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Beyond Language Comprehension: Situation Models as a Form of Autobiographical Memory

Joseph P. Magliano
Northern Illinois University

Gabriel A. Radvansky
University of Notre Dame

David E. Copeland
University of Southern Mississippi

A great deal of research has examined the role of situation models in text comprehension and memory (see Zwaan & Radvansky, 1998, for a review). This research suggests that there is an isomorphism between representations of narrative and real word events (Magliano, Zwaan, & Graesser, 1999). For example, narrative events are causally linked within a narrative time and space, in much the way that we understand real world events.

Presumably, the cognitive mechanisms that lead to understanding and memories of events operate independently of how they are experienced (Magliano, Miller, & Zwaan, 2001). As such, because they are representations of people's experiences of events in real or possible worlds, we view situation models as a form of autobiographical memory. That is, memory for encountered events, even when encountered through narratives, draws on the same cognitive machinery used to create autobiographical memories. If the same mental representations and processes are used in other circumstances where situation models are created, then they can all be viewed as a form of autobiographical memory. However, there has been relatively little research on this idea (Thompson, Skrowonski, Larsen, & Betz, 1996; Wagenaar, 1986). Although the work on situation models and text comprehension is important, it is also important to assess how well this theoretical framework can move beyond language comprehension to provide insights into cognition more generally.

Here we first provide a brief outline of situation models theory, followed by a discussion of some studies that show how this theory can be applied to areas beyond language comprehension. In particular, we discuss research assessing situation models in the context of comprehending narrative films and negotiating virtual reality interactions. In general, we explore the similarities and differences in the situation models constructed from these different experiences. Both forms of media may more closely resemble everyday experiences than do narrative texts, given their perceptual and analog nature. Furthermore, the goals that motivate one to engage in virtual reality environments are likely to differ somewhat from those that motivate one to read a narrative text. It is reasonable to expect that differences such as these would have an impact on situation model construction. However, if findings from narrative text are replicated for these media, this may suggest that many aspects of situation models for events may be independent of mode of experience and reflect a general representation for event understanding. As such, one reasonable first step in assessing the generalizability of situation model research in the context of narrative texts would be to determine whether traditional findings are replicated for other media, such as those that are described in this chapter.

SITUATION MODELS

Situation models are mental simulations of real or possible worlds (Johnson-Laird, 1983). These mental representations isomorphically capture the elements of a situation and relations among them that define it. There are a number of elements and relations that can be involved in the structure of a model, which can capture static and dynamic aspects of situations (Barwise & Perry, 1983; Wyer & Radvansky, 1998).

In terms of static components, a situation is defined and bounded by a *spatial-temporal framework*. This is the region of space that contains the situation and the stretch of time in which the situation is in force. Time is static in this sense because there is only one time period used to provide the framework to define an event. Within this spatial-temporal framework are *tokens* that represent entities, such as people, animals, objects, abstract concepts, and so forth. Associated with these entities can be various *properties*. These properties can include external physical characteristics, such as size, color, or weight, and internal properties, such as emotional state, goals, and sanity. Finally, there are *structural relations* among entities within a framework, such as spatial, social, and ownership relations. The likelihood that properties and relations are included in a situation model is a function of the degree to which they play a functional role in defining the interaction among situational elements. The more they are interacting or likely to interact, the greater the probability that they will be represented in the model.

In real or simulated situations, we are active participants. As such, the self becomes another entity in a situation model. One's internal and physical states are incorporated into our understanding of the situation. To explore the extent to which situation model theory can be applied to non-text domains, research must assess the role of this aspect in situation model constructions.

For the dynamic component, a series of spatial-temporal frameworks may be joined by a collection of *linking relations*. These linking relations can be things like temporal and causal relations and are grounded in the entities, because it is the entities that are moving through time and which have causal interactions with one another. In this case, time is dynamic because it represents the flow of changes across time in a developing situation.

There is a considerable amount of evidence consistent with the assumption that readers monitor multiple components, as specified by the event-indexing model (e.g., see Zwaan & Radvansky, 1998, for an extensive review). However, within a given context, some components are monitored more closely than others. With respect to the static elements, the spatial-temporal framework is monitored closely because it provides the context that defines the static situation (e.g., Radvansky & Zacks, 1991; Radvansky, Zwaan, Federico, & Franklin, 1998; Bower & Morrow, 1990). Beyond that, the entities and their structural relations are important because these provide the content for the static situation (Radvansky, Spieler, & Zacks, 1993; Radvansky & Copeland, 2001). Entity properties are of less importance unless they provide information about the functional relations among entities in the situation. As such these are at the lowest end of the hierarchy. Linking relations, such as time and causality, have no real definition in static situations because there is no change in time.

There is also a considerable amount of evidence that some dynamic components are monitored more closely than others. For example, during the first reading of a text, reading times increase when there are breaks in causal coherence (Zwaan, Magliano, & Graesser, 1995; Magliano, Trabasso, & Graesser, 1999; Magliano, Zwaan, & Graesser, 1999) and temporal contiguity (Zwaan, Magliano, & Graesser, 1995; Zwaan, 1996; Magliano et al., 1999; Therriault and Rinck, this volume) but not spatial contiguity (Zwaan, Magliano, & Graesser 1995; Magliano et al., 1999; Therriault and Rinck, this volume). Readers do appear to monitor shifts in spatial contiguity when they have a specific goal to do so (Zwaan & von Oostendorp, 1993), when there is a great deal of prior knowledge about the space (Rinck & Bower, 1995; Zwaan, Radvansky, Hilliard, & Curiel, 1998), or upon a second reading of a story (Zwaan, Magliano, & Graesser, 1995; Magliano et al., 1999). Presumably, causal and temporal contiguities are monitored more closely than space because those dimensions provide stronger cues for coherence in episodic memory (e.g., Zwaan et al., 1998). Indeed, causal connectivity and temporal connectivity are strong predictors of coherence judgments (Magliano et al., 1999). Fur-

thermore, the degree of causal connectivity among story constituents is a primary predictor of recall and summarization (see van Den Broek, 1994, for an extensive review). It is important to note that both temporal and spatial relations are also indicative of the extent to which story constituents are connected in memory, but they do not carry as much variance as causal relatedness (e.g., Zwaan, Langston, & Graesser, 1995).

Some researchers have argued that situation models are structured around the narrative protagonist (Ozyurek & Trabasso, 1997; Scott-Rich & Taylor, 2000). For example, Scott-Rich and Taylor (2000) found that character shifts are more likely to lead to decreases in (a) judgments of coherence, (b) judgments of cohesion between narrative sentences, and (c) the accessibility of narrative entities than shifts in either time or location. They interpreted these results as indicating that narrative events are structured around the characters and they are monitored more closely than time or location. However, Rinck and Weber (in press) argued that Scott-Rich and Taylor (2000) confounded shifts in the situation components because they did not independently manipulate them across text versions. In a study to correct this, Rinck and Weber found that characters and time shifts are monitored more strongly than spatial shifts, and there was no evidence that characters were monitored more closely than time. This suggests that when the only linking relation is time, it may not play as large a role in the situation model relative to other components unless it has the support of a causal structure.

ISOMORPHISM BETWEEN SITUATION MODELS AND REAL WORLD EXPERIENCES

As mentioned previously, work on situation models has focused largely on the comprehension and memory of narrative texts. However, situation models should also capture events in the real world. For example, this is found in ideas about embodied cognition and perceptual symbols (Wilson, 2002; Zwaan, in press; Barsalou, 1999). Before moving on, we consider the validity of such an analogical representational form.

Let's take an evolutionary view of human cognition for event comprehension and memory. Humans evolved from other species that were operating in and adapting to complex environments without the aid of human reason and cognitive complexity. Still, it is reasonable to assume that these creatures were able to mentally represent various aspects of their world, mentally manipulate that information, and store it for future use. What sort of mental representations were used?

The two most prominent candidates in current cognitive research on event comprehension and memory are abstract propositions and perceptual symbols (e.g., Barsalou, 1999). The traditional way of thinking about situation models created from text is that they are built up from a propositional textbase used as a scaffolding to create the situation model. Although this is

a possible scenario in some cases, it seems implausible for non-human organisms. Instead, it seems more reasonable that these creatures are creating a mental representation derived from the perceptual information that is readily available. The derivation of abstract propositions is a more highly developed process.

Given this, the situation model is the more fundamental form of mental representation, whereas an abstract propositional representation is a more complex and fragile form of mental representation that is more prone to distortion and forgetting. These characteristics of the different memory representations are well documented in the literature (Fletcher, 1994). As such, we adopt the view that the characteristics of situation models observed in narrative comprehension research should extend to other aspects of cognition where situation models can be assumed to operate. This chapter serves as a tour of some of these areas beyond language comprehension.

BEYOND LANGUAGE COMPREHENSION

One test of situation model theory is to examine whether the same predictions and findings hold for events not conveyed in narratives. For example, do the components involving both static and dynamic elements of a situation (Zwaan & Radvansky, 1998) have a similar influence in other types of experience? To this end we discuss some studies that we have conducted that address this question. The first study involves a different narrative medium, namely film. The latter studies extend to virtual reality experiences (e.g., video games) in which one is a participant. As such, the "self" becomes an entity in a situation model. A domain-independent hypothesis predicts that the general influence of these components on processing is independent of medium or modality of experience (Magliano et al., 2001), although it is possible that their relative importance may vary.

Narrative Film

Compared with texts, there is relatively little research on narrative film comprehension (Baggett, 1979; Magliano, Dijkstra, & Zwaan, 1996; Magliano et al., 2001; Schwan, Hesse, & Garsoffky, 1998; Tan, 1996). Because both narrative texts and films are event-based, theories and findings derived from work on texts should generalize to film (Magliano et al., 1996, 2001). Although there are some similarities, there may be differences regarding the prominence of situation model components. In general, the predictions are that people should parse their understanding of events along the same boundaries as they do events presented in a text. However, given the visual nature of narrative film, it may be the case that spatial dimensions of the situation model take on a more prominent role in defining event boundaries than in

narrative texts. As such, it may be the case that spatial shifts are routinely monitored in this medium, in contrast to narrative texts. Furthermore, the spatial dimension may take on a more prominent role than time (see Zwaan & Radvansky, 1998, for a review).

Spatial-Temporal Framework. Prior research on narrative discourse has shown that readers monitor the changes along boundaries of a temporal framework of a narrative more closely than spatial framework information (e.g., Zwaan, Magliano, & Graesser, 1995). Magliano et al. (2001) assessed whether this is also true for narrative film. Given the visual nature of film, changes in spatial location are more apparent. As such, viewers may find it easier to track spatial framework information in film. Alternatively, it may be that a dominance of time over space in narrative comprehension is medium independent.

To test these possibilities, Magliano et al (2001) used an event-partonomy task (e.g., Newtson, 1973; Newtson & Engquist, 1976). People viewed feature-length narrative films and made *situation-change judgments* by identifying points in the film that contained a change in the situation that the characters were facing. People were not told what constituted a change. One hour from each film was sampled for analyses. Each shot in that hour was coded, and the specific shots in which the participants made their judgments were identified. An *a priori* analysis of the film identified shifts in time, characters locations, and spatial region in the scenes. Note that this analysis of space differed from other discourse analyses (e.g., Zwaan, Magliano, & Graesser, 1995) in that it distinguished between two types of spatial shifts. One type of shift involved the movement to another location, and the second involved shifts to new regions of the narrative space that did not involve the movement of prominent characters.

The large number of shots (total of 2457) enabled a full Time (shift VS no shift) 3 Character movement (shift VS no shift) 3 Spatial region (shift VS no shift) analysis. We calculated situation-change scores by dividing the number of times a person indicated that there was a change by the total number of shots in that cell. For example, if there were 28 shots that had shifts in all three dimensions and a person indicated that there was a change in situation in 20 of these shots, the change score would be .71.

These situation change scores were submitted to a 2 3 2 3 2 repeated measures ANOVA. Consistent with situation model theory, it was found that people index film events along multiple components. There is evidence that these components are indexed independently, but only with respect to time and character movement. Change judgments were greater for shots that contained these shifts than for those that did not. However, change judgments did not increase when there was a shift to a new spatial region. A spatial region shift was only sufficient to create the impression of a new situation when it co-occurred with a temporal shift. There was also evidence for additivity, in which the more shifts that occurred, the greater the impact on the situation-change judgments.

Most importantly for this chapter, the importance of situational components may be medium independent. Shifts in time had a greater impact on perceptions that the situation had changed than either the movement of character or shifts of spatial regions. Furthermore, aspects of space that are linked to a character (i.e., movements) had a greater impact on the perception that the situation had changed than did the shifts to new regions.

Entities, Properties, and Structural Relations. The research in narrative film comprehension suggests that viewers do monitor and index entities, properties, and structural relations. We conducted a new analysis of the Magliano et al. (2001) data to assess whether viewers track characters in the story world. A regression analysis suggested that situation change judgments increased when new characters were introduced or established characters were reintroduced ($t(2442) = 13.801$, Beta $= .22$, $p < .001$). Furthermore, Magliano et al. (2001) showed that once these characters are introduced, viewers monitor their movements in the narrative world. Finally, using a similar paradigm, Magliano, Taylor, and Kim (in press) also found that viewers monitor the goals of multiple characters, but this was primarily the case for those characters that are prominent in the plot. These findings are consistent with picture story narration data (Trabasso & Nickels, 1992). Obviously, more research on this aspect of situation model construction is needed in the context of narrative film comprehension.

Linking Relations. One would expect that both readers and viewers infer causal relations between story events. There is a growing body of evidence for this expectation. Magliano et al. (in press) conducted a reanalysis of the situation change data from Magliano et al. (2001). In this analysis, they assessed the extent to which situation-change judgments increased at shifts in the causal goal episodes (e.g., initiation events, the beginning and ending of goal-oriented action sequences) for primary and/or secondary characters that are interacting during the films. They found that situation change scores increase at shots that depicted shifts in the causal episodes associated with multiple characters in a scene, but only when those characters were central to the plot (i.e., primary characters).

In a similar study, Baggett (1979) had people either read a description of a feature length film or view a picture flip book constructed of movie frames. Judgments of the episode boundaries were the same for both. The correspondence in the perception of these episodes entails that both readers and viewers were inferring and monitoring causal relationships between story events because these episode boundaries are determined by changes in the causal structure (e.g., Trabasso, van den Broek, & Suh., 1989).

There is considerable evidence to suggest that causal relations drive story recall for narrative texts (van den Broek, 1994). There is also some evidence to suggest that the same is true for narrative film. For example, Van den Broek, Pugzles-Lorch, & Thurlow (1996) had participants view and then later recall

a short film. They conducted a causal network analysis on a verbal description of the film. As expected, people recalled events more often that were causally central in the causal hierarchy.

Conclusion

There is a growing body of research on film understanding that is consistent with findings of studies investigating event indexing in the context of narrative text comprehension (see Zwaan & Radvansky, 1998, for an extensive review). For example, Magliano et al. (2001) found that viewers monitor shifts in time more closely than shifts in special regions, which is consistent with the text comprehension research (e.g., Zwaan, Magliano, & Graesser, 1995). In order to further bolster this assessment, we conducted new analysis of the situation-change judgments, using the discourse analyses from Magliano et al. (2001) and Magliano et al. (in press). Specifically, we conduced a series of hierarchical regression analyses in order to determine the unique variance accounted for by shifts in the spatial-temporal framework, shifts in the character entities, and shifts in the causal-goal episodes for primary characters. The second step of these analyses provides an assessment of the unique variance accounted for by variables associated with these different dimensions, while controlling for all other variables that were force entered in the first step. Shifts in the special-temporal framework (e.g., shifts in time and narrative region) accounted for approximately 7% ($F(2, 799) = 47.90$, $p < .05$); shifts in character entities (i.e., introduction of new characters, changes in location of existing characters) accounted for approximately 10% ($F(2, 799) = 66.59$, $p < .05$); and shifts the causal goal episodes (i.e. initiation events, beginning of actions sequence, ending of action sequences for primary protagonists and antagonists) accounted for approximately 12% ($F(6, 799) = 26.78$, $p < .05$). These findings are consistent with research on narrative text comprehension and indicate that situation character entities and the causal episodes in which they interact play a central role in situation model construction relative to the spatial-temporal framework.

It appears that the relative importance of the dimensions of situation continuity when a situation model is constructed is by and large medium independent, at least with respect to narratives. This finding bolsters the claim that the higher level processes involved in situation understanding are generalizable across experiences, whether they occur in text, film, or real life (Gernsbacher, Varner, & Faust, 1990).

Virtual Reality

Recently, we looked at people's performance in virtual reality situations. Of particular interest are flight and ground combat situations. In these tasks, people are asked to interact in some desktop virtual environment. Afterward,

performance was coded with respect to the components as identified by situation model theory.

In addition to looking at performance in the virtual environment, in some cases we had a second person providing assistance in the role of a coach. That is, the coach viewed the subjects' performance on a second computer monitor in a separate room and could communicate over a headphone-microphone system. These conversations were recorded along with game play to a recording device and later scored. The coaches' comments are interesting because they can be used to help our understanding of the processing of situation information when we look at their impact on performance, the type of information that was provided, and when they occurred as the situation developed and unfolded.

In general, the more assistance that was provided by the coaches, the better was player performance. Thus, outside observers are sensitive to the ongoing structure of the situation, have an awareness of what information might be lacking in the player's developing situation model, and provided assistance that was useful.

Because of the structure of these situations, according to situation model theory we can expect that spatial location is going to play a more prominent role than in text comprehension. There is no real influence of temporal shifts in this case because people are moving continuously through time and not making temporal leaps. The fact that the person is an entity in the situation should also increase the salience of entity information, although characteristics of the self are likely to be more salient. Finally, it is reasonable to expect that personal goals within the situation will have a more driving effect on the representation and processing of the situation, because this is how the person is oriented with respect to the ongoing events. The following results are based on looking at performance in 5-s bins. That is, within a given 5-s period, what was the state of the situation, what were the aims of the person, and what sort of assistance was provided?

Spatial-Temporal Framework. In our environments, spatial shifts influenced processing in the ongoing event. For example, in the ground combat situation, when there was change in location, players were more likely to be hit by their enemies when they were present. Also, when we looked at coaches' comments, fewer comments were given when there was a change in spatial location (e.g., the soldier entered a new room) as compared with the case where there was no shift. This suggests that changing location in the virtual environment requires a person to update his or her mental representation, taking away mental resources that would otherwise be devoted to other aspects of situation processing. Comments provided during this time are more likely to be disruptive. Thus, the need to process a change in location is more likely to bring about a greater demand on cognitive resources, just as is seen in text comprehension research (e.g., Zwaan, Langston, & Graesser, 1995; Zwaan, Magliano, & Graesser, 1995).

Entities, Properties, and Structural Relations. An interesting component about these virtual reality situations is the inclusion of the self. The person is an active participant in the situation, rather than experiencing the event indirectly. This self-perspective is interesting because we can look at how the structure of the situation interacting with the self can affect performance.

In our simulations, people needed to monitor various aspects about their own status, such as whether they have been hit by the enemy or are running low on ammunition. Also, people needed to actively interact with the environment through some virtual representations of themselves, either as a fighter plane or as a soldier. The influence of monitoring the self in the situation was most highlighted in terms of the comments that were provided. Specifically, when the person was actively interacting with the environment, when they needed to direct more attention to their own status and to what they needed to do to accomplish their goals, people were provided with fewer comments relative to when they were less actively engaged with the environment.

In addition to the self, a person needed to also monitor other entities in the situation. In this case, these other entities could be active ones that were trying to harm the person, or were passive ones, such as targets that the person needed to destroy. In general, the more entities that a person needed to monitor, the more difficult it was to process information about the situation, and the less effective a person was at achieving his or her goals. Also, the more entities there were in the situation, the less likely the coach was to provide disruptive assistance. The only exception to this was that when there were increased numbers of passive entities, coaches increased the number of comments they provided that updated the person about the status of the current situation, such as whether a target had been hit or not.

Linking Relations. Although the virtual reality situations that we studied progressed steadily through time and involved different causal relations, we were not able to assess these at this point, because there were no clear breaks along either of these dimensions.

Conclusion

Work has begun showing that comprehension of a situation that one is interacting with—in this case, a virtual reality environment—parallels, to some degree, what is observed in the context of narrative text comprehension. It appears that processing is disrupted whether there are significant changes in a situation, similar to what is seen in reading times from people reading texts. Moreover, this seems to influence both the person involved in the situation as well as a person who is merely monitoring this event. This further bolsters the claim that the higher level processes involved in situation understanding are generalizable across experiences (Gernsbacher et al., 1990).

SUMMARY

Although the majority of the research that has tested situation model theory has been conducted in the context of narrative discourse, we believe that situation models are general mechanisms that are used to understand and remember many different types of events. Perhaps this claim is not surprising. As we have argued, it is reasonable to expect that a common set of cognitive mechanisms would operate in many different types of events that are experienced (e.g., texts, film, video games, and real life social interactions). However, this claim must be empirically addressed.

Furthermore, although similar mechanisms may operate to construct meaning across experiences, the nature of the situation models constructed may vary across different types of experiences. Again, such differences can only be revealed through research. In this chapter we presented two different event domains where this theoretical approach has been successfully applied, although more research is needed. This research demonstrates that situation models for different types of experience are similar in some respects. For example, we expect elements of an event that provide a basis for linking parts of the events together in memory, such as causal reasoning, are critical regardless of experience. In particular, the research reported here suggests that causal relationships are important for understanding events across all modalities of experience.

However, the relative importance of static components of a situation may vary across experiences. For example, the extent to which a person monitors location and time may depend on the modality of experience. For example, monitoring changes in location is very important for performing well in a virtual environment. This is in contrast to narrative understanding, in which there is clear evidence that changes in time are monitored more closely than location changes (e.g., Magliano et al., 2001). Additionally, in many types of events, we are participants. In these experiences, characteristics of the self are important to defining the unfolding situation and may be incorporated into a situation model. Again, this is a departure from narrative experiences in which we are side participants.

It seems likely that there are other domains of cognition that are open to the theoretical insights and tools that have been successfully applied in the area of language comprehension. So much of cognition is based on the comprehension and memory of events. There are a myriad of ways that people can experience events, and it seems reasonable that a common mental apparatus underlies the comprehension of all of them.

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