

Situation models, propositions, and the fan effect

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According to theories of language comprehension, people can construct multiple levels of representation: the surface form, the propositional text base, and the situation model. In this study, I looked at how the referential nature of memory probes affects the experience of retrieval interference. All the subjects memorized sentences about objects in locations (e.g., "The potted palm is in the hotel"). When memory probes were sentences and, therefore, referential and most closely associated with the situation model level, no interference was observed during retrieval for information that could be integrated into a common situation model. In contrast, interference was observed in such cases when the memory probes were concept pairs (POTTED PALM-HOTEL) and hence not directly referential. This is interpreted to mean that nonreferential memory probes involve surface form and text base representations more than do referential sentence probes.

When people read a text, they can create three levels of representation (van Dijk & Kintsch, 1983). At the lowest level is the *surface form*, a verbatim representation of the words and syntax that were used. At a higher level is the *propositional text base*, an abstract representation of the idea units present in the text that is not directly tied to a specific surface form. Thus, the surface form and the text base represent what the text was. At the highest level is the *situation model*. This is a representation of the situation to which the text refers (Johnson-Laird, 1983; Zwaan & Radvansky, 1998). The situation model represents what the text was about.

Although all three levels can be created during comprehension, they are not used to equal degrees during memory retrieval (Kintsch, Welsch, Schmalhofer, & Zimny, 1990). For example, initially after reading, all three are in a relatively high state of availability. However, soon the surface form begins to contribute less and is quickly forgotten (Sachs, 1967). Shortly after the surface form is forgotten, the text base also begins to be forgotten. Although it endures longer, people soon have trouble discriminating between ideas that were read and those that were inferred. The situation model remains at a more constant level of availability. Because of the declining influence of the other representations, the situation model begins to dominate processing.

The relative strengths of these representations can be influenced by the perspective taken during a task, in addition to the passage of time. Tasks that focus on the described events are more likely to emphasize the situation

model than those that focus on the texts, which are likely to emphasize the surface form and text base. This is illustrated in a study by Zwaan (1994) in which subjects read a text that was described either as a newspaper report or as extracted from a piece of literature. When subjects thought the text was a newspaper article (in which the aim is to report events in the world), the situation model level was emphasized. In contrast, when subjects thought it was from a piece of literature (in which the language used is as important as the events described), they showed a stronger influence of text base.

The present study constitutes an exploration of the role of multiple representational levels on memory retrieval. The focus is on how memory probes can influence relative emphases and the consequences of such a shift in emphasis on retrieval. Specifically, probes used during recognition were considered. There were two conditions, in both of which the subjects memorized a set of sentences. Then, at recognition, they were given either sentences (e.g., "The potted palm is in the hotel") or concept pairs (e.g., POTTED PALM-HOTEL) as recognition probes. Because sentences refer to a real or possible world, they are more likely to tap into the situation models. In contrast, concept pairs, even for information that was originally learned in sentence form, would be more likely to involve the surface form and text base. They are not referential. Thus, the same information is learned in both cases. What differs is the nature of the retrieval probe.

SITUATION MODELS AND THE FAN EFFECT

Whether or not the type of material presented influences the mental representation and retrieval was assessed using the retrieval interference paradigm of the fan effect (Anderson, 1974). A *fan effect* is an increase in retrieval time and/or error rate with an increase in the number of newly learned associations with a concept. It

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reflects interference during retrieval, with more associations with a concept leading to greater interference, longer response times, and/or higher error rates.

The variant of this paradigm that was used here has been shown to reflect aspects of situation model structure (Radvansky & Zacks, 1991). In this variant, subjects memorize a list of sentences about objects and locations. Of critical importance is the associative structure of the study sentences. For example, suppose Sentences 1–6 form a subset of study materials.

1. The potted palm is in the hotel.
2. The potted palm is in the movie theater.
3. The potted palm is in the airport.
4. The wastebasket is in the hospital.
5. The pay phone is in the hospital.
6. The welcome mat is in the hospital.

Collectively, Sentences 1–3 correspond to the *multiple location* condition, in which one object is associated with a number of locations. Because this information is unlikely to refer to a single state of affairs, a separate situation model is created for each sentence. Then, during recognition, subjects experience interference because the related but irrelevant models that also contain the shared object interfere with retrieval of the appropriate one, complicating the retrieval process.

In comparison, Sentences 4–6 collectively correspond to the *single location* condition because multiple objects are associated with a single location. Because it is easy to interpret these sentences as referring to a common situation, this information can be integrated into a common situation model. During recognition, subjects do not experience interference because there are no competing irrelevant models.

Thus, there is a differential fan effect, with interference occurring in the multiple location condition but not in the single location condition. This pattern has been observed repeatedly (see Radvansky, 1999a, for a review of the literature). It has been observed for temporal (Radvansky, Zwaan, Federico, & Franklin, 1998) and ownership (Radvansky, Wyer, Curiel, & Lutz, 1997) relations as well as for spatial relations (Radvansky, 1998, 1999b; Radvansky, Spieler, & Zacks, 1993; Radvansky & Zacks, 1991; Radvansky, Zacks, & Hasher, 1996). It is important that it is not affected by the order of presentation of the concepts in the study sentences (Radvansky & Zacks, 1991; Radvansky et al., 1996) nor by whether definite or indefinite articles are used in the study sentences (Radvansky et al., 1993). This observed influence of situation models is especially interesting in the task that produced a fan effect in these studies, given that the memorization procedure focuses subjects' attention on remembering sentences verbatim.

TEXT BASES AND THE FAN EFFECT

According to a representational levels view, people create surface form, text base, and situation model rep-

resentations. How do all of these play into the fan effect? For simplicity, I treat the surface form and text base together because they both refer to the text itself, and I simply refer to them as the *text base*. For the information in Sentences 1–6, because the text base represents the text and not what the text is about, there is no reason to expect it to have a situational organization. Although it is not clear what kind of structure it will have, we can infer some likely possibilities from proposition-oriented theories, such as the adaptive control of thought (ACT) family of models (Anderson, 1974, 1983). According to this view, with other things held constant the critical factor for observing the fan effect is the number of associations with a concept. So, for the text base, similar levels of interference should be observed in both the single location and multiple location conditions. This is because both conditions involve the same number of associations. As such, a memory task that emphasizes the text base should show interference in both conditions, in contrast with the differential interference effect observed with situation models.

PREDICTIONS

One of the two subject groups in this study received complete sentence probes (e.g., "The potted palm is in the hotel"), and the other received abbreviated probes of concept pairs (e.g., POTTED PALM–HOTEL). For the complete probe group, in consistency with previous research, it is predicted that subjects will show a differential fan effect, with clear interference for the multiple location condition and substantially less, if any, interference for the single location condition.

In contrast, a different pattern of results is predicted for the abbreviated probe group. According to an extreme view whereby only the text base is used, there should be no differential fan effect, with equivalent levels of interference in both conditions. However, because sentences were initially memorized, it is unrealistic to think that subjects will disregard their situation models altogether. As such, it is more plausible that performance will reflect mixed use of both the situation model and the text base. This would be reflected by a smaller differential fan effect, with a fan effect in the single location condition as well. An alternative possibility is that the nature of the memory probe has no influence on the basic process of retrieval, and similar differential fan effects would be observed in both cases.

METHOD

Subjects

One hundred thirty-two native English speakers (74 female) were recruited from the subject pool at the University of Notre Dame and given partial class credit for their participation.

Materials

The study sentences were derived from a set of concepts combined to create 18 sentences of the form "The *object* is in the *location*," similar to those used in other studies. The associate structure

of the study list design for a hypothetical subject is shown in Figure 1. Objects and locations were randomly assigned to each condition differently for each subject. For recognition, studied probes were the memorized sentences. Nonstudied probes were generated from re-pairings of objects and locations from within the same cell of the design. For example, if the studied sentences from the same cell were Sentences 7 and 8, the nonstudied sentences would be Sentences 9 and 10.

7. The oak counter is in the hotel.
8. The fire extinguisher is in the laundromat.
9. The oak counter is in the laundromat.
10. The pay phone is in the hotel.

This method of generating nonstudied probes prevents subjects from using plausibility judgments rather than recognition decisions (Reder & Anderson, 1980). Because the same number of associations were involved for the object and location concepts in the nonstudied sentences, these sentences were assigned to single location and multiple location conditions and analyzed as such.

Procedure

The subjects memorized a list of 18 sentences using a study test procedure. During memorization, each subject was first presented with the study list and instructed to memorize the sentences as efficiently as possible. The sentences were displayed on a PC-compatible computer, in 20-point Courier font in white on a black background, one at a time for 7 sec each. The sentences appeared halfway down the screen and starting at the left-hand edge. A different random presentation order was used on each cycle. After the list was presented, a set of 24 test questions was given. The test questions were of the form "Where is the *object*?" and "What is in the *location*?" for each object and location, respectively. The test questions were randomly ordered on each cycle. Accompanying each test question was a digit indicating the number of answers (i.e., 1, 2, or 3). The subjects responded by typing their answers into the computer. The computer provided feedback on the accuracy of each answer. If there were incorrect answers, the computer displayed all of the correct answers for 3 sec per answer. After answering the test questions, the subjects returned to the study phase. This study test procedure continued until all of the test questions were correctly answered twice.

The recognition test was timed and administered by computer. There were two types of probes. The subjects in the complete probe group saw sentences (e.g., "The potted palm is in the hotel"), whereas the subjects in the abbreviated probe group saw only concept pairs (e.g., POTTED PALM—HOTEL). These pairs were presented in the same order as in the study sentences, with a dash between them. Each probe item was presented eight times, yielding a total of 288 recognition test trials.

The left button on a computer mouse was pressed to indicate a studied sentence, and the right button was pressed to indicate a nonstudied sentence. The subjects were asked to respond as quickly and as accurately as possible. The order of probes in the recognition test was randomized within each of eight blocks. If an incorrect response was made, immediate feedback was given in the form of a box that appeared along with text that read either *ERROR* STUDIED or *ERROR* NOT STUDIED, whichever was appropriate. This feedback was presented for 1 sec. A set of 18 practice trials was given to familiarize the subjects with use of the mouse buttons. On the practice trials, the computer displayed either the word STUDIED or the words NOT STUDIED, and the subject pressed the appropriate button.

The response time data for correct responses were trimmed by removal of any response time shorter than 200 msec or longer than 8,000 msec. In addition, in accordance with the criteria defined by Van Selst and Jolicœur (1994), a proportion of data trimmed served as a function of the sample size for a given person. This trimming procedure eliminated 4.2% of the data.

RESULTS

Learning

The subjects required 4.8 ($SD = 1.4$) and 5.3 ($SD = 1.7$) study test cycles to memorize the study sentences in the complete and abbreviated probe groups, respectively. This difference was not significant [$t(130) = 1.47, p = .14$].

Response Times

The response time data are summarized in Table 1.¹ These data were submitted to a 2 (probe type: complete vs. abbreviated) \times 2 (studied vs. nonstudied) \times 2 (location: single vs. multiple) \times 3 (fan) mixed ANOVA. Of central interest, there was an effect of location [$F(1,130) = 121.28, MS_e = 76,287, p < .001$], with subjects responding more slowly to multiple location probes ($M = 1,516$ msec) than to single location probes ($M = 1,363$ msec). There was also an effect of fan [$F(2,260) = 33.79, MS_e = 81,225, p < .001$], with response time increasing with an increased number of associations (fan level 1 = 1,358 msec, fan level 2 = 1,466 msec, fan level 3 = 1,495 msec). Furthermore, the location \times fan interaction was significant [$F(2,260) = 27.23, MS_e = 72,349, p < .001$]. Simple effects tests showed that the fan effect was significant for the

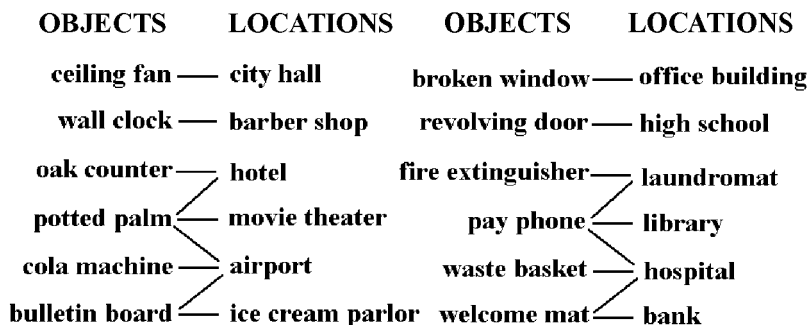


Figure 1. Associative structure between object and location concepts used in the study list design for the experiment. The object and location assignments in this figure are given for a hypothetical subject. In the actual study, the assignment of concepts to positions within this structure was randomized for each subject.

Table 1
Response Times (RTs, in Milliseconds) and Error Percentages (%Error) for the Recognition Test

	Single Location						Multiple Location					
	FL 1		FL 2		FL 3		FL 1		FL 2		FL 3	
	RT	%Error	RT	%Error	RT	%Error	RT	%Error	RT	%Error	RT	%Error
Complete Probes												
Studied	1,404	.04	1,354	.03	1,382	.02	1,401	.03	1,570	.05	1,592	.03
Nonstudied	1,478	.03	1,470	.04	1,462	.05	1,449	.03	1,748	.02	1,842	.05
Abbreviated Probes												
Studied	1,206	.03	1,232	.02	1,262	.04	1,238	.04	1,392	.06	1,435	.04
Nonstudied	1,317	.03	1,391	.03	1,397	.05	1,370	.05	1,567	.05	1,587	.07

Note—FL, fan level.

multiple location condition [fan level 1 = 1,365 msec, fan level 2 = 1,570 msec, fan level 3 = 1,614 msec; $F(1,260) = 51.95$, $MS_e = 90,006$, $p < .001$] but not for the single location condition (fan level 1 = 1,352 msec, fan level 2 = 1,362 msec, fan level 3 = 1,376 msec; $F < 1$). This result replicates those of previous research.

There was a main effect of probe type [$F(1,130) = 6.85$, $MS_e = 1,243,113$, $p = .01$], with the abbreviated probe group ($M = 1,366$ msec) responding more quickly than the complete probe group ($M = 1,513$ msec). This is likely due to the fact that the abbreviated probe group had less to read. There was a significant probe type \times location \times fan interaction [$F(2,260) = 3.79$, $MS_e = 72,349$, $p = .02$]. Although the location \times fan interaction was significant for both the complete and abbreviated probe groups [$F(2,130) = 23.43$, $MS_e = 79,206$, $p < .001$ and $F(2,130) = 5.93$, $MS_e = 65,491$, $p = .003$, respectively], the single location–multiple location difference is larger for the complete probe group ($M = 175$ msec) than for the abbreviated probe group ($M = 131$ msec).

Because the primary focus is on how probe type influences the fan effects of the single location condition, separate analyses were done on these interference effects. These analyses showed that there was no fan effect for the complete probe group (fan level 1 = 1,441 msec, fan level 2 = 1,412 msec, fan level 3 = 1,427 msec; $F < 1$). However, there was an effect for the abbreviated probe group [fan level 1 = 1,262 msec, fan level 2 = 1,312 msec, fan level 3 = 1,330 msec; $F(2,130) = 3.24$, $MS_e = 50,337$, $p = .04$]. Thus, presenting the subjects with abbreviated probes rather than complete sentences led them to experience interference during retrieval in a situation in which it would otherwise be absent.

In addition to the results of primary interest, there was a significant effect of studied versus nonstudied probes [$F(1,130) = 135.93$, $MS_e = 52,411$, $p < .001$], with the subjects responding faster to studied probes ($M = 1,373$ msec) than to nonstudied probes ($M = 1,507$ msec). There was also a significant studied–nonstudied \times location interaction [$F(1,130) = 5.41$, $MS_e = 49,547$, $p = .03$]. Although the single location–multiple location difference was smaller for the studied probes (131 msec) than for the nonstudied probes (174 msec), the effect of condition was significant for both [$F(1,130) = 75.95$,

$MS_e = 44,939$, $p < .001$ and $F(1,130) = 92.16$, $MS_e = 65,354$, $p < .001$, respectively]. Finally, there was a significant studied–nonstudied \times fan interaction [$F(2,260) = 3.68$, $MS_e = 49,547$, $p = .03$], with the fan effect being smaller for the studied probes (fan level 1 = 1,313 msec, fan level 2 = 1,387 msec, fan level 3 = 1,418 msec) than for the nonstudied probes (fan level 1 = 1,404 msec, fan level 2 = 1,545 msec, fan level 3 = 1,614 msec), although it was significant for both [$F(2,260) = 12.56$, $MS_e = 63,420$, $p < .001$ and $F(2,260) = 31.92$, $MS_e = 67,351$, $p < .001$, respectively].

Error Rates

The error rate data are also presented in Table 1. These data were submitted to a 2 (probe type: complete vs. abbreviated) \times 2 (studied vs. nonstudied) \times 2 (location: single vs. multiple) \times 3 (fan) mixed ANOVA. There was a significant effect of location [$F(1,130) = 14.04$, $MS_e = .003$, $p < .001$], with the subjects performing more accurately in the single location ($M = .033$ errors) than in the multiple location ($M = .043$ errors) condition. There was also a significant probe type \times condition interaction [$F(1,130) = 7.07$, $MS_e = .003$, $p = .009$]. For the complete probe group, there was no difference between the single location ($M = .032$ errors) and multiple location ($M = .035$ errors, $F < 1$) conditions. In contrast, for the abbreviated probe group there was a significant difference between the single location ($M = .034$ errors) and multiple location [$M = .052$ errors; $F(1,65) = 17.68$, $MS_e = .003$, $p < .001$] conditions.

In addition, there was a significant studied–nonstudied \times fan interaction [$F(2,260) = 5.45$, $MS_e = .003$, $p = .005$]. There was no fan effect for the studied probes (fan level 1 = .03 errors, fan level 2 = .04 errors, fan level 3 = .03 errors; $F < 1$), but there was a fan effect for the nonstudied probes [fan level 1 = .04 errors, fan level 2 = .04 errors, fan level 3 = .05 errors; $F(2,260) = 4.81$, $MS_e = .005$, $p = .009$]. Finally, there was a significant studied–nonstudied \times location \times fan interaction [$F(2,260) = 4.06$, $MS_e = .003$, $p = .02$]. This is due to the unusually large error rate for the studied, multiple location, fan level 2 condition. There is no clear explanation for this finding. None of the other effects or interactions was significant, including the potentially interesting location \times

fan [$F(2,260) = 1.23$, $MS_e = .003$, $p = .30$] and probe type \times location \times fan [$F(2,260) = 1.19$, $MS_e = .003$, $p = .31$] interactions.

DISCUSSION

The results support the idea that different levels of representation (van Dijk & Kintsch, 1983) can influence the dynamics of memory retrieval in different ways. Although the subjects memorized the same information, the pattern of retrieval times differed depending on the referential nature of the memory probes. For sentence probes, a differential fan effect was observed, with the occurrence of a fan effect in the multiple location condition but not in the single location condition. This is consistent with previous research (see Radvansky, 1999b). In contrast, for abbreviated probes, although there was a differential fan effect, it was less extreme. Of particular interest, there was a fan effect for the single location condition, indicating an added influence of text base interference. This finding is not simply a result of altering the format of the information presented at recognition. A recent study has shown that the same pattern of results is observed when subjects memorize sentences and then are given either sentences or pictures at recognition (Radvansky & Copeland, 2005).

Thus, these results support the idea that people create and can use different representations depending on the demands of a task. In the experiment of the present study, when the subjects were asked to respond to memory probes in which a pair of concepts was listed and which did not reflect a state of affairs in the world, they were more likely to rely on a less referential representation.

More generally, as an alternative to the perspective of the ACT family of theories, a view of the differential fan effect is that during retrieval people pay differential attention to the object and location concepts in the sentences (Anderson & Reder, 1999). Thus, for the differential fan effect observed with the complete probe group in the present study, the argument is that subjects focus all of their attention on one concept (in the present study, the objects) and ignore the other, although it has never been shown why this attention disparity comes about.

The present results pose further problems for this idea. There is no a priori explanation for the emergence of interference in the single location condition when probe pairs are used rather than sentences. Retrieval should be similar in the two cases. It is just that in one case, the relatively constant function words are missing. This consistency between the complete and abbreviated probe conditions was not observed.

In summary, these results further support the idea that people can create multiple levels of representation during learning. The pattern of performance observed during retrieval reflects the relative influences of these levels. Situation model processes are best evaluated using materials

that refer to states of affairs in a real world or a possible world. In contrast, information that is less referential will involve these representations to a lesser degree.

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NOTE

1. Response times and error rates were recorded for cells in which there were multiple associations for the objects and locations as well as for the cells of interest. These data are reported in the Appendix.

APPENDIX

Table A1
Response Times (RTs, in Milliseconds) and Error Percentages
(%Error) for Recognition Test Items Involving
Multiple Associations

	Fan Level 2-3		Fan Level 3-2		Fan Level 3-3	
	RT	%Error	RT	%Error	RT	%Error
Complete Probes						
Studied	1,669	.06	1,803	.06	1,824	.05
Nonstudied	1,802	.04	1,919	.05	1,892	.06
Abbreviated Probes						
Studied	1,503	.07	1,554	.08	1,562	.07
Nonstudied	1,654	.06	1,799	.08	1,753	.08

Note—In the notation X - Y for the fan levels, X is the number of associations with the object concept and Y is the number of associations with the location concept. Thus, the 2-3 cells line up more with the single location condition, and the 3-2 cells line up more with the multiple location condition.

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