

Lelia Yolanda Villalobos

Universidad Nacional

**A COMPARISON OF THE PSYCHOLOGICAL
PROCESSES IN TOP-DOWN AND BOTTOM-UP
PROCESSING OF INFORMATION IN
SCHEMA THEORY**

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The purpose of this article will be to present a comparison of the psychological processes involved in the Schema Theory modes of information processing: Top-Down and Bottom-Up modes. It then aims at reporting the assumptions these two modes of information processing made about the learning process in the following areas: comprehension, cognitive processing and language acquisition.

I. Introduction to Schema Theory

Recent schema theory research has shown the importance of background knowledge within a psychological model of reading comprehension. Indeed, the role background knowledge plays in language comprehension is explained and formalized in a theoretical model known as Schema Theory. The term *schema* is defined as an abstract knowledge structure. Schema is considered abstract because it summarizes what is known about a variety of things which differ in many other aspects. On the other hand, it is structured in that it represents the relationships among its component parts.

There are some theoretical assumptions made by the schema-theoretical approaches to language comprehension. First, a written text does not in itself carry meaning. Rather, it provides directions for readers so that they can construct meaning from their own cognitive structure: previously acquired or background knowledge. Second, the reader's previous knowledge is called the reader's background knowledge and the previously acquired knowledge structures are called *schemata*. In other words, schema theory

emphasizes the mental organization of an individual's past experiences while the schemata are cumulative cognitive structures that store people's knowledge in memory. Third, the organization of the text helps the reader to select among conceptual knowledge stored in his mind. Finally, the goal of the schema theory is to specify the interface between the reader and the text; that is, to specify how the reader interacts and shapes the information on the page and to state how that knowledge must be organized to support the interaction.

There are two types of schemata in the Schema Theory model: formal and content schemata. Comprehension is not only determined by the local effects of sentences and paragraphs but also by the overall organization of a text. Consequently, characteristics of a text can have a great impact on the reader's ability to comprehend it. Certainly, formal schemata refers to the background knowledge of the rhetorical organizational structure of different types of texts: scientific texts and short stories, for example. Schema Theory assumes two modes of information processing: the Bottom-Up and the Top-Down processing modes. These two processes occur simultaneously or alternatingly in the comprehension process. Furthermore, these two kinds of processes must operate under a limitation: they both involve cognitive effort. As these two processes are the focus of this article, they will be described in more detail below.

II. Modes of Information Processing in Schema Theory

The Schema Theory posits as mentioned before, two separate but interrelated modes of information processing: First, the Bottom-Up processing, which is data driven, occurs through the reader's recognition and perception of details and comments in the text. It aids the reader's sensitivity to novel information. Secondly, the Top-Down processing occurs as the mind makes general predictions on higher conceptual levels and then searches in the input for information. It facilitates the assimilation of concepts and ideas if they are anticipated or consistent with the reader's conceptual expectations. In addition, this process helps to resolve ambiguities: to select among alternatives, and possible interpretations of the material.

Top-Down and Bottom-Up processing occur at all levels

simultaneously. The data that is needed to fill out the schemata is available through Bottom-Up processing; on the other hand, the Top-Down permits the incorporation of information. Spiro quotes:

"...in which both bottom-up and top-down processes operate simultaneously or alternately, with information from each processing direction feeding into the others and influencing the other's course"¹.

Even though both modes of information processing occur at the same time, an attempt will be made to take them apart to see the contributions each one makes to the comprehension process from a psycholinguistic point of view.

In order to account for the psychological processes underlying both Top-Down and Bottom-Up modes in the areas of acquisition, insights from research are presented.

III. The Top-Down Mode and Underlying Processes

A. *Comprehension*

Research in the area of comprehension has found that schema affects the recalling process. The assumption made is that what gets stored is the major determinant of what can be remembered. In order to know exactly how a person's schema influences remembering, three hypotheses have been proposed.

1. The retrieval-plan hypothesis. According to this hypothesis, a schema provides the framework for a "Top-Down" search of memory. The idea is that search proceeds from the general concepts incorporated in the schema to the particular information related to the concepts that were learned while the passage was being read. According to the theory, a Top-Down schema-guided search provides access to information important for

1. Rand J. Spiro and Ann Myers, "Individual Differences and Underlying Cognitive Processes in Reading", *Handbook of Reading Research* (New York: Longman, 1984).

the schema activated, but it cannot turn up information unrelated to the schema. Anderson refers to this hypothesis as follows:

“The retrieval-plan hypothesis is able to explain why perspective instructions have consistent effect on recall... The essence of the retrieval-plan hypothesis is that the schema is a structure that provides access to information in memory and access is a critical process in free recall”².

The retrieval-plan hypothesis explains some of the effects of schemata on remembering. A prediction made is that rememberers should recall information in conceptually related clusters. The hypothesis then asserts that memory search is organized in terms of the general category that comprises the schema.

2. The output editing hypothesis. This hypothesis states that the schema provides the basis and the motivation for output editing. In trying to explain the effects on memory, it is stated that through output editing, a person may select or reject information to report when recalling a passage. Consequently, the pattern of results that involves increased recall of important information and decreased recall of unimportant information could be explained in terms of what is called perspective-induced shifts in standards for output editing.
3. The reconstruction hypothesis. According to this hypothesis, the rememberer’s schema facilitates reconstruction. It is maintained that the person generates inferences about the passage based on his schema and aspects of the passage that can be recalled.

The three hypothesis mentioned attempt to explain the effects of schemata on remembering; in fact, the retrieval-plan hypothesis accounts for the processes of remembering: the schema provides the rememberer with an outline of the questions he ought to ask himself. The longer the interval between reading and recall, the greater the effects on the reader’s

2. C. Richard Anderson, “A Schema-Theory View of Basic Processes of Reading Comprehension”, *Handbook of Reading Research* (New York: Longman, 1984).

schema. Besides, available data supports the idea that the readers schema is a structure that facilitates retrieval of text information from memory and permits reconstruction of elements that were not learned or have been forgotten.

B. *Cognitive Processing: The Role of Metacognition*

Not only does schema affect the recalling process but also fosters the development of cognitive strategies. Metacognition which means “transcending knowledge” is used by cognitive psychologists to refer to both the knowledge and the control an individual has over his or her own thinking and learning. Metacognition in reading to learn plays an important role in the Top-Down processing mode: the features of the text to be read influence comprehension and memory. Readers utilize context in a Top-Down processing mode to make cognitive predictions of what a text is going to be about as it is read. The tendency of this mode is the global perception of a text. Therefore, learners are aware of “global”, Top-Down reading strategies (text-gist, background knowledge and the rhetorical organization of the text).

Macropropositions are important for the text-gist. Macropropositions refer to the level of prose analysis at which the topic or gist of portions of the text become important. At this level, the concern is with the relationships among ideas represented in complexes of propositions or paragraphs. Therefore, the reader’s goal is the application of the macro-operators which transform the text base into macropropositions representing the gist of the text. Concerning macropropositions, Samuels points out:

“The formal representation of these goals is the reader’s schema. A specific schema always controls text comprehension since the schema dictates which macropropositions are relevant to the gist of the text... If the reader has an appropriate goal, comprehension should be good”³.

3. S. Jay Samuels and Michael L. Kamil, “Models of the Reading Process”. *Handbook of Reading Research* (New York: Longman, 1984).

The second schema-theoretic account of cognitive processing is background knowledge which is used to make inferences. It is asserted that inferences can occur either at the time of initial encoding of text information into memory or at the time that information is retrieved from memory. Inferences; on the other hand, are central in the overall process of comprehension. Four types of inferences are identified. 1. Inferences may be involved in the process of deciding what schema should be called into play in order to comprehend a text. 2. They are involved in the process or instantiating slots within a selected schema. 3. A reader may fill a particular slot in the schema by assigning default values in the absence of any specifically substantiating information of a text. 4. They also involve drawing a conclusion based upon lack of knowledge.

The rhetorical organization of expository texts becomes an important variable in students' understanding and remembering. Knowledge of the structure of content area reading facilitates comprehension because it provides schema or concepts for the reader to place topics and supporting details in relation to one another. Knowledge of the structure also provides readers with a network of abstract knowledge in memory to place these concepts while processing information. Thus, knowing the structure of a text can aid in organizing and storing information. So structural aspects facilitate remembering. Carrell notes:

"Thus, when the unstable interleaved input order is stored in memory for a relatively long period of time (24 hours), it tends to be converted to the ideal, story-schematic order and tends to be recalled to that schema"⁴.

As illustrated above, the Top-Down mode of information processing plays an important role in the learning process, especially in the areas of comprehension, cognitive processing and language acquisition.

C. *Language Acquisition*

In addition to recalling and the development of cognitive strategies,

4. Patricia Carrell, "The Effects on Rhetorical Organization on ESL Readers", *Tesol Quarterly*, 18, 3 (1984).

the Schema Theory promotes language acquisition. In the language acquisition area, the activation of the Top-Down information processing helps readers activate sources of preexisting knowledge that can be reassembled into new schemata. Krashen's input hypothesis illustrates the acquisition of schema: learners acquire more language only when they are exposed to comprehensible input. Therefore, language that contains structures a little beyond the learner's current level of competence ($i + 1$) is likely to be acquired. In the Top-Down mode, the "i" represents the learner's intake which they activate for the reading process and ($+ 1$) represents the new information students find in a passage to increase their background knowledge. The function of schemata is to provide a basis for determining the meaningful elements in a message or text; thus, readers acquire as long as they go for meaning. Learners who understand the significance of new content develop knowledge structures that enable them to deal with novel situations. Bransford states:

"An emphasis on the importance of helping students activate sources of preexisting knowledge that can be reassembled into new schema is consistent with Ausbel's theory of meaningful learning"⁵.

In summary, the Top-Down information processing assures language acquisition.

IV. The Bottom-Up Mode and Underlying Processes

The Bottom-Up Mode is also called "text based" and occurs when the reader initially encounters a text.

A. Comprehension

Studies in comprehension have demonstrated that lower-level ideas are not well recalled because peripheral related information gets less rehearsed in memory. So, if readers rely too much on Bottom-Up processing

5. John D. Bransford, "Schema Activation and Schema Acquisition: Comments on Richard C. Anderson's Remarks", *Theoretical Models and Processes of Reading* (Delaware: International Reading Association, 1985).

in order to process low-level information units such as letters, syllables or words, no cognitive capacity is left to discern the overall meaning of a text. Carrell refers to lower levels as follows:

“each piece of subordinate information gets stored in the proper place in the hierarchy but does not get rehearsed again as each new piece is taken in. It is thus more quickly forgotten than the top-level information, which gets rehearsed quickly”⁶.

Consequently, the Bottom-Up information processing has little to do with comprehension.

B. *Cognitive Processing*

Besides comprehension, the Schema Theory stimulates the development of cognitive strategies. In the cognitive processing, the assumption of the Bottom-Up mode is a linear decoding of information to build up units: the presence of concrete lexical items within the text which provide textual cues to the content area the text. Decoding is necessary to guarantee successful comprehension and studies in the comprehension area points out three levels of analysis:

- a. Letters that have been identified suggest neighboring letters and candidate words. The variety of type styles and scripts as well as some connections in the system between the written and the spoken language that make the identification of letters possible are important factors at this level.
- b. Knowledge and processing at the syntactic level. Bottom-Up information processing triggers different words in a sentence. Therefore, it triggers expectations for determiners, adjectives and possessives to the left and a verb phrase at the right.
- c. Knowledge and processing at the interpretative level. When information is not explicitly given, it may be signalled by the Bottom-Up mode from the structure of the passage.

6. Carrell. *Ibid.*

Attention to graphic features is the main concern of this mode and the reader cannot judge until he gets more information from the text. Therefore, comprehension is measured mainly by verbatim.

The Bottom-Up processing mode deals with local elements in the passage which aim at comprehension. These include the focus on grammatical structures, sound-letter, word meaning and text details. These clues in the text activate the schema and are means to decode the information.

Studies in the cognition area have assigned the term *local schemas* to indicate that they are local generic knowledge structures which can be used to build new representations and the issue of activating readers schema is crucial in the reading process. In the Bottom-Up mode, student's main strategy is to pay attention to the micropropositions. The content at this lower level of text structure is with the interrelationships among individual propositions: with how each new proposition or item of information given relates to what has already been presented. It has been found that readers utilize textual transparency clues, lexical clues, in a Bottom-Up processing mode to confirm cognitive predictions and to build up a mental representation of what a text is about from the information in the text itself. Therefore, the presence of transparent textual cues enhances the reader's building up of the text's meaning. This mode of processing involves episodic memory: readers recall specific events related to people, location and time. The information is organized around *wh*-words. Hasher states:

*"The ability to relate sentences to one another during encoding may be a determining factor involved in recalling the propositions of a text. If ideas are not or cannot be connected to a higher-order cue during encoding, recall will be poor"*⁷.

As has been shown, structural schema increases both encoding new information and memory.

7. Lynn Hasher and Joseph W. Alba, "Is Memory Schematic?", *Psychological Bulletin*, 93, 2 (1983).

C. *Language Acquisition*

The activation of the schema helps the readers decode information as well as the recalling of information. In addition, the Bottom-Up information processing brings about insights in language acquisition. According to Krashen's input hypothesis, acquisition takes place when readers try to understand the message and the structures are acquired later on. The internal subconscious processor in the Bottom-Up mode is called the organizer. Since its role is to work with low levels of language, it somehow needs to process and organize structural categories. Dulay notes:

*"The organizer is part of the learner's mind which works subconsciously to organize the new language system. It gradually builds up the rule system of the new language in specific ways and is used by learner to generate sentences not learned through memorization"*⁸.

Research has demonstrated that by activating the readers' Bottom-Up mode, the students will be able to acquire language.

The Schema Theory asserts that activating or building readers' existing knowledge would improve and/or alter reading comprehension and recall. It also posits that human memory is organized semantically. Not all the information in the hierarchically organized schema is equally important in encoding, storing or remembering; in fact, the top level structures are cognitively more salient than lower levels. These structures get rehearsed with the main ideas of the text.

As it has been shown, both the Bottom-Up and Top-Down modes information processing are very important in the reading comprehension learning process. They appear to have implications in the areas of comprehension, cognitive processing and language acquisition.

8. Heidy Dulay, "Internal Processing", *Language Two* (New York: Oxford University Press, 1982).

V. Conclusion

In summary, the Top-Down and the Bottom-Up processing modes occur simultaneously. The data that is needed to instantiate the schema is provided by the Bottom-Up processing; and the Top-Down processing facilitates the assimilation of the reader's conceptual expectations. The former provides a basis for assimilating text information and allocating attention to important text elements. The latter provides a basis making inferential elaborations to fill the gaps in messages, for searching memory in a very orderly way, for formulating a summary of information and last, for making inferences. What both modes store is highly selected and the schema guides the selection process; meaningful information is a priority for storage. The formation of the schema comes from both the semantic integration and the linear ordering of elements in a text.

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