Five Dimensions of Narrative Comprehension: The Event-Indexing Model

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The successful comprehension of a narrative necessarily involves the construction of a coherent mental representation of the narrated events, states, and actions, a situation model (van Dijk & Kintsch, 1983). Trabasso and colleagues have provided clear evidence that causal relations play a central role in establishing these coherent representations (e.g., Trabasso & Magliano, 1996; Trabasso & Sperry, 1985; Trabasso & Suh, 1993; Trabasso & van den Broek, 1985). However, events in narratives are related on several other dimensions, for example, time, space, and protagonists. The work discussed in this chapter reports on progress being made toward an integrated account of how the multiple dimensions of situations play a role in narrative comprehension.

A large number of studies have provided empirical evidence that readers mentally represent the temporal, spatial, and protagonist-related connections between events (see Zwaan & Radvansky, 1998, for a review) in addition to the causal and motivational dimensions studied by Trabasso and others. These five situational dimensions (time, space, causation, motivation, and protagonist) are usually investigated in isolation by text-comprehension researchers. My colleagues and I have developed the event-indexing model (Zwaan, Langston, & Graesser, 1995; Zwaan & Radvansky, 1998) in an effort to examine how these dimensions operate in concert. I first provide an overview of the event-indexing model and then
go into further detail about the assumptions behind it. Two general hypotheses about processing and representation can be derived from the model: the processing-load hypothesis and the memory-organization hypothesis. Empirical evidence bearing on these hypotheses is presented. I conclude with a discussion of future directions.

THE EVENT-INDEXING MODEL

According to the event-indexing model (Zwaan, Langston, & Graesser, 1995), comprehenders parse clauses of a text into events. During comprehension, they connect these events on five different situational dimensions: time, space, causation, motivation, and protagonist. If the event that is currently being processed overlaps with the events in working memory on a particular dimension, then a link between those events is established and stored in long-term memory. Overlap is determined based on whether or not two events share an index (i.e., a time, place, protagonist, cause, or goal).

Zwaan and Radvansky (1998) recently expanded this basic model. For example, they distinguished between: (a) the current model, the model currently under construction, that is, the model at $t_n$; (b) the integrated model of the situations at times $t_1$ through $t_{n-1}$; and (c) the complete model of the situations at times $t_1$ through $t_n$. The current model is constructed at time $t_n$ while a person reads a particular clause or sentence, called $c_n$. The integrated model is the global model that was constructed by integrating, one at a time, the models that were constructed at times $t_1$ to $t_{n-1}$ while the person reads clauses $c_1$ to $c_{n-1}$. Finally, the complete model is the model that is stored in long-term memory after all the textual input has been processed. Thus, the complete model is the same as the integrated model after all the input has been processed. Zwaan and Radvansky termed the process of incorporating the current model into the integrated model updating.

The processing-load hypothesis concerns the updating process. The more situational indices that are shared between the current model and the integrated model, the easier updating will be. The memory-organization hypothesis pertains to the structure of the integrated model and its final form, the complete model, in long-term memory.

There are four basic assumptions behind the event-indexing model:

1. Events are the central units of situation models (the event-centrality assumption).
2. Events can be linked on five dimensions: time, space, causation, motivation, protagonist (the five-dimensions assumption).
7. FIVE DIMENSIONS OF COMPREHENSION

3. Events are either related or not related on a particular dimension (the dichotomy assumption).
4. All dimensions are equal (the dimensional equality assumption).

THE FOUR ASSUMPTIONS

The Event-Centrality Assumption

According to the event-centrality assumption, events are the core units of situation models. This is based on the fact that (a) events are the most dynamic aspects of situations and (b) every clause of a text obligatorily describes an event. It is important to address two questions: What are events? and How are they represented in memory? The answer to the first question requires a definition, whereas the answer to the second requires more empirical data.

WordNet®, the lexical database maintained by the Cognitive Science Laboratory at Princeton University, defines an event as “something that happens at a given place and time.” This is a very reasonable and helpful definition. It states that events are fixated in time and space. This makes them different from, for example, people and objects, which can move through time and space. It also separates events from concepts, which are general notions, not bound by time or space. One drawback of the definition is that it tells us nothing about the grain size of events. For example, a raindrop falling on my hand would qualify as an event, but so would Woodstock and the Allied invasion in Normandy. Indeed, the Dutch poet Gerrit Kouwenaaar titled one of his volumes Landscapes and Other Events (Landschappen en andere gebeurtenissen). And indeed, on a geological time scale, landscapes can be considered events. However, in a model of event comprehension, it is necessary to limit the scope of what can be called an event. As the examples show, some events are made up of multiple events, whereas others seem more like singular events. Research on the units of (visual) perception shows that people can zoom in and zoom out on events according to situational constraints, but that they are rather consistent at identifying events at each predetermined grain size (e.g., Newtson, 1973). The event-indexing model is mostly concerned with singular events, such as a falling raindrop, an explosion, or someone tripping over a cat, given that this is the most common type of events in narratives. However, the event-indexing model currently treats events of all types alike. This is likely to change as the model is developed further.
In its current form, the event-indexing model is most concerned with how links between events are formed in the comprehender’s mind. Therefore, the model doesn’t have a lot to say yet on how events themselves are represented in memory. However, a full-fledged model of situation-model construction obviously cannot simply treat events as empty nodes (see Johnson-Laird, Hermann, & Chaffin, 1984). It is plausible to assume that events have an abstract “kernel,” somewhat akin to the semantic primitives in, for example, Schank’s (1972) conceptual dependency model. These kernels can be augmented by specific event-related information. For example, “to eat” can be represented as “INGEST FOOD,” a semantic primitive. Because eating a banana is very different from eating soup, and both are different from eating a steak, the kernel would be complemented with the relevant semantic and episodic information. Semantic information would include the knowledge that you first peel a banana before you eat it, that you use a spoon to eat soup and a fork and knife to eat a steak, as well as mental images of these foods. Episodic information would involve memories of eating these kinds of foods—for example, the odor, feel, and taste of a banana on a particular afternoon, burning your mouth when eating soup at your grandmother’s house, and, perhaps, a guilty feeling when eating a steak last week.

Whether and how much episodic information would be incorporated depends, obviously, on the comprehender’s background knowledge. Most of us would lack episodic information about performing heart surgery or reaching the summit of Mt. Everest. In these cases we may have to rely mostly on semantic knowledge. On the other hand, most of us know what it is like to give a lecture or send an e-mail message. So, when we read about someone sending an e-mail message, we may retrieve a mental image of our own computer screen and our own e-mail program from episodic memory and use it to augment the semantic primitive.

How much knowledge about an event is activated may depend not only on the reader’s knowledge base but also on the way an event is conveyed verbally. In my laboratory, we have recently obtained evidence that certain linguistic structures may cue comprehenders about how much knowledge about an event they need to activate. Specifically, Zwaan and Stanfield (1999) found that, under certain conditions, comprehenders are more likely to activate mental representations of tools such as hammers when a related action, for example, pounding, is described as ongoing, as in the past progressive, than when it is described as instantaneous, as in the simple past tense. Thus, verb aspect appears to function as a cue to comprehenders regarding the amount of knowl-
edge about an event that needs to be activated. When the event is described as ongoing, more knowledge is activated than when it is described as instantaneous.

**The Five-Dimensions Assumption**

We assume that comprehenders relate events to the evolving situation model on five dimensions: time, space, protagonist, causation, and motivation. In order to understand an event, we need to know at least the following: What happened When, Where, Why, and How and Who was involved in it? These questions map readily onto the event-indexing model. The *what* question refers to the event itself. *When, where, and why* refer to the temporal, spatial, causal-motivational, and protagonist dimensions, respectively. Finally, the *How* question was not captured in the original proposal (Zwaan, Langston, & Graesser, 1995), but would be incorporated as a label to the event in a version of the model that we are currently developing (Radvansky & Zwaan, 1998).

**Why Are Causation and Motivation Separated?** Most causal models in the text comprehension literature do not treat causation differently from motivation. That is to say, they usually do distinguish causation and intentionality theoretically, but not necessarily in their models. In the event-indexing model, causation and motivation are separate dimensions. One reason why it makes sense to have two separate dimensions is that it is possible for two events to be causally related or to be causally plus motivationally related. I can accidentally drop a hammer on your toe, which causes your toe to break. But I can also intentionally drop the hammer on your toe, for instance, when you and I are competing for a spot on the basketball team. In the first case, there is only a causal link (aside from the temporal and spatial links). In the second case, there is also a motivational link. Thus, the two events should be more strongly connected in the latter case than in the former, something that is most straightforwardly accommodated by a model that incorporates separate causal and motivational dimensions.

**Why Is There Not a Separate Emotion-Based Dimension?** Rather than questioning the separation of dimensions, one could question the selection of dimensions. For example, emotions seem a plausible candidate
dimension. Research shows that readers make inferences about the emotions of protagonists and may do so even automatically (Gernsbacher, Hallada, & Robertson, 1998). Therefore, several people have suggested to us that the event-indexing model should include a separate emotion dimension. There are two reasons why we don’t treat emotions as a separate dimension. First, many events described in narratives do not involve emotions, whereas all events involve time and space and many events involve causation and goals. Thus, connecting events based on emotions (and it is unclear how this should be done) would yield a rather sparsely interconnected network. Second, it would not be parsimonious to treat emotions as a separate dimension. Rather, emotions are deeply intertwined with goals (e.g., Stein & Levine, 1989). For example, one may get angry or sad when a plan fails or happy or proud when a plan succeeds. Therefore, emotions are treated as characteristics of protagonists that change as a result of goal success versus goal failure (Radvansky & Zwaan, 1998).

Although we do not think emotions should be regarded as a separate dimension, it is certainly possible that future research will dictate that more dimensions are to be added. However, in our view, it makes sense to add dimensions if only it turns out to be impossible or inelegant to explain findings with the current five dimensions.

The Dichotomy Assumption

Unlike the previous assumptions, the dichotomy assumption was prompted by methodological concerns, rather than theoretical ones. Thus far, we have treated situational dimensions as dichotomous: Either two events are related on a dimension or they are not. Although this simplifies matters empirically, the question is whether it is theoretically plausible. The answer to this question may be different for each dimension.

Time. In a dichotomous coding scheme, it does not matter if two events are 5 minutes apart or 5 years (all other things being equal). In Zwaan (1996), I obtained some initial evidence consistent with this scheme given that I did not find any statistically reliable differences between time intervals of 1 hour and 1 day, although there were some differences between the mean response times in these conditions. However, much more research is needed on the effects of the magnitude of time shifts on comprehension processes before the dichotomy issue regarding the temporal dimension can be addressed satisfactorily.
Space. In a detailed analog spatial model, readers would represent the distance between, for example, the protagonist and objects. In a more abstract representation, the reader would link objects that are close to the protagonist (e.g., in the same room) but not objects that are in different rooms, no matter how far or close those rooms are to the protagonist’s current location. Recently, Rinck, Hähnel, Bower, and Glowalla (1997) found initial support for this position.

Causation. As mentioned earlier, Trabasso and his colleagues have developed sophisticated methods to analyze causation in narratives. For example, they distinguished enablers as a weak form of causation. In the event-indexing model, enablers were not considered causal relations. However, in unpublished data, we found that the fit of the model with data reflecting memory organization improved significantly when we augmented the causal analysis with enablers, but only when enablers received half the weight of the other causal relationships. This seems consistent with Trabasso’s work and thus shows that the event-indexing model analysis could be refined. Moreover, van den Broek (1990) argued how the strength of causal relations may differ according to criteria of necessity and sufficiency. Thus, causal necessity and sufficiency may provide a good basis for converting the causal dimension from a dichotomous into a continuous one.

Goal. Goal-plan structures are conceived of as hierarchical representations (e.g., Graesser, 1981; Schank & Abelson, 1977), such that actions that are more relevant to the goal are higher in the hierarchy than less important actions. For example, when the goal is to buy a book, entering the bookstore is a relevant action but it is less important than paying for the book. Foss and Bower (1986) obtained initial evidence that the degree of priming between actions increased with the proximity of these actions within the goal hierarchy.

Protagonist. The protagonist dimension seems rather straightforward. Either a protagonist is the main agent in an event or he or she is not. However, the situation is not always that clear-cut. For example, some events have two or more agents, such as when people are kissing, hugging, arguing, fighting, debating, or slugging it out. In such a case, the event could be linked to other events that each of the protagonists was the main agent.
The question here is whether the link strength should be equal to that in the case of a single protagonist or whether it should be smaller. This question can be addressed empirically. An alternative would be to treat the cluster of participants as a new participant node, but this seems neither elegant nor plausible.

To summarize, it seems that the dichotomy assumption is likely to be an oversimplification and that different schemes might be needed for the different dimensions. However, a great deal more research is needed before a finer-grained system of determining the strengths of dimensional links can be developed. Until that time, the dichotomy assumption serves as a useful approximation.

The Dimensional Equality Assumption

The assumption that each dimension is weighted equally was, similar to the dichotomy assumption, made for methodological rather than theoretical reasons. However, as the various tests of the processing-load and the memory-organization hypothesis discussed in the next section show, the dimensions are not really equally weighted. We assume that readers can differentially weight the dimensions according to their reading goals. For example, if their goal is to form a spatial map, they may emphasize the spatial dimension more than under “normal” reading conditions (e.g., Zwaan & van Oostendorp, 1993). It may also be the case that some dimensions are constructed obligatorily. Questions involving the comparison among the situational dimensions are high on our empirical agenda.

HYPOTHESES AND EVIDENCE

The Processing-Load Hypothesis

The processing-load hypothesis holds that the integration of an event into the evolving situation model is facilitated to the extent that the event overlaps situationally with the current model. This assumption is not uncommon in the text-comprehension literature. For example, Gernsbacher’s (1990) structure-building framework also assumes that online comprehension is facilitated with situational overlap. However, the structure-building framework assumes that lack of situational overlap on any dimension will lead to an increase in comprehension time, because it
will be a cue to the comprehender to build a new substructure. According to the event-indexing model, situational overlap is a matter of degree. Overlap can be on anywhere from zero to five dimensions. The greater the situational overlap, the greater the facilitation. Thus far, this hypothesis has been investigated in its full extent using only multiple-regression techniques. However, aspects of it have been investigated using factorial designs.

Zwaan, Magliano, and Graesser (1995) had college students read short stories one sentence at a time on a computer screen. The subjects pressed the space bar on the computer keyboard when they had read a sentence and the time between key presses represented the reading time for that sentence. The reading times were analyzed using multiple-regression techniques. In these analyses, a set of variables was used to predict reading times. Three of these variables represented dimensions of the situation model: time, space, and causation. In addition, variables that coded for surface level aspects of the sentences, such as the number of syllables and their serial position in the text, known to be robust predictors of reading times, were included as auxiliary measures. Thus, the effects of the three situational dimensions analyzed in this study were assessed after those of the auxiliary variables had been partialed out statistically. Zwaan, Magliano, and Graesser found reliable effects of temporal and causal discontinuities, but not spatial discontinuities, on reading times.

Recently, Zwaan, Radvansky, Hilliard, and Curiel (1998) provided an important extension of these results. They used the same paradigm as Zwaan, Magliano, and Graesser, (1995) but different materials. Furthermore, they analyzed all five situational dimensions rather than only three. In all three of their experiments, Zwaan, Radvansky, and their colleagues found reliable effects of temporal and causal discontinuities on reading times, thus replicating the results of Zwaan, Magliano, and Graesser. Moreover, in all three experiments, there were reliable effects of the goal and protagonist dimensions.

The pattern was less straightforward for the spatial dimension. As mentioned earlier, Zwaan, Magliano, and Graesser (1995) did not find effects of spatial discontinuities on reading times. Zwaan et al. (1998) obtained a similar finding in their first experiment. They reasoned that a lack of an effect for the spatial dimension might reflect one of two alternatives. Either readers do not monitor spatial continuity during narrative comprehension or the regression methodology is not sensitive enough to detect effects of spatial discontinuity.

To address these questions, Zwaan et al. (1998) used a paradigm introduced by Morrow, Greenspan, and Bower (1987) and further developed by
Rinck and Bower (1995). In the Morrow–Bower–Rinck paradigm, people first memorize the layout of a building before they read a set of narratives about events taking place in that building. Important to note, each text explicitly describes the movements of a protagonist from one room to another. Thus, the general logic of this paradigm is to first ensure that readers possess a detailed spatial model by having them learn a spatial layout of a building to criterion before reading the narratives about people moving about in that building.

The question of interest studied by Morrow, Bower, Rinck, and their colleagues is not so much whether or not readers construct spatially based situation models during comprehension. Rather, the question was whether and how readers use previously constructed mental maps during comprehension. However, Zwaan et al. (1998) were interested in whether spatial information has an influence on comprehension when it is not needed to respond to a memory probe or resolve an anaphoric reference. In their Experiments 2 and 3, they used the texts from Rinck and Bower (1995) and measured participants’ sentence-reading times. In Experiment 2, the participants first memorized the layout of the building. In Experiment 3, they did not. Zwaan et al. found that spatial discontinuities were reliable predictors when people had first memorized the map (Experiment 2) but not when they had not (Experiment 3). The other four dimensions were reliable predictors in both experiments. Thus, whether or not people monitor spatial discontinuities appears to depend on the prior availability of a mental map.

Table 7.1 summarizes the results for the five experiments conducted in my lab that have employed multiple-regression analyses of reading times. The reading-time analyses have established reliable effects for time and causation in five out of five experiments, for goal and protagonist in three out of three experiments, and for space in only one out of five experiments.

### TABLE 7.1

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<tr>
<th>Experiment</th>
<th>Time</th>
<th>Space</th>
<th>Causation</th>
<th>Motivation</th>
<th>Protagonist</th>
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<tr>
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<td>ZRHC Experiment 3</td>
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One advantage of multiple-regression analyses is that they allow the researcher to use naturalistic texts. Thus, it is possible to examine situation models in their “natural” complexity. On the other hand, it is sometimes difficult to isolate effects of specific variables using these methods. This can be achieved better in factorial designs. For instance, Zwaan (1996) examined, among other things, whether temporal discontinuities influence sentence-reading times. The materials consisted of a set of stories that came in three versions. Somewhere in the middle of the story, a sentence described a target event (e.g., “She walked onto the stage”). This sentence was followed by a sentence that started with a temporal marker (“a moment/hour/day later”) and described an event that was causally unrelated to the previous event (e.g., “She collapsed”). Reading times for the hour and day sentences were significantly longer than those for the moment sentences (which were assumed to preserve temporal continuity). This pattern was markedly different from that in a control experiment in which the critical sentences were not embedded in stories. In this experiment, the reading times for the moment sentences were reliably longer than those for the moment and hour sentences. In other words, the reading times for the critical sentences obtained in the main experiments did not reflect at all their “base rate” reading times, thus eliminating the potential confound that the pattern of reading times in the main experiments was a result of differences in wording among the different versions of the critical sentences.

Many other researchers have examined the effects of causal, motivational, and protagonist-related discontinuities on reading times (see Zwaan & Radvansky, 1998, for a review). The evidence for the processing-load hypothesis is quite strong as far as time, causation, motivation, and protagonist go. However, the evidence regarding the spatial dimension is mixed. Current findings suggest that whether or not people monitor spatial information during narrative comprehension depends on whether (a) they have a previously constructed mental map available during comprehension or (b) they are explicitly instructed to focus on spatial information (e.g., Zwaan, 1993; Zwaan & van Oostendorp, 1993).

The Memory-Organization Hypothesis

According to the memory-organization hypothesis, the strengths of the connections between events in the comprehender’s long-term memory are a function of the number of dimensions on which the events are connected. As with the processing-load hypothesis, this hypothesis has thus far been
investigated in its full extent only using multiple-regression techniques. However, aspects of it have been investigated using factorial designs.

Zwaan, Langston, and Graesser (1995) developed a method to assess the strength of the various dimensions of the reader’s situation model in long-term memory: the verb-clustering task. After reading a text, participants were presented with a set of verbs taken from that text. These verbs denote story events. The event-indexing model had been used in prior analyses of the texts to arrive at predicted verb-clustering scores on the five situational dimensions. The participants then clustered these verbs according to their memory for the text. The clustering scores for all possible verb pairs were subsequently analyzed using multiple-regression analyses. Among the predictor variables in these analyses were the five situational dimensions. The multiple-regression analyses provided estimates of the strength of the long-term memory links on each situational dimension. The results of several experiments that have used the clustering task are summarized in Table 7.2.

The results show some interesting trends. There are two experiments in which all five dimensions were significant predictors. Causation was a significant predictor in all seven experiments, motivation in six, protagonist and space in five, and time in four. Furthermore, in all experiments a majority of dimensions were reliable predictors. Moreover, in the experiments where two dimensions were nonsignificant, the experiment or experimental condition involved special populations, such as students with relatively low proficiency in the language of the narratives (Zwaan &

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Brown, 1996, French texts) or older adults (Zwaan, Charness, & Dijkstra, 1998), who were expected to construct weaker situation models, given their more limited processing resources compared to younger adults.

In memory-organization research, our factorial designs have thus far included only single dimensions. Specifically, we have used two different methods to assess the strengths of the connections between events in long-term memory. The first method is a primed-recognition task, which was originally developed by Ratcliff and McKoon (1978). The second is a memory-retrieval task that was originally developed by J. R. Anderson (1974) and later adapted by Radvansky and Zacks (1991) to study situation models.

In a primed-recognition task, participants read narratives and are presented afterwards with a list of statements for each text that they read. Their task is to indicate as quickly as possible whether or not those statements were from the text. The lists contain a prime-target pair, two statements from the text that are presented consecutively. The assumption is that subjects will access their long-term memory representations of the texts and corresponding situation models when making the recognition responses. Thus, when the prime item is read, subjects will activate the corresponding event node in their long-term memory representation. Activation will subsequently spread to events that are connected to the activated event. The stronger the connection between the prime event and the target event, the more priming the latter should receive and the faster the recognition responses to that item should be. The recognition responses to the target item should reflect the strength of the long-term memory connection between the prime and the target event.

Using this paradigm, Zwaan (1996, Experiment 3) showed that comprehenders connect events in their long-term memory based on temporal contiguity. Recognition responses to target statements (e.g., “She collapsed”) presented after the prime event (“She walked onto the stage”) were significantly faster when the events were temporally contiguous (“She walked onto the stage. A moment later she collapsed”) than when they were not (e.g., “She walked onto the stage. An hour later she collapsed”).

Recently, Hilliard and Zwaan (1998) used this paradigm to investigate long-term memory connections on the motivational dimension. Their study replicated and extended a study by Trabasso and Suh (1993; Suh & Trabasso, 1993). In this study, subjects were presented with one of two versions of a text. In both versions, a protagonist has a goal, such as buying a present for her mother’s birthday. In the goal-success version, this goal is met halfway through the story and the protagonist sets up a new goal, for example, knitting a sweater for her mother. This goal is unrelated to the
initial goal of wanting to buy a present. However, in the goal-failure condition, the goal is not met initially, for example, the protagonist does not have the money to buy a present, and the protagonist sets out to satisfy the initial goal of giving her mother a birthday present in a different way, for example, by knitting a sweater. Thus, in the goal-failure condition, wanting to give a birthday present and knitting a sweater are part of the same goal structure, but in the goal-success condition they are not. Trabasso and Suh’s findings were consistent with this idea. When participants were comprehending the critical sentence about the protagonist engaging in a new action (e.g., knitting a sweater) the initial goal, giving a birthday present, was more activated in the goal-failure condition than in the goal-success condition. Thus, these findings suggest that a connection between the initial goal and the new action was more likely to be made during online comprehension in the goal-failure condition than in the goal-success condition, given that the two events were more likely to co-occur in working memory in the goal-failure condition.

Hilliard and Zwaan (1998) replicated and extended these effects using a primed recognition task (Experiment 1) and a primed-verification task (Experiment 2). In both experiments, participants read the 8 stories used by Trabasso and Suh, 8 new stories that were similar in structure to the Trabasso and Suh stories, as well as 20 filler stories. After the stories, the participants performed a primed recognition task as in Zwaan (1996). The primes were the goal sentences, for example, “giving a birthday present,” and the targets were the new-action sentences (e.g., “knitting a sweater”). In both experiments, subjects who had received the instruction to read “normally” showed significant facilitation in the goal-failure condition compared to the goal-success condition.

Radvansky, Zwaan, Federico, and Franklin (1998) provided evidence for the memory-organization hypothesis for the temporal dimension using J. R. Anderson’s (1974) memory-retrieval paradigm. In this paradigm, participants memorize a set of statements and are later on tested on their memory for these statements by way of a speeded recognition task. In their first experiment, Radvansky and colleagues presented their subjects with statements such as “The banker checked his watch when the camera flashed.” All statements described the event of a protagonist performing an action (e.g., “checking his watch”) plus an “anchoring event” (e.g., “the camera flashed”) during which the action was performed. Among the list of studied items, there could be one, two, or three protagonist-actions paired with an event, that is, three different protagonists performing three different actions during the same event (e.g., the banker checking his watch, the
plumber raising his glass, and the lawyer scratching his ear) or one action paired with one, two, or three different events (e.g., a camera flashing, an alarm sounding, a microwave beeping).

The idea behind this paradigm (see Radvansky & Zacks, 1991) is that memory retrieval is facilitated when events can be integrated into a single situation model. The memory-organization hypothesis predicts that events that take place at the same time should be more integratable than events that take place at different times, all other things being equal. Consistent with this hypothesis, Radvansky et al. (1998) found that response times increased reliably with the number of anchoring events that were linked to a single action whereas there was no reliable increase with the number of actions per anchoring event. Thus, when there were three sentences describing the lawyer scratching his ear at three different times (e.g., “when the telephone rang, when the alarm went off, when the camera flashed”), participants were experiencing retrieval interference, presumably because these three actions could not be integrated into a single situation model. On the other hand, when three actions were described that took place during one event (e.g., the lawyer scratching his ear, the banker checking his watch, and the sailor raising his glass when the camera flashed), participants integrated the three actions into a single situation model and experienced no appreciable retrieval interference. Thus, these results, like those of Zwaan (1996) and the clustering studies discussed earlier, show that people integrate events based on temporal overlap.

FUTURE DEVELOPMENTS

This overview of the assumptions behind, hypotheses generated from, and empirical evidence relevant to the event-indexing model shows that a great deal of work is still ahead of us, both theoretically and empirically.

In the theoretical domain, we need to learn more about how exactly the individual dimensions are represented and whether a uniform, dichotomous, representational format is the optimal solution. This is most likely not the case. Furthermore, we need to seriously consider the representation of the events themselves, rather than merely the nature of the relationships between them. We expect that the work in this area will make contact with research on autobiographical memory (e.g., S. J. Anderson & Conway, 1997), as well as with research on visual media (e.g., Zacks & Tversky, 1997). Researchers in these areas are also concerned with the mental
representations of events. Although these events are not “acquired” through language, situation-model theory (e.g., van Dijk & Kintsch, 1983) predicts that there should be commonalities among how events are mentally represented, regardless of the mode of acquisition. Therefore, it might be fruitful for text-comprehension researchers to take note of these literatures, as others have observed as well (Taylor & Tversky, 1997). The implementation of the event-indexing model in a computer model would provide an important conceptual tool to flesh out the details of some of the assumptions made with respect to the model. In collaboration with Paul van den Broek, I am currently attempting to integrate the event-indexing model with the landscape model (van den Broek, Risden, Fletcher, & Thurlow, 1996).

In the empirical domain, there are many unresolved issues. For example, we need to learn more about the potential role of long-term working memory (Ericsson & Kintsch, 1995) in situation-model construction. Zwaan and Radvansky (1998) proposed that long-term working memory plays an essential role in situation-model construction. Long-term working memory holds promise as a theory of working memory that is more compatible with the demands of online discourse comprehension than traditional short-term working memory. Work is currently underway in my lab to examine this issue. Furthermore, as the previous discussion shows, we know very little about whether and how the situational dimensions interact. Given that regression-type approaches using naturalistic texts do not allow the researchers to control the frequencies with which links on particular combinations of dimensions occur, it is almost impossible to perform statistically powerful tests of potential interactions among situational dimensions. Factorial designs might provide a more promising avenue of research here. The only published study that examines combinations of situational dimensions using factorial designs that I am aware of is Taylor and Tversky (1997), who compared time, space, and protagonist. It will require a great deal of imagination, norming studies, and pilot work to come up with stimulus materials in which relationships are manipulated while relationships on other dimensions are kept constant.

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REFERENCES


