DISCOURSE PROCESSES, *39*(2&3), 125–128

An Overview of Top-Down and Bottom-Up Effects in Comprehension: The CI Perspective

Walter Kintsch
University of Colorado

The construction–integration model describes the interplay between top-down and bottom-up processes in comprehension: how top-down processes guide comprehension and how bottom-up processes constrain it. At every level of analysis—from basic linguistic processing to knowledge integration—both top-down and bottom-up processes jointly determine the nature of the mental representations formed in comprehension.

Cognitive processes can be ordered along a dimension that ranges from conscious, intentional, analytic problem solving on one end to automatic perception. The process models psychologists have proposed for these two extremes differ in important respects. Newell and Simon (1972) provided the framework for theories of problem solving. Notions such as problem space, search, strategies, and production rules characterize this style of theorizing. In contrast, perception is most readily described as a process of constraint satisfaction, involving both sensory and memory or knowledge components. *Comprehension* is a vague term: We can talk about comprehending a problem, which would put us at one end of the continuum, or comprehending a perceptual scene, which would put us at the other end. Text comprehension is somewhere in between. One approach to text comprehension is to regard it as a kind of problem solving: Reading is active problem solving (e.g., Britton & Black, 1985). Although this is sometimes an appropriate characterization (especially for the struggling novice reader), fluent adult reading is more akin to automatic perception than deliberate analysis. Kintsch (1998) therefore suggested constraint satisfaction as a basis for the theory of text comprehension.

Correspondence and requests for reprints should be sent to Walter Kintsch, University of Colorado, Department of Psychology, Boulder, CO 80309. E-mail: wkintsch@psych.colorado.edu

Text comprehension is more like perception in this respect; only when the normal flow of comprehension breaks down does strategic problem solving take over. It is from this perspective that I want to discuss top-down and bottom-up effects in text comprehension.

Both top-down and bottom-up processes are integral parts of perception, problem solving, and comprehension. Without sensory input (bottom-up) we could neither perceive, nor comprehend, nor think. However, perception, comprehension, and thought would be equally impossible without a memory or knowledge component (top-down). It makes no sense to ask whether one is more important than the other: Nothing happens without both. So the question for the theorist is not top-down or bottom-up, but how do these processes interact to produce fluent comprehension?

It has long been recognized that top-down and bottom-up processes interact in perception. Helmholtz (1860) pointed out that perception often contains elements that are not directly represented in the stimulus. His solution was to distinguish sensation prior to unconscious inference and perception dependent on unconscious inference. He conceived of unconscious inference as initially an effortful, conscious process, becoming automatic and unconscious as a result of repetition. This view has been varied and elaborated in many ways in modern times. One way to think about top-down effects is as a kind of filter that facilitates expected sensations and inhibits the unexpected and unwanted. Thus, perception researchers (e.g., Bruner & Postman, 1949) started out with demonstrations that we see what we want or expect, only to be forced very quickly into a less extreme view where sensations and expectations interact, without one dominating the other. Theories of attention followed a similar trajectory. Boadbent (1958) initially thought of attention as a filter that excluded unattended channels, but quickly realized that an attenuator rather than a filter better described attention. Instead of focusing on one thing at a time to the exclusion of everything else, experiments showed that attention took into account a broad range of sensory information before focusing on some particular component (e.g., Shiffrin & Gardner, 1972). Theories of text comprehension underwent a similar evolution. First, inferences (the counterpart in comprehension of Helmholtz's unconscious inferences in perception) were thought to be schema-controlled: Schemas, like a perceptual filter, made possible schema-relevant inferences and at the same time inhibited numerous other conceivable inferences that were not schema-relevant (e.g., Schank & Abelson, 1977). Discourse comprehension, however, turned out to be much more flexible than early schema theories supposed. A number of solutions were proposed to deal with that flexibility (see the articles in this issue), among them the CI model (Kintsch, 1988). In the CI model, a lot of inferences, relevant or not, are made in parallel, but an integration process quickly deactivates the irrelevant ones. Integration is constraint satisfaction, modeled as a spreading activation process: Text propositions and inferred propositions that go together strengthen each other, although those that do not fit into the broader context are inhibited.

In the CI model, the words of the text are used to construct propositions; these activate further propositions without top-down control and then ambiguities and contradictions are resolved by an integration process. Bottom-up and top-down processes both play their part in the CI architecture. Knowledge is indeed activated promiscuously and bottom-up. However, among the activated knowledge will be structures that function as control units. Consider the classical restaurant story. The restaurant schema will be one of the knowledge structures activated by that story and it will be linked to many propositions in the story. As a result of the integration process, it will become a strongly activated item, and hence it will start to control the other items in the textbase, feeding activation to anything it is connected with, thereby deactivating elements it is not connected with.

A simple example illustrating the interaction between top-down and bottom-up processes in the CI model was presented in Kintsch (1998). The text used in this example is eight sentences long, describing a trip to the grocery store during which the protagonist becomes annoyed for various reasons. The grocery shopping script becomes the strongest item in the textbase or situation model that the model generates. Indeed, the script plays a crucial role because it makes possible the bridging inferences necessary for the construction of a coherent representation. However, the second theme of this ministory—that the woman became upset—is not suppressed as irrelevant by the grocery shopping schema, but plays its proper role in the memory representation the model generates. Once established, a schema is a powerful determinant of how additional sentences are interpreted: Material that fits the schema is definitely at an advantage and material that is ambiguous would, at least initially, be interpreted in a schema-conforming way. Suppose there were another sentence in this mini-story, "She was surprised by how much she had to pay." "Pay" would immediately be linked to the corresponding slot in the grocery shopping script, so that, if asked for, the information *where* she paid (at the checkout counter) or *for what* (for the groceries she bought) would be readily available. Thus, classical, schema-driven top-down effects can be observed in the CI model. Indeed, any model of comprehension would have to deal with such effects.

Of course, not all texts are as simple as the one used in this example, nor do schemas always apply in such a straightforward way. The point of the example is that if there is a simple schema, it plays a role much like in any schema-based model in facilitating the interpretation of the text. The difference is in the manner in which it plays that role: not as a filter that irrevocably biases the interpretation, but as one (a major one) of many constraints that need to be satisfied to arrive at a correct interpretation.

Text comprehension, from the perspective of the CI model, is highly interactive. Processes at many different levels interact—the perceptual processes involved in reading or listening, syntactic and semantic analyses, knowledge integration, as well as reasoning processes whenever they are necessary. All of these are both top-down and bottom-up. What we see is in part determined by what we expect to see. Sen-

tences are parsed with a bias for expected structures. Prior knowledge plays a crucial role in how a text is interpreted. However, the top—down processes never dominate, except in degenerate cases, because what is out there strongly constrains and guides comprehension. The CI model is one way to describe the interplay between top-down and bottom-up processes in comprehension: how top-down processes guide comprehension and how bottom-up processes constrain it.

REFERENCES

Britton, B. K., & Black, J. B. (Eds.). (1985). *Understanding expository text*. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Broadbent, D. E. (1958). *Perception and communication*. New York: Pergamon.

Bruner, J. S., & Postman, L. (1949). Perception, cognition, and behavior. *Journal of Personality, 18*, 14–31.

Helmholtz, L. F. V. (1860). *Handbuch der physiologischen Optik* [Handbook of physiological optics]. Leipzig: Voss.

Kintsch, W. (1988). The use of knowledge in discourse processing: A construction-integration model. *Psychological Review, 95*, 163–182.

Kintsch, W. (1998). *Comprehension: A paradigm for cognition*. New York: Cambridge University Press.

Newell, A., & Simon, H. A. (1972). *Human problem solving*. Englewood Cliffs, NJ: Prentice Hall.

Schank, R. C., & Abelson, R. P. (1977). *Scripts, plans, goals, and understanding*. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Shiffrin, R. M., & Gardner, G. T. (1972). Visual processing capacity and attentional control. *Journal of Experimental Psychology, 93*, 72–82.