

SHEMATA AND READING COMPREHENSION

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INTRODUCTION

At school, and also after formal schooling takes place, the acquisition of new knowledge is in great measure dependent on reading comprehension. The total task of understanding written discourse depends on the distribution of information in the printed text, and on the voluntary and automatic activation of information or "schemata" in the reader's mind. Thus, what different readers 'comprehend' of a given text may vary considerably. Reading comprehension is a function of the nature of the text itself and of the extent to which the reader possesses, uses, and integrates pertinent background knowledge, or schemata.

Schemata can be loosely defined as patterns which represent the way experience and knowledge are organized in the mind. The schema for a concept like "break", for instance, will have associated with it at least the variables "breaker", "the thing broken", "the method or instrument" for the action of breaking, and the notion of "causing something to change into a different state" (Rumelhart and Ortony 1977). Schemata constitute a powerful means used by readers in understanding information which is both explicit and implicit in texts. As an illustration, let us say that we read (or hear) the following sentences: "The Karate champion broke the cinder block" (Brewer 1977:3). The sentence does not mention the instrument for breaking the block. Notwithstanding, our schema for BREAK, associated with our schema for KARATE CHAMPION, leads us to infer that the instrument for breaking the block was the champion's own hand. This inference is crucial for the understanding of the sentence and it can only be drawn because the schemata for BREAK and KARATE CHAMPION are already part of the knowledge stored in our minds.

The concept of background knowledge, schemata, or patterns stored in the mind, has attracted the attention of research in narrative comprehension, L1 reading, and, more recently, L2

reading comprehension. Today the claim that background knowledge is an essential determiner of reading comprehension is relatively well developed and generally agreed upon in the literature on L1 reading comprehension (Anderson, Spiro, and Anderson 1978; Adams and Collins 1979; Bransford 1979; Adams and Bruce 1982). These and other studies give evidence that patterns stored in the mind (Sowa 1984:43) are imposed on texts, thus determining processing and understanding of written (as well as oral) discourse (Bower 1976; Bransford and Johnson 1972, 1973; Tannen 1979).

Most present day models of reading comprehension emphasize the significance of background knowledge or schemata in reading comprehension. Among these models are reading as a psycholinguistic guessing game (Goodman 1970); reading as information processing (Smith 1971, 1975); reading as a generative process (Wittrock 1981; Wittrock, Marks, and Doctorow 1975); reading as strategy utilization (van Dijk and Kintsch 1983); and, of course, reading as based on schema theory (Adams and Collins 1979; Adams and Bruce 1982).

The following quotation from Adams and Bruce (1982:37) provides an excellent example of the importance that scholars concerned with reading comprehension attribute to background knowledge or schema availability with regard to comprehending written discourse.

A more correct statement of the role of background knowledge would be that comprehension is the use of prior knowledge to create new knowledge. Without prior knowledge, a complex object, such as a text, is not just difficult to interpret: strictly speaking, it is meaningless.

In this paper, I look at the concept of schemata and some of its relations to text comprehension. The paper is subdivided into five parts. In the first part, I further elaborate on the definition of schemata by providing a historical overview of the origin and uses of the concept. Next, I look at the schema-related notions of bottom-up and top-down processing. In section three, I discuss relationships between schemata and text

structure. In section four I examine the role of schemata in inferencing. Finally, I discuss relationships between context and the activation of schemata with especial reference to reading in a non-native language.

HISTORICAL OVERVIEW

In order to further understand the meaning of the term schemata, we may start by referring to the more common concept of background knowledge. Background knowledge, also referred to as "world knowledge", is all the knowledge an individual possesses. It is all the knowledge that an individual has stored in the mind as a result of the innate capabilities that the human mind is endowed with to organize the experiences that the individual has been exposed to (Kant 1781, cited in Sowa 1984; Chomsky 1976; Piaget 1951, cited in Clark 1975). Background knowledge could also be referred to as all the knowledge contained in what Tulving (1972) calls "semantic memory" and "episodic memory", roughly, all the generalized and particularized knowledge stored in the mind.

How does the term schema (plural form schemata) enter the arena of knowledge related taxonomy? The term was first used by the philosopher Kant (1781) and by the British psychologist Bartlett (1932). It has been reintroduced in the taxonomy of discourse understanding by scholars in linguistics, cognitive psychology, and artificial intelligence (AI) interested in characterizing the way world knowledge or background knowledge is organized and the way such organization allows readers and hearers to understand what they read or hear.

Kant (1781) used the term schemata to refer to the rules that supposedly organize smaller units of perception into larger unitary wholes such that we can assign given objects to given categories, say a triangle to the category isosceles. To give another example, if we had in our mind simply a 'fixed image' of a dog, we would not be able to recognize other dogs as members of the same species. Instead of one 'fixed image' we develop schemata in the form of patterned knowledge structures that allow

us to match given 'objects' with those schemata and thus perceive them as belonging or not to given categories. Kand did not elaborate upon structures of schemata. Indeed, he was not much more specific than affirming that schemata are "an art hidden in the depth of the human soul" (cited in Sowa 1984).

In 1932, Bartlett defined the schema as

... an active organization of past reactions, which must always be supposed to be operating in any well-adapted organic response. That is, whenever there is any order or regularity of behavior, a particular response is possible only because it is related to other similar responses which have been serially organized, yet which operate, not simply as individual members coming one after another, but as a unitary mass (p.200, emphasis added).

Bartlett's main contribution is probably represented by the italicized parts of the above quotation, that is, his pointing out that schemata operate as a "unitary mass", and that schemata are "active" and "always operating" in orderly behavior. In other words, we do not go around reinterpreting the world every time we need to respond to a given situation. We answer to most everyday situations more or less analogically and automatically, in terms of the knowledge that we have, which has been accumulated by the "active organization of [our] past reactions". Like Kant, Bartlett did not attempt to explore the structure of schemata: he stayed within the realm of effects of mental patterns.

Another early appearance of the notion is in Piaget's theory of learning. As Clark (1975:312) puts it,

"Piaget distinguishes two types of organizations [in the human mind]: the organization which determines the general way in which the human being will interact with his environment and learn from it, and the organization which is the product of that interaction." (Emphasis added).

The first principle, with which every human being is born, Piaget calls "functional invariants". The mental patterns of

organization that result from the way such "functional invariants" handle the experience the individual is exposed to are the "schemata", or "cognitive structures".

More recently, there have been attempts to specify and represent schemata more precisely. This new effort originated with scholars interested in dealing with discourse understanding from the perspective of artificial intelligence (AI) (Rumelhardt 1975, 1980; Rumelhardt and Ortony 1977; Minsky 1975). Among other things, to this group is owed the notion that schemata are structures of knowledge that contain further schemata embedded within them, and also that schemata contain "variables" and notions, as illustrated with the schema for BREAK in the introduction.

To further clarify the point that schemata contain notions, suppose that an AI researcher wants to "teach" a computer how to understand natural language. Suppose he "teaches" the computer that "Shakespeare wrote Hamlet." Then, he wants to know whether the computer can -- based on this piece of information -- answer the following simple question, "Who is the author of Hamlet?" If we think that the computer can respond to the question, we are mistaken. In order for the computer to answer this question, it is absolutely essential that when it activates the WRITE schema, it finds connected to this schema the notion "be the author of". In other words, the computer will only be able to answer the question when it is explicitly fed in this information: "to be the author of" is a possible component of the schema for WRITE. Once the computer has this bit of information associated to the WRITE schema, it will then have the necessary 'background knowledge' to answer that of "Shakespeare wrote Hamlet", then "Shakespeare is the author of Hamlet." The question of schema components will be further elaborated upon in the section on schemata and inferencing below.

Before closing this section, it is worth mentioning the dichotomy "content" versus "formal" schemata. In a recent article, Carrell (1983b) made a clear differentiation between these two types of schemata. Formal schemata relate to the knowledge that readers have of the ways different genres are rhetorically

organized. Content schemata, on the other hand, relate to the knowledge readers have of the semantic content of texts. Within the domain of content schemata there is a growing body of literature about culturally-determined or culturally-bound schemata. Research has explored the influence of such schemata in L1 reading and the implications for reading comprehension for minorities and L2 learners (Stephenson, Joag-Dev, and Anderson 1979; Carrell and Eisterhold 1983; Johnson 1981, 1982). Carrell and Eisterhold (1983) provide a clear summary of this research. Formal schemata have been explored mainly in narratives. A result of this exploration was the creation of "story grammars" (Rumelhardt 1975; Mandler and Johnson 1977; Thorndike 1977; Stein and Glenn 1978; Stein and Nerzowsky 1978). According to this view, the rhetorical structure of narratives contains slots — or variables — for setting (characters, location), theme (goal), plot (subgoals), outcome and resolution. It is believed that readers are able to understand stories not only because of the content of the stories but also because they have developed formal schemata that allow the content to be properly assimilated under specific structural slots. Unfortunately, relatively little is known about the formal properties of expository discourse. Though from an educational point of view it is more ecologically valid to study expository discourse than narrative, work on expository text structures is intrinsically more difficult. Expository texts' formal structures are not as 'fixed' as story formal structures. Expository text structures are dynamically derived by the reader on the basis of an interplay between his or her (tacit) knowledge of rhetorical relations and each text's semantic content. The same thing of course can be said of stories, but while stories typically contain setting (characters, location), theme (goal), plot (subgoals), outcome and resolution, expository texts are much more 'loose' in structural terms.*

I conclude this section by repeating that this brief historical overview has concentrated on what is meant by schemata.

*See Figueiredo (this volume) for further discussion. (Ed.)

The elaborations on the meaning of the term should add flesh to the skeleton of the concept as it was presented in the introduction, namely, that schemata are patterns representing the way experience and knowledge are organized in the mind.

BOTTOM-UP AND TOP-DOWN PROCESSES

Related to schemata and to inferencing information implicit in texts (see Schemata and Inferencing section below) are the notions of "top-down" and "bottom-up" processing. The former is also referred to as "conceptually driven" processing, and the latter as "data driven" processing (Bobrow and Collins 1975, cited in Rumelhardt and Ortony 1977:128). Bottom-up processing starts with the printed symbols and derives meaning from individual words, phrases, clauses, sentences, paragraphs, and entire texts. This bottom to top movement goes from specific to general. Top-down processing, on the other hand, goes from general to specific. It starts in the mind of the reader who then samples textual information only to confirm his hypotheses and predictions about that text.

Today it is generally accepted by those interested in reading comprehension that readers derive meaning by the interplay of bottom-up or data-driven processes, i.e., material in the text, and top-down or conceptually-driven processes, i.e., schema-derived information. Because of the "contract"* that exists between readers and writers (Eco 1979, Grice 1975), not everything is — nor can it be — made explicit in the written text. This makes it imperative that readers apply top-down processes in order to make texts understandable. At the same time, readers do not normally read materials that are entirely predictable. Instead, they choose materials that present at least some novelty to them. This, in turn, makes it imperative that readers use bottom-up processes in order to put together the actual content of the text read.

*For further discussion and exemplification of this 'contract' see Kato (this volume). (Ed.)

A recent position concerning top-down and bottom-up processing is that represented by Stanovitch's (1980) "interactive-compensatory model" of reading comprehension. According to this model, top-down and bottom-up processing take place at the same time at all levels of text information processing. This is what Stanovitch means by "interactive". By "compensatory" he means that if there is a deficit in any particular process, this deficit will be compensated by a heavier reliance on other knowledge sources (Stanovitch 1980:32)*. For example, if a reader faces difficulty in identifying graphic symbols, or word meaning, he may more strongly rely on top-down strategies such as use of context to compensate for the difficulty. Or, where a reader knows little about a given topic, he may more strongly rely on bottom-up sampling of the text to compensate for his inability to make predictions about its content.

Now, reliance cannot be too great on one source of knowledge at to expense of the others. Thus, readers may over-rely on their predicting abilities to the point of sampling too little from the text to understand the message conveyed (Hudson 1982). On the other hand, because of natural limitations on human processing capabilities, reading performance may be impaired if readers depend too heavily on bottom-up processes. In this case, readers may be 'caught' in the microstructure of the text and fail to 'create' a coherent macrostructural representation for it. This is more likely to happen when texts are unfamiliar and difficult.

The matter just discussed is closely related to formal schemata — also referred to as text structure — to which I turn next.

*Note, however, that this compensation need not be **automatic**: it will certainly depend on the reader's **strategies**. It is not rare for readers to fail to compensate adequately for their deficits because of inadequate use of strategies. Kleiman (this volume) found some partial compensation, though weak. (Ed.)

SCHEMA THEORY AND TEXT STRUCTURE

Developments in text structure analysis coincide with developments in schema theory. Research in schema theory from the mid 1970s on provides new insights into text structure. Just as the human mind stores frames or schemata for the sequential events that normally take place in routinized situations such as going to restaurants, (Schank and Abelson 1977), it also stores formal schemata for the structural or rhetorical organization of different genres. The general belief is that once readers develop specific knowledge about the rhetorical structure of specific genres, these schemata facilitate readers' task of constructing hypotheses and confirming predictions while they read.

Recent research has found that readers who perceive the rhetorical structure used by the author tend to perform better than those readers who do not "see" such structures (Meyer 1979, 1984; Slater, Graves, and Piché 1985). Also, different text organization — narrative versus expository, or Meyer's (1975) "response" as opposed to "description", for instance — have been shown to be differently recalled after reading (Meyer 1979, 1984). When readers "see" the authors' organizational structure, they automatically activate a coherent structure which — in a top-down fashion — helps them integrate lower level hierarchies of information in the text. Comprehension in this case is more efficient. If the opposite happens, that is, when readers' structural, or formal, schemata are not activated, comprehension will then depend on bottom-up processes and the integration of the text as a whole will be more difficult. The consequence is lower performance after reading*.

SCHEMATA AND INFÉRENCING

Artificial intelligence attempts at discourse understanding have shed light on human cognitive processes and on the ingredients

*For further discussion of the role of rhetorical structure, see Figueiredo (this volume). (Ed.)

necessary for comprehending written discourse. The example provided in the historical overview section suggests that for understanding even simple information — like "be the author of" as being related to "write" — it is necessary to have and create knowledge that goes beyond the text. The use of such knowledge is known as inferencing. Inferencing, thus, is the apprehension of information that is not explicit in a text.

That reading involves the skill of identifying information in the text and the skill of integrating knowledge in the reader's mind is a generalized consensus today. Also, there is general agreement that the phenomenon of inferencing is possible because of schemata in readers' and speakers' minds, or in computer memories, for that matter. Inferencing is so common in our understanding that we hardly notice that it takes place at all.

A study by Brewer (1977), revealed that even when people were explicitly instructed to reproduce literally information presented through print, their recalls contained more "Inferential implications" (explained in the next paragraph below) than literal information. For example, the sentences "The clumsy chemist **had** acid on his coat", and "The hungry python **caught** the mouse", were reproduced by most subjects as "The clumsy chemist **spilled** acid on his coat", and "The hungry python **ate** the mouse", respectively. The examples point to the interaction of readers' schemata with the information in the text. In other words, because readers understand texts by means of their schemata, it is possible that schemata sometimes 'direct' them to perceive not the literal information conveyed by the text but possible logical and pragmatic implications of that information instead.

An implication is a schema-based response, that is, a response which may be traced back to the original text but is not explicitly stated in the text. Instead, it is a product of knowledge, or schemata, previously stored in the reader's mind. Implications are triggered by the incoming information in the text via bottom-up processes but come into existence only because

readers already possess the necessary background knowledge to produce them via top-down processes.

An implication may be of two general types: logical and pragmatic. A logical implication is a response necessarily implied by an idea in the original passage. For instance, sentence (1) taken from a text about rats,

(1) These "primitive" animals are capable of a richer and more flexible social organization than has been thought possible by most animal behaviorists.

logically and necessarily implies sentence (2),

(2) Animal behaviorists have thought these animals' social behavior is less flexible than it actually is.

A pragmatic implication, on the other hand, is a response which derives from the text and is possible according to our expectations about the world but is neither logically nor necessarily implied by the original passage. Thus, just as "The hungry python ate the mouse" is a pragmatic implication of "The hungry python caught the mouse", sentence (3) is a pragmatic implication of sentence (1).

(3) In some ways, rats' social behavior is as complex as that of man.

Both logical and pragmatic implications are defined as schema-based because they are not explicitly stated in the text but originate from readers' knowledge or schemata. A computer would never reproduce sentence (3) or (2) above, or any other implication for that matter, had it not been fed in pertinent implicational knowledge.

Inferences like these ones are probably produced "by default". This means that the literal information to be reproduced causes the reader to activate schemata so closely related to that literal information that he or she ends up reproducing schemata-related information, or implications, rather than the literal information itself. A simpler example of "default" can be seen in the

activation of the schema for BREAK as shown in the introduction. When we read that "The Karate champion broke the cinder block", we "know" that the instrument used for breaking it was the champion's own hand. This happens because in the schema for BREAK there is a "slot", or a variable, for the "instrument" with which to perform the action of breaking. Once the BREAK schema — together with the schema for KARATE CHAMPION — is instantiated, that is, activated and present in the reader's mind, the "slot" for "instrument" is filled automatically or by default, with no need for this bit of information to be explicitly stated in the text.

Several studies have repeated the finding that information apprehended by default or implication usually becomes indistinguishable from information explicit in the text. (Loftus and Palmer 1974; Loftus 1979; Perkins 1983). In other words, it is not rare for subjects to believe that information that they have inferred as a result of schemata instantiation was actually part of the text, not a product of inferencing. Because schemata have components that are activated as readers try to understand written discourse, it is possible that default information and implications become so firmly established as part of the representation created by the reader for the text that he or she no longer distinguishes it from information explicit in the text*.

In the next section, I examine some relationships between context and schema activation. I am especially interested in recent findings concerning reading in a non-native language.

CONTEXT AND THE ACTIVATION OF SCHEMATA

Confirming a top-down view of reading comprehension, studies have shown that the availability of a context significantly influences readers' understanding and recall of written texts. Context has been created by advance organizers (Ausubel 1961; Ausubel and Fitzgerald 1961, 1962), a title or a picture

*The evidence seems to be that we store the meaning of text, not verbatim traces of the actual words used. (Ed.)

(Bransford and Johnson 1972, 1973; Hudson 1982; Carrell 1983a; Carrell and Wallace 1983), and paragraph environment (van Dijk and Kintsch 1983, Meurer 1984). Context is supposed to activate higher order schemata which then allow for a top-down processing of the text to be read and, thus, facilitate comprehension.

The bulk of studies exploring the presence versus the absence of a higher order schema to which further information could be assimilated have dealt with English as the L1. Very recently this relation has started being investigated in the L2 as well. Among these studies are the ones carried out by Hudson (1982), Carrell (1983a), Carrell and Wallace (1983). A most striking finding of of the studies by Carrell, and Carrell and Wallace was that while context had a facilitative effect for L1 readers, it had no such effect for L2 readers.

Carrell and Wallace (1983) compared the effects of context on the reading performance of native speakers of English and non-native ESL readers. Their results revealed that the percentage of ideas recalled by natives was significantly higher in the context environment than in the no-context environment. However, context had no significant influence on the percentage of ideas recalled by the ESL readers. The authors conclude that non-native readers do not behave the same way as native readers do: Non-native readers do not use context "as part of a top-down processing strategy to make cognitive predictions based on context about the text's meaning" (p.305). The study by Carrell (1983a) yielded results that suggested a similar conclusion.

Carrell and Wallace (1983) further state that if research continues to show that non-natives do not take advantage of context, one major component of reading comprehension, the question then is whether they behave the same way when reading in their L1. As observed by Alderson (1984) the issue is whether L2 reading is a reading problem or a linguistic problem. If subjects who read poorly in an L2 also read poorly in their L1, then the problem seems to be a reading problem, not a linguistic problem. However, when subjects who are considered good L1 readers read less effectively in the L2, then the problem does

seem to be a linguistic problem, not a reading problem*.

Hudson's study (1982) shed some light on the above question. Hudson looked at reading comprehension as a process dependent on 3 major components. These could be broadly defined as the linguistic component, the prior knowledge or schemata component, and the affective component. In his own words,

The first component is composed of basal elements such as letter and word recognition, phoneme-grapheme correspondence, and recognition of the lexical syntactic, semantic, and discourse **linguistic relationships** which are present through the text. The second component involves the reader's hypothesis production and testing, guessing and identification of meaning, categorization of information, fitting new information to **prior knowledge**, reconciliation of assumptions to new possibilities of meaning, and the internalization of information. The third involves **affective features** which surround the reader... (emphasis added).

Hudson investigated whether it is possible to minimize the effects of the linguistic component on L2 learners by deliberately activating the second component, that is, schemata related to materials to be read. His subjects were three groups of ESL students representing three different levels of proficiency: beginning, intermediate, and advanced. Each group was submitted to three types of schemata inducing treatments before reading and being tested. The treatments were as follows: 1) PRE: Ss saw pictures related to the passage to be read, answered questions about the pictures, and made predictions about the passage. 2) VOC: Ss saw and discussed the meaning of a list of vocabulary from the passage. 3) RT: Ss read each passage and took a test, and then re-read the passages and took the same tests again.

The results showed that the different schemata inducing devices were effective at different proficiency levels. As Hudson summarizes the findings, "while the VOC and RT treatments were less effective than the PRE treatment at the beginning and

*See Carioni (this volume) for further discussion of this important question. (Ed.)

intermediate levels, they were as or more effective at the advanced level" (1982:18). According to the author the results indicate that advanced level Ss were better able than both beginning and intermediate level Ss to form schemata from the text itself without the aid of external schema inducing devices.

One conclusion from the Hudson study was that different Ss at different levels of proficiency seem to utilize different reading strategies. However, more important for our concern is the conclusion that reading comprehension depends both on the first and second components as defined by Hudson. The fact that "induced schemata apparently allowed access to language decoding which was otherwise not available" (1982:20) supports the view that linguistic knowledge is just one determinant of reading comprehension performance.

Regarding the issue of whether poor L1 or L2 reading performance is a reading problem or a linguistic problem, the answer seems to be that it might be both: poor reading seems to be the result of a breakdown at either the linguistic component or at the prior knowledge, or schemata, component. (The matter is further investigated in Meurer, forthcoming). The first component depends on bottom-up processes, that is, text-based information, while the second component depends on top-down processes, that is, schema-based information. Comprehension is a consequence of the simultaneous activation of the two processes*.

CONCLUSION

In this paper, we saw that the representation a reader stores in memory after reading a text is a function of information contained in texts and of content and formal schemata already available in the reader's mind. A historical overview of the meaning and uses of the concept of schemata was provided; the

*Note, however, that poor results might well derive from poor strategy use, not only from inadequate schemata. As Figueiredo (this volume) remarks, the reader may know the scientific content schemata but fail to use them to predict text structure for more efficient reading. (Ed.)

notions of top-down and bottom-up processing were explained; schemata were related to both content and structure of texts; and the activation of schemata was seen as providing an explanation for the phenomenon of inferencing and context utilization. Regarding context utilization, some studies were reviewed in which L2 readers were reported as not being able to utilize context as effectively as native readers.

Schema theory is a general theory of knowledge. Understanding the concept of schemata will help those interested in reading comprehension to understand how readers can acquire new knowledge and also how we might help readers in this endeavor. We should not forget, however, that reading is a multi-faceted process and schema utilization is just one aspect of the set of interacting processes involved in comprehension.

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