have stated the importance of unified theories in science, briefly reviewed the growth of theory in cognitive science and reading, listed central aspects of reading that form the phenomenal domain of any unified cognitive theory, and introduced five general principles for evaluating cognitive theories with examples. We now turn to the current scene, a discussion of candidates for a unified theory, and a brief evaluation of them.

MICROTHEORIES, MACROTHEORIES, AND UNIFICATION

A useful metaphor for scientific theory was suggested by Judson (1980): Scientific theories are the invisible mansions of the mind. As applied to developing fields, this metaphor implies that a theory should be a developing architecture with many rooms and a plan that is open to additions and modifications: a dynamic architecture. Larger theories encompass and unify smaller theories within their developing larger structures. For example, Newtonian physics is one wing in the mansion of Einsteinian relativity, itself encompassing the rooms of Galileo and Kepler. Likewise, Carver (1993) precisely explained how the simple view of reading (Hoover & Gough, 1990) was encompassed within the larger architecture of rauding theory.

Theories of different, limited aspects of the reading process proliferate (cf. Ruddell & Unrau, 2004). For example, there are theories or models that deal with eye movements in reading (e.g., Reichle, Pollatsek, Fisher, & Rayner, 1998), word recognition (e.g., Ehri, 2005; Seidenberg & McClelland, 1989), comprehension (e.g., Kintsch, 1998, 2004), making causal inferences while reading (van den Broek, 1990), varieties of reader response (e.g., Rosenblatt, 2004), attitude and motivation (Mathewson, 2004), and so on. We do not attempt to catalog and evaluate them all here. Rather, we briefly discuss selected influential theories as examples.

The LaBerge and Samuels Theory

Perhaps the most widely cited and influential theory of reading is the LaBerge and Samuels (1974) theory as modified by Samuels (1977, 2004). This is an interactive theory that accounts for a broad range of phenomena associated with decoding, although much less for comprehension and response (Samuels, 2007). It has certain advantages over Rumelhart's (1977) influential interactive theory in that Rumelhart's theory does not address the role of phonology in reading. As noted earlier, this theory has been modified to account for top-down effects on decoding, but it otherwise retains its original structure and processes.

The LaBerge and Samuels (1974) theory is well known for the concept of *automaticity*, a word recognition concept sometimes taken too literally. The original conceptualization was *not* that word recognition literally becomes automatic, that is, a mechanical or electronic act with no options given a set of circumstances. The term was meant only as a metaphor for an act that no longer requires conscious awareness for its performance: "Our criterion for deciding when a skill or subskill is automatic is that it can complete its processing while attention is directed elsewhere" (LaBerge & Samuels, 1974, p. 295). That is, what happens below the threshold of conscious attention is the same as what happens above the threshold of conscious attention; no new mechanisms are theorized to take over. Samuels (2004) explained automaticity not as a unique construct but as a normal memory phenomenon (cf. Stanovich, 1991).

This theory accounts for multiple possible routes in going from letter-feature perception to the comprehension of word meaning (cf. Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001). It postulates modality specific visual and phonological memory representations and discriminates between the effects of episodic and semantic memory, although it does not deal with the modality issue in these memory stores. Rather, it postulates word and word-group "meaning codes" or "episodic codes" whose form is not specified. Samuels (2004) added a discussion of the effects of sentence grammar on word-group meaning codes and comprehension. However, the theory does not deal extensively with the effects of syntax and grammar, the integration of meaning across sentences, the construction of episodic mental models, or the way these affect decoding.

Samuels (2004) invoked schema theory as a possible explanation of comprehension and memory, but what this adds beyond the constructs of episodic and semantic memory is not clear. It also conflicts with an original description of deep levels of comprehension involving the formation of mental images:

> When reading is flowing at its best, for example in reading a mystery novel in which the vocabulary is very familiar, we can go along for many minutes imagining ourselves with the detective walking the streets of London, and apparently we have not given a bit of attention to any of the decoding processes that have been transforming marks on the page into the deeper systems of comprehension. (LaBerge & Samuels, 1974, p. 314)

This description directly implies a modality-specific episodic memory in the form of a mental image. Schema theory does not recognize mental imagery because all established versions of schema theory are abstract and amodal. Moreover, schema theory would not apply well to the modality-specific visual and phonological memory codes that are basic to the LaBerge and Samuels theory. Therefore, we believe that schema theory is not a good candidate for extension of the Samuels version, violating the conservation principle. The same argument can apply to other theories of word reading that posit modality-specific orthographic and phonological memories on one hand but appeal to abstract, amodal schema theory on the other (e.g., Ehri, 2005).

This influential theory is not a unified theory of reading, but it could be sufficiently conservational, accurate, parsimonious, and heuristic to develop into one. More propitiously, it can be absorbed into larger theories of general cognition as applied to reading so long as those theories allow for modality-specific mental representations.

The Construction-Integration (CI) Theory of Comprehension

Kintsch's (1998, 2004) CI theory has developed through several iterations as summarized earlier. CI theory deals with comprehension and memory but not with decoding and little with response. It begins with word meaning and extends through problem solving and learning with the goal being a comprehensive theory of reading comprehension.

This theory assumes three codes or forms of knowledge representation: verbatim information, the propositional text base, and the situation model. Verbatim information is surface structure information including specific words and syntactic structures. The propositional code is an abstract, amodal code formed when abstract proposition-schemata are instantiated with surface structure information. Individual propositions are then merged into a propositional text base comprised of micropropositions and macropropositions. The situation model is either a well-integrated propositional text base or a mental image of a situation that is derived from the text base. These models draw on the reader's background knowledge that may be in the form of schemata. Hence, this theory can be seen as a multiple-coding theory that assumes that verbal language and mental imagery may be inputs and outputs, but the central processing unit is run by abstract, amodal schemata and propositions (Sadoski, 1999).

Recent modifications of this theory have moved away from the proposition as the basic unit of knowledge representation. The theory now treats verbal knowledge as vectors of numbers in a multidimensional statistical space with each number indicating the strength with which a word is associated with other words based on their cooccurrence in computer scans of texts (i.e., latent semantic analysis). Whatever its ultimate potential, the accuracy of latent semantic analysis in predicting human reading outcomes so far has been limited (e.g., Millis, Magliano, & Todaro, 2006).

CI theory has the scientific advantage of operationalizing its constructs for empirical tests but the disadvantage that those operationalizations are mathematical formalisms and computer programs that have uncertain plausibility and place a premium on constructs that are hard to observe or are vaguely understood (e.g., propositions, schemata). Such computer formalisms run the risk of reification—the fallacy of explaining something and then treating the explanation as real rather than the thing being explained. From a strict AI perspective this makes no difference—if computer programs model human responses, those computer programs are valid demonstrations of human cognition. However, this view remains very controversial in cognitive science (e.g., Norris, 2005; Paivio, 2007; Searle, 1987; Utall, 2005) partly because formalisms cannot "grow" to accommodate probabilistic phenomena outside the system. For example, CI theory has difficulty dealing with mental imagery and the established effects of concrete language on comprehension and memory. Kintsch (2004) acknowledged, "Situation models may be imagery based, in which case the propositional formalism currently used by most models fails us" (p. 1284).

On the other hand, CI theory has demonstrated considerable heuristic influence. It has generated theoretically driven research into learning, the way inferences are made, how various problems are solved, and so on. Kintsch (1998) further advanced CI theory in reading as a paradigm case of all cognition. That is, CI theory principles can be extended to apply to cognition beyond reading, a major advancement of the theory. CI could potentially develop into a unified theory of reading under the aegis of a general theory of cognition, the ultimate goal. However, many phenomena not currently explained by the theory's formalisms would have to be addressed (e.g., imagery, affect).

To become a fully unified theory of reading, CI theory also needs an account of decoding that is consistent with its current assumptions. One possibility is the word recognition theory of Seidenberg and McClelland (1989). In this theory, word recognition is part of a larger interactive theory with three main components: orthography, phonology, and semantics. Like CI theory, it uses computer formalisms to simulate human performance in limited ways. Like CI theory, it postulates abstract, amodal mental entities ("units"). The ultimate goal is an integrated theory of reading and its brain bases with the computational model acting as an interface between the two (Seidenberg, 2005). The viability of this theory and its compatibility with CI theory remain to be seen. It may develop into a unified theory in its own right, but it may also serve as a much-needed room in the mansion of CI theory.

Theories of Reader Response

Reader response is perhaps the most difficult aspect of reading to define, theorize, and empirically test. Response can be cognitive, as in our reasoned, critical reactions to a thought-provoking essay. Response can be affective, as in our responses to literary fiction or other emotion-evoking text. Response can be defined both cognitively and affectively, as interest appears to have both a cognitive and an affective component (Schiefele, 1999). Codifying the varieties of reactions that fall under this general label is a problem much in need of a theoretical solution.

One influential theory of reader response is that of Rosenblatt (1978, 1983, 2004). It deals with some of the same constructs as theories of comprehension and further attempts give an account of the way readers react to a printed text using intention, selective attention, evoked meanings, and response in both cognitive and affective terms. In this theory, every moment-to-moment reading event falls somewhere on a continuum between a predominantly *efferent stance* and a predominantly *aesthetic stance*. The efferent stance centers attention on what is to be extracted and retained later, such as reading medical directions, legal documents, and so on. The aesthetic stance centers attention on what is being lived through during the reading event: the situations, conflicts, emotions, images, and so on.

The reader may vary stances so that, for example, epic poetry could be read as a source of historical information, or an historical exposition could be read to imagine the sights, sounds, and emotions of the historical events. Moreover, readers can slide along the continuum from moment to moment within a reading, so that no reading is probably ever purely efferent or aesthetic. Response may affect what is attended to during reading, our reactions to it, and our motivation to continue.

This theory has some direct empirical support (e.g., Many, 1990), and related research on literary reading tends to support it. For example, Miall and Kuiken (1999) argued on empirical grounds that literary reading is a unique kind of reading involving processes not explained by CI theory or other cognitive theories that do not deal well with affect. Miall and Kuiken (1995) factor analyzed a questionnaire of 68 items covering a broad spectrum of literary responses and found factors for imagery and empathy, among others. They grouped these into a higher-order factor they called *experiencing*, the dimension of being absorbed in a literary work. Empirical support for efferent reading is widely provided by studies where readers read with the purpose of remembering specific information. Further, the theory seems generally compatible with Mathewson's (2004) theory of attitude and motivation, and work in engagement by Guthrie and Wigfield (2000), among others.

The unification of reader response theory with theories that heavily favor decoding or comprehension has some way to go, but possibilities clearly exist. We turn next to a theory that has attempted to unify decoding, comprehension, and response under the aegis of a general theory of mind including its evolution.

Dual Coding Theory (DCT)

DCT is a general theory of mind that has been directly applied to literacy. As noted earlier, this theory was originally developed to account for verbal and nonverbal effects on memory, but it has been extended to other domains through a systematic program of research over many years (Paivio, 1971, 1986, 1991, 2007). It has been extended to literacy as an account of reading comprehension (Sadoski & Paivio, 1994; Sadoski, et al., 1991), written composition (Sadoski, 1992), spelling (Sadoski, Willson, Holcomb, & Boulware-Gooden, 2005), and as a unified theory of literacy (Sadoski & Paivio, 2001, 2004). As a candidate for a unified theory of reading, its strengths lie in the body of research it conserves and the parsimony of applying the same theoretical constructs and principles to decoding, comprehension, and response. These accounts have been detailed in the references given, and we briefly summarize them here.

DCT posits only modality-specific mental representations that can be empirically observed and tested in various ways; it posits no abstract mental mechanisms such as propositions, schemata, or undefined units. All modality-specific mental representations derive from sensory experience and can be classified as either verbal or nonverbal (i.e., the dual codes) depending on their linguistic or nonlinguistic nature, respectively. Thus sensory modalities are orthogonal to the verbal and nonverbal codes such that we can have verbal representations derived from various senses and nonverbal representations derived from various senses.

The specific verbal representations that derive from our various senses are well known. In the auditory and articulatory modalities, the representations are phonemes, word pronunciations, stress intonations and rhythms, and so on. In the visual modality (tactile in the case of Braille), the units and arrangements are letters, written spellings, punctuation marks, and so on. Even more than language, the imagery code is represented in multiple sense modalities. We can imagine the sights, sounds, smells, tastes, and touch sensations of the objects, scenes, and events of the world, although visual imagery is prominent to most people. Sometimes mental imagery is multimodal and approaches actual experience, if vicariously. These two codes have distinct forms of processing that are also derived from experience, such that the verbal code is more sequential in processing and the nonverbal code more simultaneous in processing.

Associative connections within and between the two codes are the vehicle for all processing and memory structures. Hence, the mansion of DCT has rooms for decoding, comprehension, and response. DCT is therefore an associationist or connectionist theory that differs from all others in that class in that what gets connected is as important as the strength of the connections.

Hence, the LaBerge and Samuels (1974; Samuels, 2004) theory of decoding would be readily encompassed by DCT because the codes theorized in both are modality specific (e.g., visual, phonological) and are associated sequentially into larger representations such as phrases and syntactic units. DCT explains episodic and semantic memory using the same modality-specific principles and therefore provides a conservational, parsimonious account of meaning. The DCT emphasis on mental imagery as a form of comprehension is consistent with LaBerge and Samuel's example of "deeper systems of comprehension" quoted earlier.

Likewise, Rosenblatt's (2004) theory of reader response could be explained in DCT terms. Verbal and nonverbal goal states serve to motivate the initial stance of the reader because people may be motivated to read primarily for factual, verbal information, or for the imagery and associated affective states of literary reading. Considerable reading research has demonstrated the connection between mental imagery and affective response in reading both literary and informative text (reviewed in Goetz & Sadoski, 1996; Sadoski & Paivio, 2001). DCT also allows for changing the motivational or attitudinal stance during reading. However, DCT suffers the same limits as other theories due to the complexity of defining and operationalizing reader response.

There is also much in common between the DCT explanation of comprehension and memory and the CI explanation. CI theory posits three codes: verbatim language, a propositional text base, and a situation model that can be a mental image. DCT posits two codes: the verbal code, which uses verbatim language as input to an associative network of verbal representations, and the nonverbal code of mental imagery that is evoked in reading by the activated verbal representations. However, there are no abstract propositions or schemata in DCT; the operation of the verbal code and connections to the nonverbal code are sufficient to account for the mental representation of the text and abstractions do not contribute anything more to the explanation.

This basic distinction occurs between DCT and all theories that assume that knowledge in memory is abstract and amodal, existing in a state that has no objective reality and is associated with no sensory modality. How any knowledge that is not innate becomes divorced from sensory input is an important theoretical, epistemological, and evolutionary question that has not been well addressed. Such theories typically propose no answer to this question; rather, they treat the existence of abstract, amodal knowledge as axiomatic. One practical reason for this is so that these theories can be modeled by AI and subjected to computer simulations. Whether AI formalisms are useful in advancing our understanding of human reading behavior remains to be seen (Seidenberg, 2005). They may ultimately fail to meet the plausibility principle as our knowledge of neuroscience grows. For example, Kosslyn (1994) abandoned AI as an explanation of mental imagery in favor of a brain-based explanation.

However, from the AI perspective, DCT is deficient in terms of its amenability to computer modeling. Kintsch (2004) noted the problem of testing imagery this way:

> At present there is no [computational] language that we can use to represent the salient features of complex mental images. This deficiency is a major reason why much of the research on text comprehension has focused on the verbal aspects, neglecting the role of mental imagery for all its acknowledged significance. (p. 1272)

Whether this is ultimately a deficiency of DCT depends on one's views of the AI debate, but DCT at present relies heavily on behavioral data rather than computer simulations that seek to approximate behavioral data. We hope that future research will resolve these issues.

A Word on Neuroscience and Reading

Correlating reading behavior with brain areas and their activity is a growing line of research. However, as in cognitive psychology, cognitive neuroscience is characterized by localist and fragmented theories. Although observations from MRIs, event-related potentials, and neuron recordings proliferate, no theory as yet explains how the brain engenders the reading mind. Without a theory of how it does, all these observations float free of any interpretive mooring. The leap from electrochemical brain activity to concepts imported from psychology and linguistics is too great a leap for some: "Now, if we don't have any kind of unified theory about how the brain works, how can we reduce our everyday psychological concepts to neural accounts? The answer is, we can't" (Brothers, 2002, p. 861).

We do not dismiss the findings of neuroscientists working in reading; their contribution to understanding reading is certainly as valuable as anyone else's. In fact, DCT could be useful to neuropsychology as a systematic framework for analyzing and interpreting brain-behavior connections (Paivio, 2007). Our purpose in pointing out the very real gap between brain theory and mind theory is to reiterate the need for unified theories throughout science.

CONCLUSION

In this article, we have (a) argued the privileged position of unified theories in science, (b) briefly summarized the growth of theory in cognitive science in general and reading in particular, (c) proposed the phenomenal domain of a unified scientific theory of cognition in reading, (d) proposed general principles for evaluating such theories, and (e) discussed selected influential theories and their potential for unification. We have not discussed all theories, and our selections should not be interpreted as neglect for the rest. We extol all those who are bold enough to theorize about something as complex as reading, and we await their further valuable contributions. However, reading theory cries for unification to provide an overall architecture within which we can interpret research and envision more. We have presented several possibilities with distinct theoretical differences. We see this as fruitful territory for discussion and progress.

We reiterate that all theory is incomplete and tentative, and the development of better theories is dependent on critical, collegial discussion among theorists and researchers. We hope that this article prompts such discussion.

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