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Mental Model Organization

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Previous research (Radvansky & Zacks, 1991) has shown that the fan effect is mediated not by the number of nominal associations paired with a concept but by the number of mental models into which related concepts are organized. Specifically, newly learned "facts" about different objects in one location are integrated into a single mental model and no fan effect is produced, whereas facts about one object in different locations are not integrated and a fan effect is produced. In 6 experiments we investigated several factors' influence on location-based organization preferences. We found no impact of either article type (definite or indefinite) or object transportability. However, animate sentence subjects (people) reduced preference for location-based organizations. A clear person-based organization emerged by using locations that typically contain only a single person (e.g., phone booth) to make location-based situations less plausible.

In six experiments we explored several factors that could potentially mediate the organization of sets of preexperimentally unrelated facts into mental models (Johnson-Laird, 1983). In a previous set of experiments, Radvansky and Zacks (1991) obtained evidence suggesting that mental model representations are used in fact retrieval. In those experiments, a fan effect paradigm (Anderson, 1974, 1983) was used to assess the organizational structure of information in memory. A *fan effect* is a retrieval time or error-rate increase (e.g., on a recognition memory test) accompanying an increase in the number of newly learned facts associated with a concept. For example, it takes longer to retrieve the fact "The yuppie is in the park" when it is also known that "The yuppie is in the bank" and "The yuppie is in the BMW dealership" than if only the first fact is known. In the first case, the concept of yuppie has three associations, whereas in the second case there is only one association.

In the Radvansky and Zacks (1991) research, it was found that a fan effect occurred when several locations were associated with a single object, but not when a single location was associated with several objects, even in the absence of any preexperimental associations. In the present experiments, we used the fan effect methodology as an assessment of the organizational structure of the mental models rather than as a test of the mental model position. Here is an example for clarification. In the Radvansky and Zacks study, each subject memorized a list of sentences, such as the following:

1. The display case is in the city hall.
2. The potted palm is in the city hall.
3. The broken window is in the city hall.
4. The cola machine is in the hotel.
5. The cola machine is in the public library.
6. The cola machine is in the high school.

In this set of sentences, two subsets can be clearly differentiated. The first condition is illustrated by Sentences 1–3, in which a single location (i.e., the city hall) is associated with several objects. This condition is referred to as a single location (SL) condition. The second condition is illustrated by Sentences 4–6, in which several locations are associated with a single object (i.e., the cola machine). This condition is referred to as a multiple location (ML) condition.

We believe that subjects construct mental models (Johnson-Laird, 1983) of the situations described by the sentences. These situational representations are derived from the functional relations among the described entities. With the Radvansky and Zacks (1991) materials, the entities are the objects and locations, and the relation that defines the situations is one of containment (i.e., the objects are contained in the locations). As each new sentence is encountered, information that is consistent with the situation represented in a previous mental model is integrated into that mental model. Furthermore, it is easy to conceive of a single location containing several objects, as is found in the SL condition, as being part of a single situation. On reading sample Sentence 1, a mental model of the display case in the city hall will be created because this sentence describes a situation that is inconsistent with any of the previously described situations. On reading Sentence 2, the potted palm will be integrated into the city hall mental model because one can have multiple objects in a location such as a city hall. In the SL condition, all of the information about a location can be integrated into a single mental model and stored as a unit in long-term memory. During fact retrieval, no matter how many objects are associated with the location, retrieval time is relatively constant. This presumably

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occurs because only a single mental model needs to be retrieved and hence there is no interference and no fan effect for the SL condition. This is consistent with previous research that has shown that information that can be integrated into a single representation produces no fan effect (Moeser, 1979; Smith, Adams, & Schorr, 1978). However, the important difference in our research was that the reduction in interference from integration was based on the situational characteristics of the information rather than any preexperimental association or the presence of a story structure.

By contrast, new information that is inconsistent with all of the previously formulated mental models results in the creation of a new one. A single object associated with several locations, as is true for the ML condition, seems to imply different situations. In this case, several mental models are constructed, one for each of the locations mentioned, although they are considered to be related by virtue of containing a common object. After Sentence 4 has been encoded, Sentence 5 is read and a new mental model based on the public library is created because, although both sentences share the "cola machine" concept, one cannot have the same cola machine in two or more places as part of a single situation. The same applies to Sentence 6. The hotel, public library, and high school mental models are consequently stored separately in long-term memory. During the process of fact retrieval, related but irrelevant mental models interfere with the retrieval of the target model. The amount of interference generated by such irrelevant mental models is greater with an increasing number of them, and retrieval time is lengthened accordingly. As a result, a fan effect occurs in the ML condition. The difference in the fan effects for the SL and ML conditions is taken as an indicator of the use of location-based mental models.

Radvansky and Zacks (1991) also found that if a person knows which separate mental model will be needed for the verification of the probe sentence, then, in the ML condition, the interference from the related and irrelevant mental models, and hence the fan effect, will be attenuated. When the location concept is provided as a precue 1 s before the onset of the probe sentence, such as "hotel" before the sentence "The potted palm is in the hotel," the difference between the fan effects in the SL and ML conditions is eliminated with no fan effect in either condition, whereas providing the object concept as a precue, such as "potted palm," has no consequence on the difference in the fan effects. This evidence supports the assumption that the information in the ML condition is independently stored in separate location-based mental models.

However, the nature of the interference from the irrelevant mental models is unclear at this time. One possibility may be that there are simply more mental models that need to be actively searched in the ML condition but only a single mental model in the SL condition. Greater numbers of mental models that need to be actively searched would increase retrieval time. Another possibility may be that a suppression mechanism is operative during mental model retrieval and that for the ML condition the amount of suppression is divided, whereas for the SL condition it is not. The increased number of mental models in the ML condition would place a greater strain on the suppression mechanism and would lead to an increase in retrieval time.

It should also be noted that the grammatical roles of the location and object items are not at issue here. Previous experiments have shown that there is no difference in the pattern of results for sentences in which the location served as either the sentence predicate (e.g., The potted palm is in the hotel) or the subject (e.g., The hotel has the potted palm).

The Radvansky and Zacks (1991) experiments demonstrated that location-based mental models are used in a fan effect situation when the facts concern object–location associations. In the present six experiments, we used the same methodology to explore several factors that could potentially moderate that organization. The first factor is the type of article (definite or indefinite) associated with the location and nonlocation (i.e., person or object) concepts (Experiments 1, 2, and 4). By varying the articles associated with the concepts, the basis for organizing the mental models could be shifted to and from the location concept by emphasizing the "givenness" of one concept over another. A second factor is the transportability of the object to which the concept refers (Experiment 2). Subjects may be more willing to create object-based mental models when a referent of an object concept can be easily moved from one place to another (e.g., a backpack is more transportable than a cola machine). A third factor is the animacy of the nonlocation concept, specifically, the use of people rather than objects (Experiment 3). Subjects may be less willing to create location-based mental models when the entity concept refers to something that can voluntarily move from place to place. Finally, we explored the possibility that subjects would be less willing to create location-based mental models when the situation of several people occupying a single location at one time is made implausible (Experiments 5 and 6).

Definite and Indefinite Articles

The first factor explored that might have an influence on mental model organization was definite versus indefinite articles. Although the definite article (i.e., *the*) was used with both object and location terms in the earlier research, we suggest that a different pattern of results would emerge when one or both types of concepts are presented with an indefinite article (i.e., *a* or *an*). This is because of the contrasting properties of definite and indefinite articles in terms of given and new information. In a sense, if we take the previous results at face value, then the present experiments attempt to assess the relative power of different bases of mental model organization: location containment versus givenness.

If both the object and location concepts are marked with the same article type, either both definite or both indefinite, there is some evidence that subjects will focus on the relation between the concepts rather than the two entities referred to by the concepts. For example, Hupet and LeBouedec (1975) asked subjects to provide conclusions for sentences, such as "I thought that a/the gangster injured a/the policeman, but I was mistaken, in fact . . . ." When

the concepts were differentially marked, the definitely marked article was the focus of the continuation, but when both concepts were marked equivalently, the event was the focus of the continuation. Grieve and Wales (1973) obtained similar findings in a study reminiscent of the game show "Jeopardy" by having subjects provide questions to statements in which two concepts were either similarly or differentially marked, although the event was the focus only when both concepts were indefinitely marked. The event in the present studies' sentences was the containment of the objects within the locations. So, if the object and location concepts are similarly marked, a location-based organization would be favored. However, when the concepts are differentially marked (one with a definite article and the other with an indefinite article), the definiteness of the article may guide the organization of the information by differentially marking the concepts' givenness and sentential importance.

Definitely marked concepts tend to be identified as given information, whereas indefinitely marked concepts can be identified as new information (Grieve, 1973; Haviland & Clark, 1974; MacWhinney & Bates, 1978). Evidence for this distinction can be seen in the fact that there is faster processing of concepts identified with a definite article than an indefinite article, provided that there is a prior context to establish the given information (Irwin, Bock, & Stanovich, 1982; Yekovich & Walker, 1978). Presumably, this occurs because a definite article refers to an element already present in a mental model, whereas an indefinite article refers to a new element that may or may not be part of an already existing mental model (Murphy, 1984). In general, definite articles imply that a description's referents are specific entities. Mentioning "*the* city hall" several times will often be interpreted as referring to the same city hall, whereas mentioning "*a* city hall" several times does not necessarily imply that the same city hall is being mentioned each time. In fact, the indefinite article implies different city halls.

In fan effect experiments, it may be that in cases in which concepts are differentially marked with definite and indefinite articles, subjects will be more inclined to incorporate the definitely marked information into previously existing mental models when possible (Schultz & Kamil, 1979). This would not lead to a fan effect in the SL condition, as was found by Radvansky and Zacks (1991). Integration is possible in the SL condition, but not the ML condition. In the cases in which the concepts are marked with indefinite articles, the subjects may be less inclined to incorporate facts into previously created mental models because each concept is marked as new in each fact. This could imply that each mention of a concept refers to a separate entity.

Another question that can be asked is as follows: Under conditions in which the object is the given information (e.g., The potted palm is in a city hall), and potentially the basis for organization, what sort of situational representation would be organized around the object? Situations can be generally described of as being two types, either as *states of affairs* or as *courses of events* (Barwise & Perry, 1983). In the cases in which information is organized by location, the situation is a state of affairs. All of the elements are in one place and at one time. In the cases in which information is organized by the nonlocation concept (a person or object), the situation could be a course of events. In that case, there would be some consistent entity that moves from place to place, such as a person going from one place to another as part of a series of errands. Marking the location concept with a definite article (e.g., A yuppie is in the park) could serve to suggest a state-of-affairs interpretation, whereas marking the object with a definite article (e.g., The yuppie is in a park), at least when the location is indefinitely marked, could serve to suggest a course-of-events interpretation. The predicted results for such an organization from the current experimental paradigm would be just the opposite of what has been demonstrated to date, namely, a fan effect for the SL condition, but not for the ML condition.

To test whether the type of article paired with the concepts does have an effect on the type of situation encoded, we presented the subjects in Experiments 1 and 2 with one of four conditions. These conditions were a definite object–definite location (DD) condition (e.g., *The* cola machine is in *the* hotel), a definite object–indefinite location (DI) condition (e.g., *The* cola machine is in *a* hotel), an indefinite object–definite location (ID) condition (e.g., *A* cola machine is in *the* hotel), and an indefinite object–indefinite location (II) condition (e.g., *A* cola machine is in *a* hotel). If the article type has an effect, the strongest location organization should occur for the ID condition. This is because the definite location article identifies the location as a specific one, so if it is mentioned several times it is more likely to be interpreted as the same instance each time. The indefinite object is more likely to be interpreted as a different instance in each location. The strongest object organization should occur for the DI condition because the definite object article identifies it as a specific instance, as with the location in the ID condition. A parallel line of reasoning can be applied to the indefinite location for the DI condition as to the object in the ID condition. This concept is not identified as a specific instance and so does not become the focus of organization. The DD and II conditions are expected to show a location-based organization because the relation of containment will be the focus rather than either the object or location concepts (Grieve & Wales, 1973; Hupet & LeBouedec, 1975). However, these conditions may show a weaker location-based organization than the ID condition because neither concept is overtly favored by article type.

Experiment 1

Method

Subjects. Twelve subjects were tested in each of the four groups (DD, DI, ID, and II). Two additional subjects were replaced, one because of equipment failure and the other because of a failure to memorize the sentences. All subjects in this and subsequent experiments were recruited from the Michigan State University subject pool and were native speakers of English. All subjects were given partial class credit for their participation (except in Experiment 4).

Materials. The sentences were created by randomly pairing an object and a location to create sentences such as the following:

7. The revolving door is in the public library.
8. A pay phone is in a hotel.

In order to determine the sensibility of using different object–location pairs, a normative study was conducted. A set of 48 objects was paired in all combinations with 12 common locations (e.g., barber shop and hotel) to yield a set of 576 sentences. These sentences used only definite articles. The locations were the same as those used by Radvansky and Zacks (1991). The sentences were divided up into six lists, such that each object appeared twice on each list. In addition to the experimental sentences, a set of 16 deliberately nonsensical sentences was added to each list. The order of the sentences in each list was random. The sentences in each list were rated by 6–15 (M = 12) subjects, with a total of 72 subjects participating.

In anticipation of Experiment 2, we also obtained transportability ratings of the objects used in the sentences. The objects presented during the normative study were designed to be either highly transportable or nontransportable. We chose to use nontransportable objects in this experiment because these were similar to the types of materials used previously by Radvansky and Zacks (1991).

The subjects' task was to rate each sentence on two criteria. The first was how sensible each sentence seemed. A 1–5 scale was used, with 1 indicating *completely nonsensicle* and 5 indicating *completely sensible*. The second criterion was how transportable the object in the sentence was. Again, a 1–5 scale was used, with 1 indicating *not easily transportable* and 5 indicating *easily transportable*. Subjects indicated their ratings by filling in the appropriate circles on a computer scan sheet.

Mean sensibility and transportability ratings were obtained for each object across all of the sentences mentioning it. The objects were divided up into two groups on the basis of the transportability rating. The objects with a mean transportability score greater than 3 were placed in the high-transportability group and the rest in the low-transportability group. From within each of these groups, the 12 objects with the highest overall sensibility ratings were chosen as the objects to be used in Experiments 1 (low transportability) and 2 (high transportability). For high- and low-transportability objects respectively, the mean transportability ratings were 4.7 and 1.8, and the mean sensibility ratings were 4.3 and 4.1. The transportability ratings between the two object types differed, $t(22) = 22.17$ (all statistical tests reported here relied on a significance level of .05 unless otherwise stated), whereas the sensibility ratings did not, $t(22) = 1.49$, $p > .10$. Because of this selection process, the 12 objects used in each experiment could each be paired with any of the 12 locations and the resulting sentences would be more or less sensible. A complete list of objects and locations used in Experiments 1 and 2 appears in Appendix A.

The study list design for each subject is presented in Appendix B. The lowercase letters indicate object concepts and the uppercase letters indicate location concepts. Across subjects, different objects served as specific *a–l* items and different locations served as specific *A–L* items through a computerized randomization. Although the conditions of interest were those in which a single location was associated with one or more objects or a single object was associated with one or more locations, other conditions involving sentences in which several objects were associated with several locations were included in the study list to create the necessary number of associations. Twice as many sentences were included in the condition in which both the object and location occurred in only one sentence (Fan Level 1) so that half could be assigned to the SL condition and half to the ML condition. This provided a baseline with which to compare the larger fan levels within both conditions. This assignment of the Fan Level 1 sentences to the SL and ML conditions was done arbitrarily.

Procedure. Subjects were tested individually in a single session lasting approximately 1 hr. Each subject was first presented with a study list consisting of 18 sentences with the instruction to memorize those sentences as efficiently as possible. The sentences were displayed one at a time for 7 s each on a monochrome (green) screen controlled by an Apple IIe computer. The sentences appeared halfway down the screen beginning on the left-hand edge. A 40-column presentation mode was used.

A study–test procedure was used for sentence list memorization. Each subject studied a different set of sentences. After viewing the study list items, subjects were given a series of test questions. These questions were of the form, "What is in a(n)/the *location*?" and "Where is a(n)/the *object*?" for each location and object, respectively. The appropriate articles were used based on the group the subject was in. If a subject failed to give a correct answer, the experimenter provided it for the subject using the appropriate article. After all of the questions had been presented, the subjects returned to the study portion. This study–test procedure was repeated until the subjects could correctly answer all of the test questions on two successive cycles. This was the criterion for memorization. A different random presentation order was used for each study and test trial. For the DD, DI, ID, and II conditions, subjects took an average of 3.8, 3.8, 3.9, and 4.0 cycles to memorize the sentences. There were no differences among the different article conditions ($F < 1$).

Once a subject had memorized the list, a speeded recognition test was administered on the computer. Studied and nonstudied facts were presented. Subjects pressed a button held in the right hand to indicate a studied fact and pressed a button held in the left hand to indicate a nonstudied fact. A practice period of 18 trials was provided to familiarize the subjects with using the buttons in this manner. On the practice trials the computer displayed either "SENTENCE STUDIED" or "SENTENCE NOT STUDIED," and the subject had to press the appropriate button. On the recognition test itself, the studied probes were sentences from the study list and the nonstudied probes were generated by re-pairing the object and location concepts from within a cell of the design. For example, if the studied sentences from the same cell were Sentences 9 and 10, the nonstudied sentences would be Sentences 11 and 12.

9. The pay phone is in the public library.
10. The big desk is in the hotel.
11. The pay phone is in the hotel.
12. The big desk is in the public library.

Responses to the nonstudied sentence probes could be expected to show the same pattern of results as for the studied probes. For the verification of information from the SL condition, there were two mental models that contained the probes for appropriate information: the one for the location concept and the one for the object concept. Because there were two mental models to be searched rather than one, a general increase in reaction time (RT) would occur, but no fan effect would be expected. For the ML condition, the probed information was contained within the mental model of the location concept as well as the mental models associated with the object concept. Therefore, the RTs would be longer than for studied probes because more mental models were involved; furthermore, the greater number of mental models associated with the object concept would result in greater amounts of interference and hence a fan effect for the verification of nonstudied probes in the ML condition. In addition, for both the SL and ML conditions, subjects may impose an additional increase in a wait time during retrieval in order to allow for the po-

tential retrieval of weakly stored information when the retrieval process becomes complicated by several associations with a concept (Anderson, 1983).

The order of probe presentation in the recognition test was random. The sentences from cells in which several objects were associated with several locations were not presented during the recognition test. This was because the data from these cells did not apply to the question being asked in these experiments: whether there would be fan effects in the SL and ML conditions. All of the remaining sentences from the study lists and their nonstudied equivalents were presented eight times each, yielding a total of 192 trials. Subjects were allowed a self-timed break halfway through the experiment. The computer recorded RTs and errors.

If a subject responded incorrectly on a trial, he or she received immediate feedback. The feedback consisted of the presentation of a line that read either "*ERROR* SENTENCE STUDIED" or "*ERROR* SENTENCE NOT STUDIED," whichever was appropriate. This feedback was presented for 500 ms. For purposes of analysis, errors also included trials for which the RTs were shorter than 500 ms or longer than 10,000 ms. Also for purposes of analysis, for each subject, RTs that were 2.5 *SD*s from the mean of a given cell of the design were dropped from the analysis, although they were not counted as errors. This trimming procedure eliminated 2.8% of the data in Experiment 1.

Results

Basic studied–nonstudied and fan effect results. In all of the experiments, the main effects of studied–nonstudied and fan usually reached significance, and the Studied–Nonstudied × Fan interaction often did as well. This was generally true for both RTs and error rates. Although this information is important and consistent across experiments, it is not central to the hypotheses. Consequently, rather than reporting the results for these effects for each experiment, we present the statistical tests and means in Table 1. The general pattern of the results was that studied probes were responded to faster and with fewer errors than were nonstudied probes; increases in the level of fan resulted in increased RTs and error rates; and the fan effect was smaller for studied probes than nonstudied probes. This pattern replicated the basic findings usually obtained (e.g., Anderson, 1974) in fan effect studies. We turn now to the data of primary interest: those relating to the SL–ML differences.

RTs. The mean RTs for Experiment 1 are presented in Figure 1. The data presented in this and all other figures were collapsed across studied and nonstudied probes. The primary indexes of fact organization were the SL–ML difference and the fan effects for the SL and ML conditions as described earlier. For a location-based organization, we predicted that the SL condition would be faster than the ML condition and that only the ML condition would show a fan effect. The opposite was true for an object-based organization. In this experiment, probes from the SL condition were responded to faster (1,526 ms) than those from the ML condition (1,662 ms). This was further qualified by the fact that there was only a small fan effect for the SL condition but a substantial fan effect for the ML condition. This supported the notion that there was a general tendency across the different article combinations to organize the facts into location-based mental models. As can be seen in Figure 2, the type of article combination had no effect on the organization of the facts. All conditions showed a location-based organization.

The RT data were submitted to a 4 (article type) × 2 (studied–nonstudied) × 2 (SL–ML) × 3 (fan) mixed analysis of variance (ANOVA) to support these observations. The first variable was between subjects and the rest within. (All statistical tests relied on a significance level of .05 unless otherwise stated.) The main effect of SL–ML was significant, $F(1, 44) = 17.25$, $MS_e = 154{,}190$, as was the SL–ML × Fan interaction, $F(2, 88) = 14.28$, $MS_e = 80{,}944$. As assessed by simple effects tests, the SL fan effect was marginally significant, $F(2, 88) = 2.93$, $MS_e = 93{,}236$, $p < .06$ (Newman-Keuls tests showed no significant pairwise differences), whereas the ML fan effect was clearly significant, $F(2, 88) = 38.60$, $MS_e = 97{,}904$. Newman-Keuls tests showed significant differences between all three fan levels. Importantly, the main effect of article type and the Article Type × SL–ML and Article Type × SL–ML × Fan interactions were not significant (all $Fs \leq 1.03$).

There were two other effects that reached significance in the RT analysis, although these were of lesser interest to the issues addressed here. The first was the Studied–Nonstudied × SL–ML interaction, $F(1, 44) = 7.43$, $MS_e = 55{,}772$. The difference between the SL and ML conditions was larger for nonstudied probes than for studied probes. The mean SL and ML RTs were 1,468 and 1,550 ms for studied probes and 1,585 and 1,775 ms for nonstudied probes, respectively. The other was the Article Type × Studied–Nonstudied × Fan interaction, $F(6, 88) = 2.46$, $MS_e = 51{,}033$. The difference between the fan effects for the studied and nonstudied probes was statistically significant for the DI and ID groups, $F(2, 22) = 5.08$, $MS_e = 51{,}218$, and $F(2, 22) = 4.73$, $MS_e = 36{,}791$, respectively, but not for the DD and II groups (both $Fs \leq 1.88$). This interaction was of little importance because it failed to approach significance in two similar subsequent experiments.

Errors. The pattern of results for the error rates largely paralleled those of the RTs. Subjects made fewer errors in the SL condition than the ML condition. There was no fan effect in the SL condition, but there was in the ML condition. There were no differences involving the type of article.

The error rates were submitted to an ANOVA similar to that for the RT data. The main effect of SL–ML and the SL–ML × Fan interactions were significant, $F(1, 44) = 6.70$, $MS_e = 63$, and $F(2, 88) = 5.42$, $MS_e = 50$, respectively. Simple effects tests showed that the ML fan effect reached significance, $F(2, 88) = 8.58$, $MS_e = 64$, whereas the SL fan effect did not ($F < 1$).

The SL–ML difference was smaller for the studied probes than the nonstudied probes, with mean studied errors of 2.9% and 2.8% for SL and ML probes, respectively, and with mean nonstudied errors of 2.5% and 6.0%, respectively. Both the Studied–Nonstudied × SL–ML interaction and the nonstudied probe SL–ML effect reached significance, $F(1, 44) = 14.99$, $MS_e = 44$, and $F(1, 44) =$

Table 1
Statistical Results and Cell Means for Studied–Nonstudied and Fan Main Effects and Studied–Nonstudied × Fan Interaction for the Six Experiments

Experiment	F	df	MS_e	M
		Reaction times		
Experiment 1				
Studied–Nonstudied	87.66*	1,44	48,257	1,509 and 1,680 ms
Fan	27.81*	2,88	110,358	1,453, 1,634, and 1,696 ms
Studied–Nonstudied × Fan	4.88*	2,88	51,033	
Studied fan	11.87*	2,88	69,245	1,409, 1,526, and 1,591 ms
Nonstudied fan	25.20*	2,88	94,378	1,497, 1,742, and 1,801 ms
Experiment 2				
Studied–Nonstudied	80.19*	1,44	64,791	1,445 and 1,635 ms
Fan	8.41*	2,88	134,649	1,460, 1,548, and 1,613 ms
Studied–Nonstudied × Fan	6.78*	2,88	51,622	
Studied fan	1.56	2,88	73,376	1,411, 1,444, and 1,480 ms
Nonstudied fan	12.12*	2,88	112,895	1,508, 1,651, and 1,746 ms
Experiment 3				
Studied–Nonstudied	64.80*	1,23	49,131	1,380 and 1,590 ms
Fan	14.38*	2,46	108,664	1,342, 1,525, and 1,588 ms
Studied–Nonstudied × Fan	< 1			
Experiment 4				
Studied–Nonstudied	67.72*	1,44	105,760	1,408 and 1,631 ms
Fan	14.86*	2,88	149,598	1,402, 1,546, and 1,612 ms
Studied–Nonstudied × Fan	8.13*	2,88	60,890	
Studied fan	5.43*	2,88	72,355	1,334, 1,445, and 1,445 ms
Nonstudied fan	16.83*	2,88	138,132	1,469, 1,647, and 1,779 ms
Experiment 5				
Studied–Nonstudied	47.38*	1,23	61,717	1,397 and 1,598 ms
Fan	11.75*	2,46	106,905	1,384, 1,497, and 1,612 ms
Studied–Nonstudied × Fan	5.66*	2,46	32,494	
Studied fan	3.41*	2,46	70,294	1,327, 1,394, and 1,469 ms
Nonstudied fan	17.37*	2,46	69,105	1,440, 1,599, and 1,756 ms
Experiment 6				
Studied–Nonstudied	48.42*	1,47	156,506	1,627 and 1,789 ms
Fan	8.40*	2,94	228,800	1,627, 1,742, and 1,756 ms
Studied–Nonstudied × Fan	8.18*	2,94	142,405	
Studied fan	< 1			1,609, 1,631, and 1,641 ms
Nonstudied fan	11.77*	2,94	258,126	1,645, 1,853, and 1,871 ms
		Errors		
Experiment 1				
Studied–Nonstudied	9.60*	1,44	32	2.8% and 4.3%
Fan	6.90*	2,88	43	2.3%, 3.5%, and 4.8%
Studied–Nonstudied × Fan	8.15*	2,88	34	
Studied fan	< 1			2.8%, 2.9%, and 2.9%
Nonstudied fan	9.65*	2,88	59	1.9%, 4.2%, and 6.8%
Experiment 2				
Studied–Nonstudied	< 1			3.2% and 3.6%
Fan	4.65*	2,88	31	2.7%, 3.2%, and 4.4%
Studied–Nonstudied × Fan	3.28*	2,88	42	
Studied fan	< 1			3.1%, 3.3%, and 3.2%
Nonstudied fan	6.79*	2,88	41	2.2%, 3.2%, and 5.5%
Experiment 3				
Studied–Nonstudied	< 1			3.6% and 3.4%
Fan	1.37*	2,46	25	3.2%, 3.2%, and 4.2%
Studied–Nonstudied × Fan	< 1			
Experiment 4				
Studied–Nonstudied	2.18	1,44	30	3.1% and 3.7%
Fan	< 1	2,88	62	2.9%, 3.3%, and 4.0%
Studied–Nonstudied × Fan	3.15*	2,88	37	
Studied fan	< 1			3.3%, 3.0%, and 2.9%
Nonstudied fan	2.42***	2,88	71	2.5%, 3.6%, and 5.1%
Experiment 5				
Studied–Nonstudied	1.21	1,23	32	2.9% and 3.6%
Fan	5.42*	2,46	32	2.7%, 2.2%, and 4.8%
Studied–Nonstudied × Fan	< 1			
Experiment 6				
Studied–Nonstudied	< 1			
Fan	1.34	2,94	41	
Studied–Nonstudied × Fan	4.02*	2,94	64	
Studied fan	3.18*	2,94	41	3.4%, 4.0%, and 2.3%
Nonstudied fan	2.85**	2,94	64	2.7%, 3.6%, and 4.6%

* $p < .05$. ** $p = .06$. *** $.10 < p < .05$.

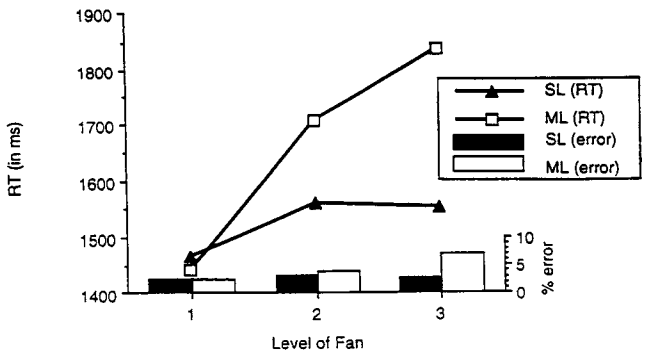

Figure 1. Overall comparison of the reaction times (RTs) and error rates for the single location (SL) and multiple location (ML) conditions for Experiment 1.

14.21, $MS_e = 64$, whereas the studied probe SL–ML effect did not ($F < 1$).

Discussion

Experiment 1 investigated the possibility that the type of article paired with the object and location in the asymmetrically marked conditions could affect how the sentences were organized or what mental models they suggested. In particular, when one article was definite and the other was indefinite, there was reason to expect that the concept marked with the definite article might serve as the basis for organizing the mental model. This was because concepts identified with definite articles tend to be marked as given information (Grieve, 1973; Haviland & Clark, 1974; MacWhinney & Bates, 1978). There was no evidence in this experiment to support this hypothesis. However, the data do replicate the results of Radvansky and Zacks (1991) in demonstrating a fan effect in the ML condition, but not the SL condition. This supports the notion that mental model representations are being used.

Transportability

Another factor that may influence the organization of information into mental models is the transportability of the object concepts mentioned in the study sentences. Highly transportable objects may be more amenable to a course-of-events representation because the objects can be easily moved from one location to another. By contrast, nontransportable objects should not be similarly represented because they typically stay in one place for long periods of time. Therefore, only state-of-affairs descriptions would be encoded.

In the Radvansky and Zacks (1991) experiments, the objects used included things such as ceiling fans, revolving doors, and cola machines, objects that are low in transportability. Because of this, course-of-events situations would have been implausible. It is rare that someone would encounter situations in which a revolving door goes from place to place as part of a coherent sequence of events (except perhaps during a tornado). This leaves state-of-affairs representations as the basis for organizing the information. Experiment 2 replicated Experiment 1, except that the objects presented in the study sentences were transportable. We made the same predictions for the effects of article type on the organization of the mental models for Experiment 2 as for Experiment 1, although, given the results of Experiment 1, there was reason to doubt that these predictions would be upheld. However, we repeated this manipulation because of the possibility that the effect of article definiteness could interact with object transportability.

Experiment 2

Method

Subjects. Twelve subjects were tested in each of the groups. Six additional subjects had to be replaced, 3 each because of experimenter error and failure to memorize the sentences.

Materials and procedure. The materials for Experiment 2 were taken from the normative study described in Experiment 1. The generation of the study sentences was identical to Experiment 1, except that transportable objects were used rather than nontransportable ones. Subjects were tested in a fashion identical to Experiment 1. For the DD, DI, ID, and II conditions, subjects took an average of 4.4, 4.3, 4.7, and 4.3 cycles, respectively ($F < 1$) to memorize the sentences. The trimming procedure eliminated 3.0% of the recognition test data.

Results

RTs. The means for Experiment 2 are summarized in Figure 3. Like Experiment 1, the mean RT for the SL condition was faster (1,475 ms) than for the ML condition (1,605 ms). In addition, there was a difference in the fan effects for the two conditions. The fan effect was present for the ML condition, but not for the SL condition. These results are consistent with a location-based organization of the mental models. Also, as can be seen in Figure 4, there were no differences in organization for the different definite and indefinite article combinations.

The RT data were submitted to a 4 (article type) × 2 (studied–nonstudied) × 2 (SL–ML) × 3 (fan) mixed ANOVA. The first variable was between subjects and the rest within. The main effect of SL–ML and the SL–ML × Fan interaction were significant, $F(1, 44) = 29.70$, $MS_e = 82{,}443$, and $F(2, 88) = 13.88$, $MS_e = 76{,}931$, respectively. Simple effects tested showed that the fan effect for the ML condition was significant, $F(2, 88) = 21.65$, $MS_e = 95{,}962$, but not for the SL condition, $F(2, 88) = 1.06$. For the ML condition, Newman-Keuls tests showed significant differences between Fan Level 3 and Fan Levels 1 and 2. There were no significant effects involving article type.[1] There

[1] Although the statistical analyses did not show any effects of article type on the organization of mental models, a closer look at the data suggested that this conclusion was premature. A priori, the condition most likely to show a difference from the previous single location (SL)–multiple location (ML) pattern would be the definite object–indefinite location condition for Experiment 2, in which

was also a significant Studied–Nonstudied × SL–ML interaction, $F(1, 44) = 4.91$, $MS_e = 48{,}284$. The difference between the SL and ML conditions was larger for nonstudied probes than for studied probes. The mean SL and ML RTs were 1,400 and 1,490 ms for studied probes and 1,550 and 1,721 ms for nonstudied probes, respectively.

Errors. The pattern of error rates paralleled the RT data. The subjects made fewer errors in the SL condition relative to the ML condition. Also, although the ML condition showed a fan effect, the SL condition did not. There were no effects of article type on the error rates.

The error data were submitted to an analysis similar to that done on the RT data. There was a main effect of SL–ML and an SL–ML × Fan interaction, $F(1, 44) = 5.20$, $MS_e = 24$, and $F(2, 88) = 3.76$, $MS_e = 37$, respectively. Simple effects tests showed that the fan effect was significant for the ML condition, $F(2, 88) = 6.01$, $MS_e = 46$, but not for the SL condition ($F < 1$). The Studied–Nonstudied × SL–ML × Fan interaction also reached significance, $F(2, 88) = 3.63$, $MS_e = 42$. There was no difference in the SL and ML fan effects for the studied probes ($F < 1$). However, for the nonstudied probes there was a difference in these fan effects, $F(2, 88) = 6.79$, $MS_e = 42$. The SL condition did not show a fan effect ($F < 1$), whereas the ML condition did, $F(2, 88) = 8.46$, $MS_e = 65$.

Comparison of Experiments 1 and 2. Because the only difference between Experiments 1 and 2 was object transportability, these results could be compared in order to directly assess any effects of object transportability on the organization of the facts into mental models. In general, there were no significant effects of object transportability on organization. The only differences involved variations of studied–nonstudied differences in specific conditions.

The RT data were combined and submitted to a 2 (experiment) × 4 (article type) × 2 (studied–nonstudied) × 2 (SL–ML) × 3 (fan) mixed ANOVA, with the first two variables varied between subjects and the rest within. The experiment variable can be thought of as an effect of transportability. There were two interactions involving experiment that approached significance: the Experiment × Article Type × Studied–Nonstudied × SL–ML interaction, $F(3, 88) = 3.02$, $MS_e = 52{,}601$, and the Experiment × Studied–Nonstudied × SL–ML × Fan interaction, $F(2, 176) = 2.90$, $MS_e = 38{,}748$, $p < .06$.[2] These interactions reflected minor variations in the studied and nonstudied differences in various conditions of the two experiments. What is important is that the Experiment × SL–ML and Experiment × SL–ML × Fan interactions did not approach significance ($F < 1$) and $F(2, 176) = 1.48$.

For the errors, only the five-way interaction was significant, $F(6, 176) = 2.16$, $MS_e = 40$, but error rates were low, so this interaction probably means little. Again, the Experiment × SL–ML and Experiment × SL–ML × Fan interactions did not approach significance (both Fs < 1).

Discussion

Experiment 2 investigated the possibility that if subjects were presented with transportable objects, they may be more willing to consider them as the basis for organizing mental models because they can be readily and typically moved from location to location. This hypothesis was not supported by the data. Furthermore, in an analysis involving both Experiments 1 and 2, there were no meaningful differences between the way subjects treated transportable and nontransportable objects. In both cases, the subjects considered the situations as being location based. This was consistent with previous results (Radvansky & Zacks, 1991). Experiment 2 also failed to support the possibility that the article types paired with the objects and locations in the study sentences could affect the way situations were encoded.

Animacy

The Radvansky and Zacks (1991) experiments and Experiments 1 and 2 all used study sentences in which the nonlocation term referred to an inanimate object. This fact might have contributed to the tendency to organize the mental models around the location concepts. Specifically, inanimate objects do not typically move of their own volition from place to place. They are often bound to a single location on the basis of their inanimateness, which would result in the location serving as the basis for organizing the mental models. If animate sentence subjects were used, a different set of results may be obtained.

This hypothesis is a reasonable one to make on the basis of other evidence showing that information concerning inanimate and animate concepts is processed and represented differentially. For example, words referring to animate entities are remembered better than words referring to inanimate entities (Byrne & Davidson, 1985; Glanzer & Koppenaal, 1977; Rohrman, 1970). Also, in sentences that contain both animate and inanimate concepts, there is a

transportable objects were used. If the mean reaction times (RTs) for the studied probes are considered, there is a substantial overlap in the SL and ML RTs. This suggested that perhaps there was indeed an effect of the article type. To explore this possibility, we tested an additional 12 subjects in this condition. The inclusion of the additional subjects, however, did not support this idea. Instead, the effect of the larger group size was to make this condition more like the others. The mean RTs with the additional 12 subjects were 1,457 ms, 1,467 ms, and 1,465 ms for the SL studied probes; 1,472 ms, 1,649 ms, and 1,539 ms for the ML studied probes; 1,604 ms, 1,662 ms, and 1,560 ms for the SL nonstudied probes; and 1,572 ms, 1,946 ms, and 1,962 ms for the ML nonstudied probes. Although the SL–ML difference was significant for both group sizes, $F(1, 11) = 5.62$, $MS_e = 103{,}598$, and $F(1, 23) = 18.46$, $MS_e = 92{,}749$, the SL–ML × Fan interaction was significant only when the 24 subjects' data were considered, $F(2, 46) = 3.81$, $MS_e = 124{,}578$, but not when the 12 subjects' data were considered ($F < 1$).

[2] If the additional 12 subjects' data mentioned in Footnote 1 are included, only the Experiment × Article Type × Studied–Nonstudied × Single Location–Multiple Location interaction remains significant, but only marginally so, $F(3, 100) = 2.67$, $MS_e = 53{,}799$, $p < .06$.

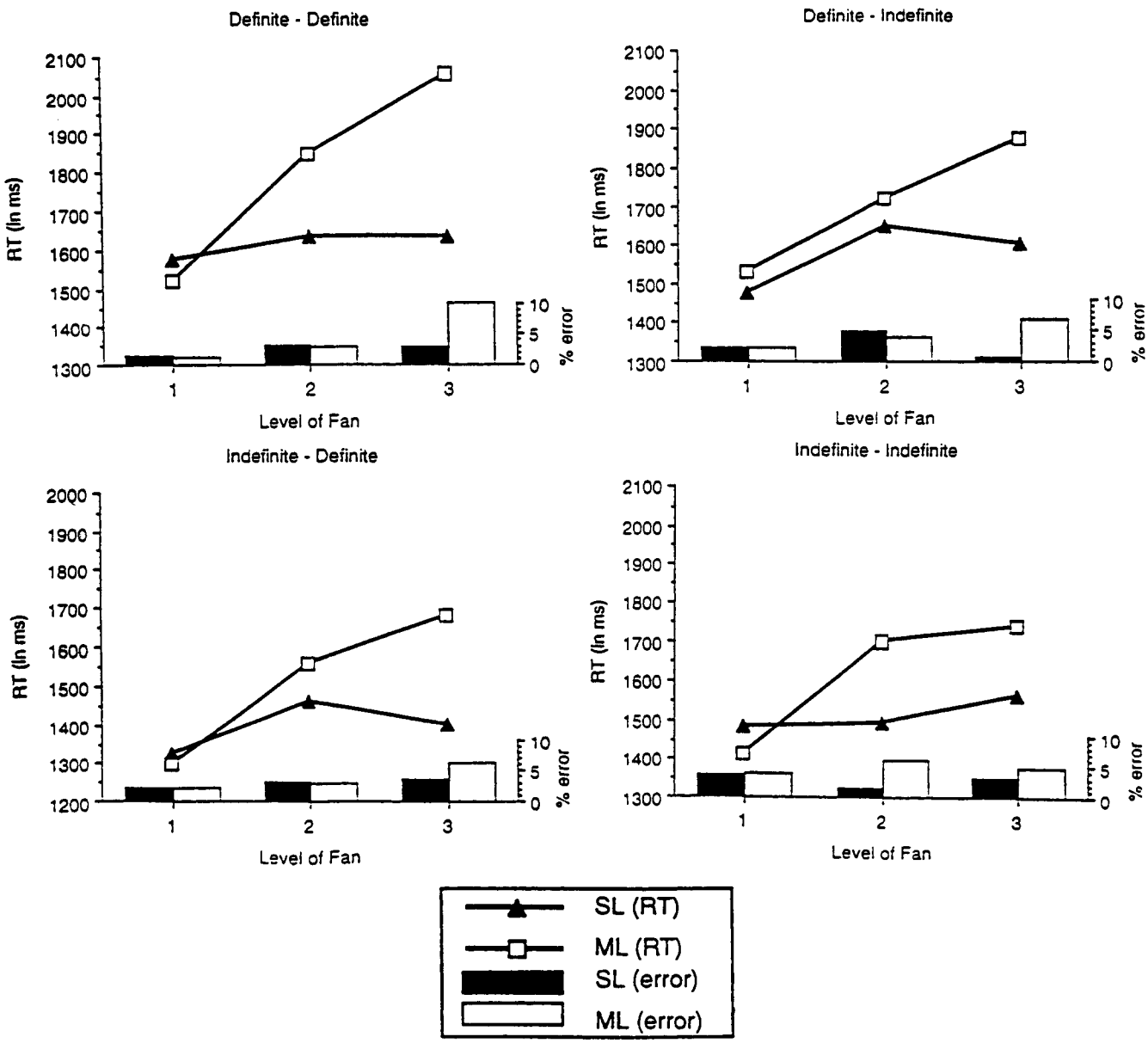

Figure 2. Comparison of the reaction times (RTs) and error rates for the single location (SL) and multiple location (ML) conditions for each of the article combinations in Experiment 1.

preference to select the animate concept as the subject of a sentence (Bock & Miller, 1991; Corrigan, 1988). This evidence gives reason to suppose that if the study sentences were to pair an animate concept with a location, there would be a bias to prefer the animate concepts as the basis for organizing the mental models.

This supposition is further supported by recent research on the use of mental models in discourse comprehension. Ample evidence exists showing that when people are probed about spatial information in a mental model containing an animate protagonist, the retrieval of that information is mediated by the positioning of a salient individual relative to the target locations (Bryant & Tversky, 1992; Bryant, Tversky, & Franklin, 1992; Franklin & Tversky, 1990; Glenberg, Meyer, & Lindem, 1987; Morrow, Bower, & Greenspan, 1989; Morrow, Greenspan, & Bower, 1987). Therefore, it would seem that if locative and animate concepts are put in competition, the animate concept will be preferred as the basis for organization.

Experiment 3 investigated the possibility that an organizational bias different from that found by Radvansky and Zacks (1991) will be used when people are substituted for objects in the study sentences. It may be that when subjects create mental models of the described situations involving person concepts, the organization of those mental models will be a person-based course of events.

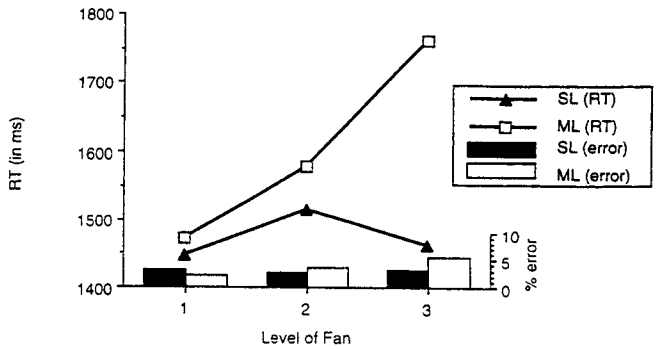

Figure 3. Overall comparison of the reaction times (RTs) and error rates for the single location (SL) and multiple location (ML) conditions for Experiment 2.

Experiment 3

Experiment 3 was conducted to test the impact of an animate sentence subject on the organization of information into mental models. If the person concept is indeed selected as the basis for organizing the mental model, then the fan effect results for the SL and ML conditions will show a reversal relative to what was found in previous experiments in which object–location sentences were used. Specifically, the SL condition, in which several people are associated with a single location, should show a fan effect, whereas the ML condition, in which a single person is associated with several places, should not.

Note that in the Radvansky and Zacks (1991) experiments, the number of locations was directly related to the number of mental models generated. In particular, the SL condition produced a single mental model and the ML condition produced multiple mental models. However, in the present set of experiments, if there is a person-based organization, the opposite pattern would be true: The SL condition would be expected to produce multiple mental models, whereas the ML condition would be expected to produce a single mental model.

Method

Subjects. Twenty-four subjects were tested. One additional subject was replaced because of experimenter error in the creation of the recognition test file.

Materials. The sentences were created in a fashion similar to that of Experiments 1 and 2. The major exceptions were that person concepts were used rather than objects and only definite articles were used for both concepts. The same location concepts were used as in Experiments 1 and 2. Some examples of the types of sentences presented to the subjects in this experiment are as follows:

13. The janitor is in the public library.
14. The teacher is in the hotel.

The people were referred to by occupational title and were not intuitively preassociated with any of the locations, with the exception of teacher and high school because of an oversight.[3] The occupational titles were drawn from those listed in the Battig and Montegue (1969) norms. A complete list of the occupations and locations used is given in Appendix C.

Procedure. The procedure was similar to Experiments 1 and 2, except for a few changes. First, during the test portion of the study–test period, the form of the questions were "Who is in the *location*?" and "Where is the *person*?" for each location and person, respectively. Subjects in this experiment took an average of 4.8 cycles to memorize the sentences.

During the speeded recognition test, subjects were presented with all of the sentences, rather than a subset of them, as had been done in Experiments 1 and 2. This change was done because part of the original purpose of the experiment involved a test of a hypothesis tangential to the current concern and that required the use of the entire set of sentences. Appropriate foils were created and presented for the additional sentences as well. Also, each of the probe sentences was presented 12 times, yielding a total of 432 trials. Subjects were allowed a self-timed break every 108 trials.

Even though sentences from all of the cells of the design were presented during the recognition test, we analyzed only a subset of them, namely, the probes from the cells for the "pure" SL and ML conditions. In other words, we did not analyze the cells in which there were both location and person fans greater than one. Including these sentences in the analysis would have complicated interpretation of the results because they could not be assigned to either the SL or ML conditions. The same 2.5-*SD* trimming procedure was used on the data as was done in Experiments 1 and 2. This eliminated 3.1% of the data.

Results

RTs. The means for Experiment 3 are summarized in Figure 5. Unlike Experiments 1 and 2, the RT data did not provide clear evidence for either a location-based or person-based organization of the mental models. In the ML condition, RTs were faster (1,428 ms) than in the SL condition (1,542 ms), which was consistent with a person-based organization. However, there was no statistical difference between the fan effects of the two conditions. Both conditions showed a fan effect, with increased level of fan accompanied by increased RTs, although it appeared to be somewhat smaller for the ML condition. This lack of a difference suggested that there was some ambiguity in the organization of the information.

The RT data were submitted to a 2 (studied–nonstudied) × 2 (SL–ML) × 3 (fan) repeated measures ANOVA. The SL–ML main effect was significant, $F(1, 23) = 8.34$, $MS_e = 111{,}634$, but not the SL–ML × Fan interaction, $F(2, 46) = 1.05$, $MS_e = 118{,}453$.[4] No other interactions were significant. Even though the SL–ML × Fan interaction was not

[3] The actual combination of teacher and high school occurred for 6 subjects.

[4] Motivated by the possibility that some of the subjects would have elected just one organization and the rest of the subjects the other, we conducted an additional analysis in which the subjects were divided into two groups on the basis of the direction of the single location (SL)–multiple location (ML) difference. There were 17 subjects whose data were consistent with a person-based organization (with ML faster than SL; *M*s = 1,498 ms and 1,707 ms, respectively) and 7 whose data showed the opposite pattern (*M*s = 1,523 and 1,420 ms, respectively). For the person-based subjects, the main effect of SL–ML was significant, $F(1, 16) = 21.96$, $MS_e = 101{,}496$, but the SL–ML × Fan interaction was not,

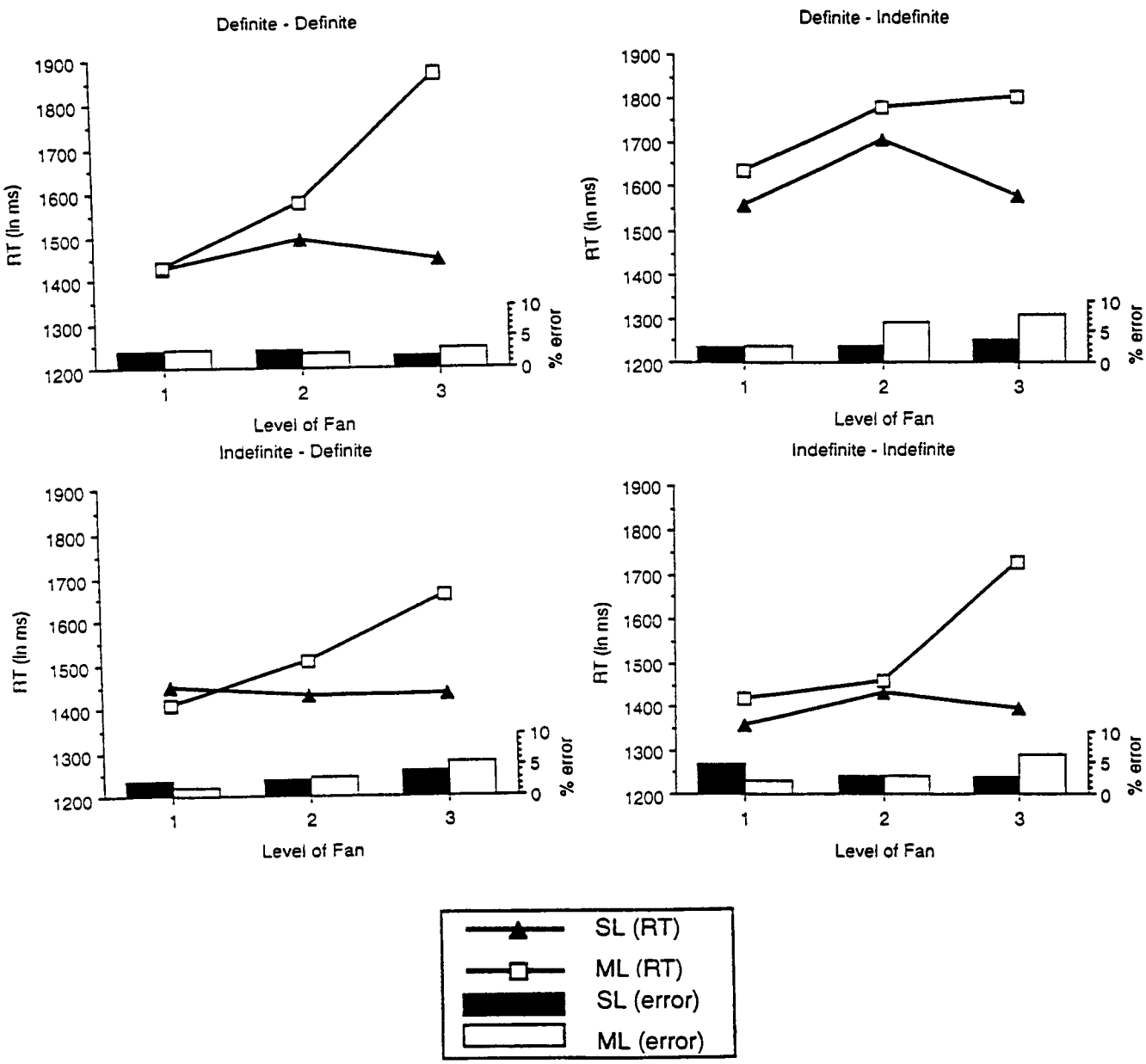

Figure 4. Comparison of the reaction times (RTs) and error rates for the single location (SL) and multiple location (ML) conditions for each of the article combinations in Experiment 2.

significant, because the predictions concerning the organization of the mental models directly involved the fan effects for the SL and ML conditions, we conducted a separate analysis for each of these. Both of these were statistically significant, $F(2, 46) = 8.08$, $MS_e = 135{,}272$, and $F(2, 46) = 6.46$, $MS_e = 91{,}845$, for the SL and ML conditions, respectively. For the ML condition, Neuman-Keuls tests showed a significant difference between Fan Levels 1 and 2, whereas for the SL condition, Fan Levels 1 and 3 differed significantly.

Errors. Subjects made an average of 3.5% errors on the recognition test. An error analysis revealed no significant effects.

Discussion

In previous experiments (Experiments 1 and 2; Radvansky & Zacks, 1991), the data suggested that the mental

$F(2, 32) = 1.70$, $MS_e = 139{,}713$, $p < .20$; this was also true for the location-based subjects, $F(1, 6) = 7.31$, $MS_e = 30{,}729$, and $F(1, 6) = 1.8$, $MS_e = 25{,}123$, $p < .21$. The current data did not support a clear division of organizational strategies by subjects but instead were more consistent with a position that suggested that the strategies were mixed within subjects.

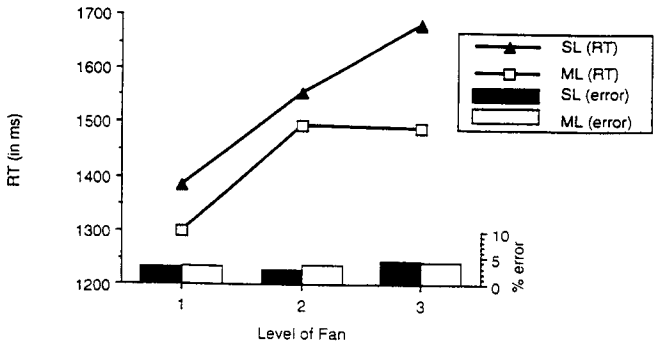

Figure 5. Comparison of the reaction times (RTs) and error rates for the single location (SL) and multiple location (ML) conditions for Experiment 3.

models were reliably organized around locations. Experiment 3 put location and animate concepts in competition with the prediction that the latter could be used as the basis for organizing the mental model. The results demonstrate that by using an animate sentence subject, the pattern of results was indeed rendered inconsistent with previous research in that the SL condition was slower than the ML condition and that both conditions showed a fan effect. Although the difference between the SL and ML conditions was in the predicted direction for a person-based organization, the lack of a difference in the fan effects failed to support the position of a person-based organization of the mental models.

These data are not entirely inconsistent with other studies involving the organization of multiple facts about animate concepts. There is some evidence from research in social cognition that person-based organizations do not predominate, especially when the information is about less familiar individuals (Pryor & Ostrom, 1981; Pryor, Simpson, Mitchell, Ostrom, & Lydon, 1982). In these tasks, subjects are presented with series of statements about sets of individuals and asked to sort them as best as possible. The results of a meta-analysis over a large group of such studies by Sedikides and Ostrom (1988) have demonstrated that with materials using unfamiliar individuals, a person-based organization of information was not preferred over organization in terms of other categories, including spatial–temporal contexts.

The lack of a difference in the SL and ML fan effects in Experiment 3 more closely resembled the results of Anderson (1974) than those of Radvansky and Zacks (1991). All of these studies explored the fan effect using materials consisting of sentences about something or somebody being in a location. When the nonlocation concepts referred to inanimate objects (Radvansky & Zacks, 1991; the present Experiments 1 and 2), there was a clear difference in the fan effects for the SL and ML conditions. However, when the nonlocation concepts referred to animate entities (Anderson, 1974; the present Experiment 3), there was no clear difference between the fan effects for what corresponded to the SL and ML conditions. The difference in result patterns apparently could be attributed to the animacy of the entity concept.

The results of Experiment 3 and Anderson (1974) do differ slightly in that SL responses were slower than ML responses in Experiment 3, whereas there was no discernable difference in Anderson's study (an admittedly hazardous comparison). Although this contrast may be spurious, one difference was that Experiment 3 used definite articles and Anderson used indefinite articles. Although it has been noted that when the articles are the same, subjects will focus on the relation between the entities (Grieve & Wales, 1973; Hupet & LeBouedec, 1975); the presence of definite articles in Experiment 3 could have led subjects to be more inclined to integrate the facts into mental models (Murphy, 1984). If the person concepts were a slightly more preferred organizational basis, then this could have led to a trend toward a person-based organization. Furthermore, although Experiments 1 and 2 showed that with objects and locations there was a clear preference for location-based mental models regardless of article type, with people and locations there appeared to be no preference for either type of organization or a slight preference for a person-based organization. Because of this organizational ambiguity of person–location sentences, it may be possible to influence the organization of the mental models through the article types. An asymmetry between the person and location article types could make the definitely marked concept more important, leading to an organization of the mental model in terms of that concept.

However, there is also some evidence to suggest that concept type (animate vs. inanimate) has no effect on either the selection of an article type (Wright & Glucksburg, 1976) or the differential saliency of animate and inanimate concepts (deVilliers, 1974). Still, there is no direct evidence that there will be no differential effect of article type on the organization of mental models involving animate concepts. Experiment 4 was conducted to test this possibility.

Experiment 4

Experiment 4 replicated Experiments 1 and 2, with the exception of the inclusion of person concepts in the place of object concepts. Because people can voluntarily move about from place to place or gather in one location, the organization of the information into either location-based or person-based organizations may allow for an organizational guidance by definite and indefinite articles.

Method

Subjects. Twelve subjects were tested in each of the four groups. These subjects were tested during the summer session at Michigan State University. They were recruited through an advertisement in the school paper and paid $5 for their participation.

Materials and procedure. The materials were the same as those used in Experiment 3, except for the appropriate changes in the person and location articles. The procedure was similar to the previous experiments. The questions asked during the study–test portion of the experiment were modified with the appropriate article, as was done in Experiments 1 and 2. For the DD, DI, ID,

and II conditions, subjects took an average of 3.9, 3.9, 4.3, and 5.1 cycles, respectively, to memorize the sentences. The differences between the number of cycles to memorize was statistically significant, $F(3, 44) = 4.27$, $MS_e = 0.85$. Tukey tests showed significant pairwise differences between the II group and the DD and DI groups. Given the pattern of results for Experiments 1 and 2 and the small sample size of each of the groups of the current experiment, it is unlikely that this reflected any real difference in the ease of creation of mental models attributable to article type. The recognition test was similar to that of Experiments 1 and 2 in that none of the sentences from cells in which multiple people were associated with multiple locations were presented. Additionally, each of the probe sentences was presented eight times, yielding a recognition test that was 192 items in length. Subjects were allowed a self-timed break in the middle of the testing. For this experiment the trimming procedure eliminated 2.6% of the data.

Results

RTs. The data for Experiment 4 are summarized in Figure 6. The results of Experiment 4 were similar to Experiment 3 in that there was no clear organizational preference, although there was a slight tendency toward a person-based organization. Although the ML probes were responded to faster (1,492 ms) than the SL probes (1,548), this difference was small. Furthermore, although there was a difference between the SL and ML fan effects, the RTs in both conditions were affected by the number of associations with a concept. For the SL condition, the RTs increased with increasing fan, whereas for the ML condition they showed an increase from Fan Level 1 to Fan Level 2 but then a decrease at Fan Level 3. As can be seen in Figure 7, there were no effects involving article type. So, the articles were not able to shift the focus and bring out either a clear location-based or person-based organization.

The RTs were submitted to a 4 (article type) × 2 (studied–nonstudied) × 2 (SL–ML) × 3 (fan) mixed ANOVA. The first variable was between subjects and the rest were within. The main effect of SL–ML was not significant, $F(1, 44) = 2.40$, $MS_e = 185{,}216$, $p > .10$. Despite this, there was a SL–ML × Fan interaction, $F(2, 88) = 7.56$, $MS_e = 131{,}560$, which was qualified by a Studied–Nonstudied × SL–ML Fan interaction, $F(2, 88) = 3.00$, $MS_e = 58{,}759$. In all four cases, the fan effects reached statistical significance, $F(2, 88) = 5.19$, $MS_e = 68{,}378$, and $F(2, 88) = 14.76$, $MS_e = 198{,}789$, for the studied and nonstudied probes, respectively, of the SL condition, and $F(2, 88) = 4.06$, $MS_e = 57{,}594$, and $F(2, 88) = 4.81$, $MS_e = 76{,}046$, for the studied and nonstudied probes, respectively, of the ML condition. There were no significant effects involving article type.

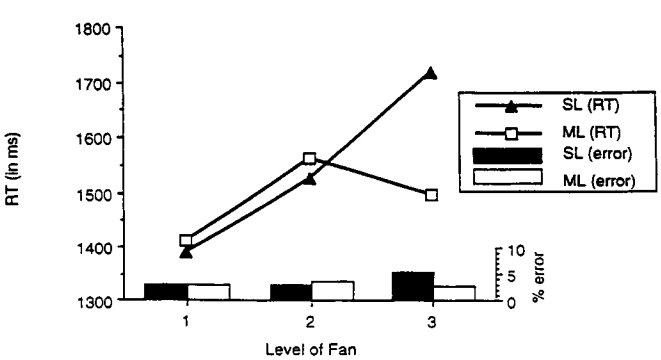

Figure 6. Overall comparison of the reaction times (RTs) and error rates for the single location (SL) and multiple location (ML) conditions for Experiment 4.

Errors. Like the RT data, the error rates did not show any clear organizational pattern, although there was a tendency toward a person-based organization. There was no difference between the SL and ML condition errors. Furthermore, the SL condition suggested a fan effect, with no change in error rate from Fan Levels 1 to 2 and then a sharp increase for Fan Level 3, whereas the ML condition mirrored the RT data, with an increase in error rate from Fan Levels 1 to 2 and then a decrease to Fan Level 3. There were no effects of article type involving the error-rate data.

The error data were submitted to an ANOVA similar to that of the RT data. The main effect of SL–ML was not significant, $F(1, 44) = 2.03$, $MS_e = 32$, $p > .10$. However, the SL–ML × Fan interaction was significant, $F(2, 88) = 4.43$, $MS_e = 39$. The fan effect was marginally significant for the SL condition, $F(2, 88) = 2.88$, $MS_e = 70$, $p < .07$, but not for the ML condition, $F(2, 88) = 1.02$.

Additionally, there were two interactions that were significant. The first was the Studied–Nonstudied × SL–ML interaction, $F(1, 44) = 6.64$, $MS_e = 25$. For the studied probes the difference between the SL and ML conditions (2.9% vs. 3.3%) was not significant ($F < 1$), whereas for the nonstudied probes it was (4.6% vs. 2.9%), $F(1, 44) = 6.22$, $MS_e = 35$. The second was the Article Type × Studied–Nonstudied interaction, $F(3, 44) = 3.07$, $MS_e = 30$. For the DD and ID conditions, there were fewer errors for the studied probes than the nonstudied probes (3.2% vs. 4.4% and 2.7% vs. 5.5%), respectively, whereas the opposite was true for the DI and II conditions (3.8% vs. 3.1% and 2.4% vs. 1.9%, respectively). Neither of these interactions was central to the issues studied here because they did not involve changes in the SL–ML difference.

Comparison with Experiment 1. To provide a direct assessment of any effects of using an animate sentence subject as opposed to an inanimate object, we statistically compared the results of Experiment 4 with those of Experiment 1. There was a clear difference in the organization of the facts as reflected in both the RT and error-rate data. In general, for inanimate objects there was a preference for location-based organizations, with the SL condition producing faster RTs and fewer errors than the ML condition. Furthermore, for the ML condition increased levels of fan were accompanied by increased RTs and error rates, whereas there was no change for the SL condition. For animate sentence subjects, there was no clear preference for either a location-based or person-based organization. The

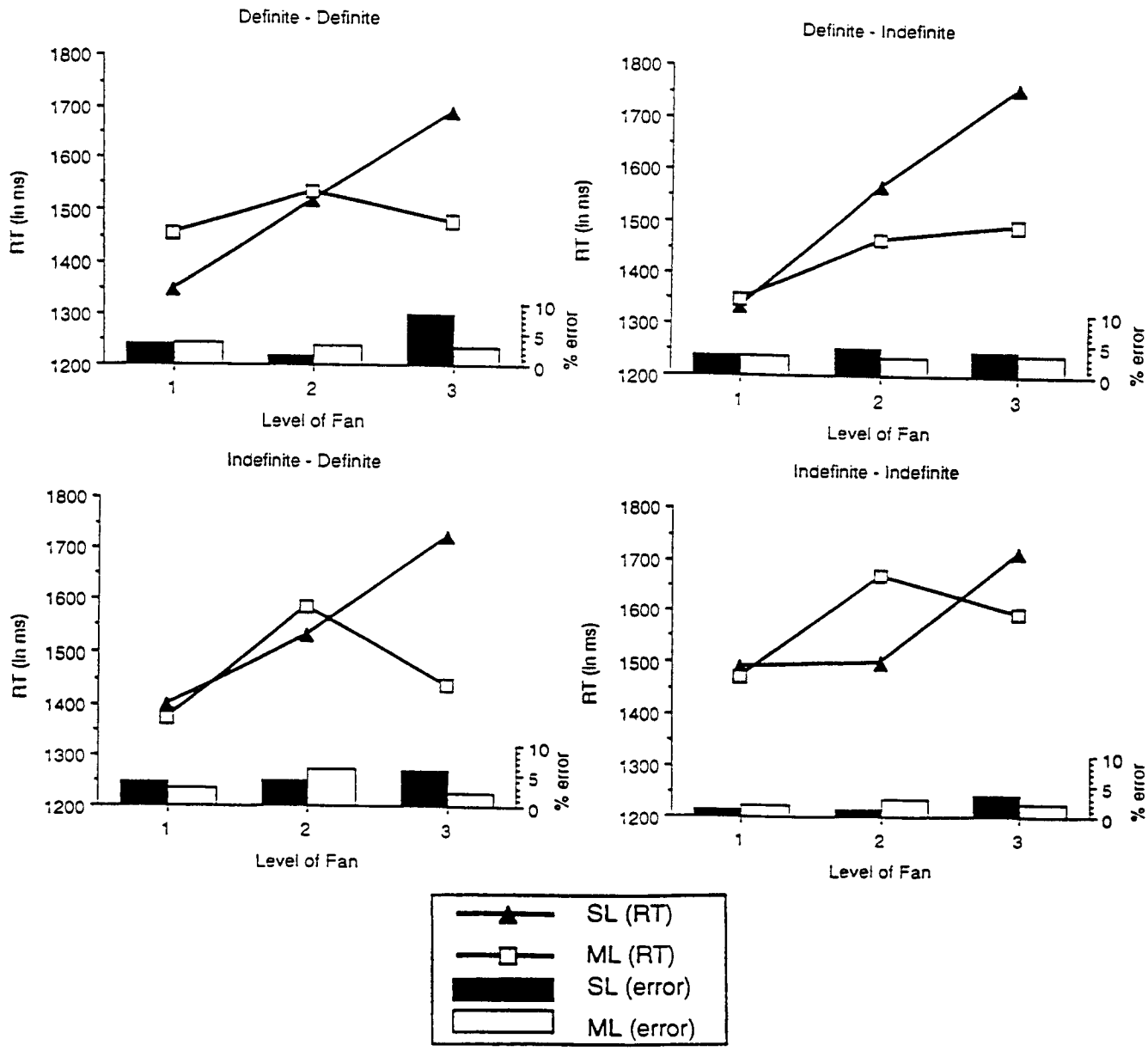

Figure 7. Comparison of the reaction times (RTs) and error rates for the single location (SL) and multiple location (ML) conditions for each of the article combinations in Experiment 4.

SL and ML RTs and error rates were equivalent. Both conditions were affected in terms of the RTs and error rates by increased levels of fan.

The RT data were submitted to a 2 (experiment) × 4 (article type) × 2 (studied–nonstudied) × 2 (SL–ML) × 3 (fan) mixed ANOVA. The first two variables were between subjects and the rest within. The experiment variables can be considered an assessment of the impact of animacy, at least as it might be tested as a between-subjects variable. Importantly, the Experiment × SL–ML and Experiment × SL–ML × Fan interactions were significant, $F(1, 88) = 15.06$, $MS_e = 168{,}915$, and $F(2, 176) = 17.62$, $MS_e = 105{,}736$, respectively. The Experiment × Studied–Nonstudied × SL–ML interaction was also significant, $F(1, 88) = 16.84$, $MS_e = 52{,}881$, as well as the four-way Experiment × Studied–Nonstudied × SL–ML × Fan interaction, $F(2, 176) = 3.31$, $MS_e = 51{,}393$. The difference between the two experiments was more pronounced in the studied probes than the nonstudied probes.

The error-rate data were submitted to analysis similar to that of the RTs. There were three interactions involving experiment that reached significance. The Experiment × SL–ML and the Experiment × SL–ML × Fan interactions were significant, $F(1, 88) = 8.62$, $MS_e = 48$, and $F(2, 176) = 9.48$, $MS_e = 45$, respectively. Also, the Experiment × Studied–Nonstudied × SL–ML interaction was significant, $F(1, 88) = 21.29$, $MS_e = 29$. The error-rate data paralleled the RT data.

Discussion

The results of Experiment 4 support two basic findings of the earlier experiments. First, like Experiments 1 and 2, there was no evidence that definite and indefinite articles had an effect on the organization of information into mental models. We thought that because facts about people being in locations do not strongly imply either a person-based or location-based organization, article type might have an influence on the organization of the information, with the definitely marked concept serving as the basis of the mental model organization. Our data failed to support this.

Experiment 4 also supported the results of Experiment 3 in that the use of person concepts in the studied sentences produced no clear organizational preference. In fact, the data from these two experiments did not even support the notion that subjects were forming mental models of the situations described by the facts when person concepts were involved.

Experiment 5

An alternative explanation for the pattern of results obtained in Experiments 3 and 4, and Anderson's (1974) study, is that there might have been an insufficient suggestion on the part of the sentences as to what type of situation was being described. This was because both types of organizations were equally plausible. The situations could have been location based because the locations were ones that could contain several people at one time. Alternatively, they could have also been person-based because people move from place to place often. In Experiment 5 we attempted to make the determination of the type of situation described by the facts less ambiguous. This was done by presenting sentences that included locations that were unlikely to contain several people as part of a single situation. This would lead to a decreased preference for a location-based organization of the information and, in turn, would lead subjects to choose a person-based organization for their mental models.

The locations were changed from large ones that usually contain several people (e.g., city halls and barber shops) to small ones that usually contain only a single person (e.g., phone booths and confessionals).[5] When subjects are determining what types of situations are being described, they may be more inclined to consider a set of sentences about several people being in a small place as describing several different situations. This idea is based on the implausibility of encountering a situation in which several people are jammed into a small area that typically contains only a single person. However, several sentences about a person being in several small places may be thought of as a course of events constituting a single situation in which the person is moving from place to place.

If this were true, then subjects should more clearly organize their mental models around the person concepts than they did in Experiments 3 and 4. There should be a fan effect only in the SL condition, not in the ML condition. In addition, the SL condition should produce longer retrieval times and more errors than the ML condition.

Method

Subjects. Twenty-four subjects were tested in Experiment 5. No subjects needed to be replaced.

Materials and procedure. The materials and procedure for Experiment 5 were similar to Experiment 3, with only a few changes. First, small places were used in the study sentences rather than large ones. In order to help in the selection of the places, 21 undergraduates at Michigan State University were asked to list as many places as they could that typically contained a single person. The best answers from this informal survey were then selected for the materials in this and the following experiment. Unfortunately, "best" could not be defined as the most popular answers because people would often list things that did not exclude the possibility of a second person occupying the location at the same time (e.g., "bedroom"). In addition, subjects would often list locations that were often found in collectives, such as "a seat in a movie theatre," so it would not be clear that a location mentioned several times in the study list was the same location. (The decision of which of the provided locations to use was made by the first author.) Various adjectives were added to the small places (e.g., *nearest* voting booth) to further encourage the subjects to consider them as the same instance of each location each time rather than separate ones. All of the locations are listed in Appendix C. Definite articles were always used.

Subjects required an average of 5.3 study–test cycles to learn the study list sentences. The recognition test was structured the same as in Experiments 1, 2, and 4. The trimming procedure resulted in the elimination of 2.4% of the recognition test data.

Results

RTs. The results of Experiment 5 are summarized in Figure 8. With the inclusion of small places, a clear person-based organizational preference emerged in the pattern of RT data. This was in sharp contrast to the previous experiments. Subjects' RTs were faster in the ML condition (1,427 ms) than the SL condition (1,568 ms). Furthermore, the SL condition showed a fan effect, with RTs increasing with increasing levels of fan, whereas the ML condition RTs remained fairly constant across the different fan levels.

The RT data were submitted to a 2 (studied–nonstudied) × 2 (SL–ML) × 3 (fan) repeated measures ANOVA. The main effect of SL–ML and the SL–ML × Fan interaction reached significance, $F(1, 23) = 16.20$, $MS_e = 87{,}612$, and $F(2, 46) = 9.12$, $MS_e = 104{,}464$, respectively. Simple effects tests showed that the fan effect was significant for the SL condition $F(2, 46) = 18.01$, $MS_e = 121{,}108$, but not for the ML condition ($F < 1$). Neuman-Keuls tests showed significant differences between all fan levels for the SL condition. In addition to these effects, the difference between the SL and ML conditions was greater for nonstudied probes (1,712 and 1,484 ms) than studied probes (1,423 and 1,370 ms), $F(1, 23) = 12.76$, $MS_e = 43{,}374$.

Errors. There was a marginally significant difference between the error rates in the SL and ML conditions, $F(1, 23) = 3.39$, $MS_e = 34$, $p < .08$. There were 3.9% errors in

[5] We would like to thank Lynn Hasher for the idea of using small places.

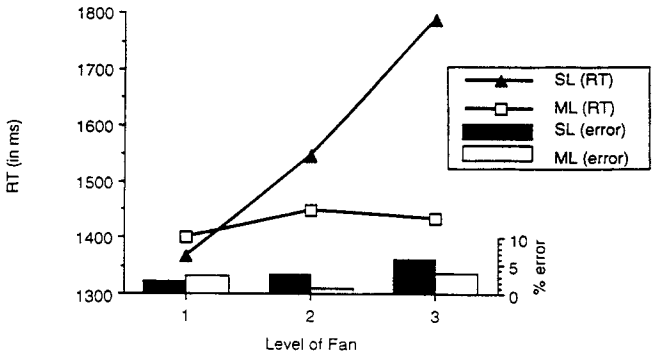

Figure 8. Comparison of the reaction times (RTs) and error rates for the single location (SL) and multiple location (ML) conditions for Experiment 5.

the SL condition and 2.6% errors in the ML condition. This was consistent with the RT data. No other effects were significant.

Discussion

The results of Experiment 5 show that when location and person concepts were put in competition and situations in which several people were in one location were made less plausible, subjects organized their mental models on the basis of the person concept. This was produced through the inclusion of small, as opposed to large, places in the studied facts. This person-based organization was revealed through a fan effect for the SL condition, but not the ML condition. This evidence was consistent with the notion that the subjects in Experiment 3 and the Anderson (1974) study might have been presented with facts that did not strongly suggest one type of situation over another. In Experiment 5, however, the situation of several people being in a single location at one time was less plausible, so subjects were more inclined to interpret the situation as being based on the person concept and thus to build their mental models around that concept.

If subjects are presented with both large and small places as part of the same study set, they might show less ambiguity than they did in Experiment 4 in terms of the type of situation being described when the location is large. That is, the presence of small locations in the study list would make the option of a location-based organization less plausible in general, allowing for a clear person-based organization of the mental models to emerge, even for large location sentences. In order to test this, we included both large and small places in each subject's study list in Experiment 6.

Experiment 6

Method

Subjects. Forty-eight subjects were tested in Experiment 6. No subjects were replaced.

Materials and procedure. The method for Experiment 6 was identical to that of Experiment 5, except for a change in the materials. Specifically, both large and small places were used in the study sentences, with half (n = 9) of the sentences containing small places and the other half large places. The distribution of large and small locations was balanced in each cell of the design. The study lists were constructed so that for person Fan Levels 2 and 3, all of the locations for a particular person concept were either large or small places, but not both. For example, the architect could be in the airport and the barber shop but could not be in the airport and the tanning bed. Subjects in this experiment required an average of 4.7 cycles through the study–test portion of the experiment to memorize the sentences. None of the recognition test data was eliminated by the trimming process because of the low number of observations per cell.

Results

RTs. Like in Experiment 5, there was a clear person-based organization of the mental models. The RTs were longer for the SL condition (1,768 ms) than the ML condition (1,649 ms). Furthermore, RT increased with increasing fan for the SL condition, but not for the ML condition. As can be seen in Figure 9, although for the different location types there was no difference in the general organization of the information based on the pattern of results, there was a difference in the ML fan effect patterns. In particular, with large places, fan level had no effect on RT, whereas with small places it did. The small places RTs for Fan Level 2 were unexpectedly long. As can be clearly

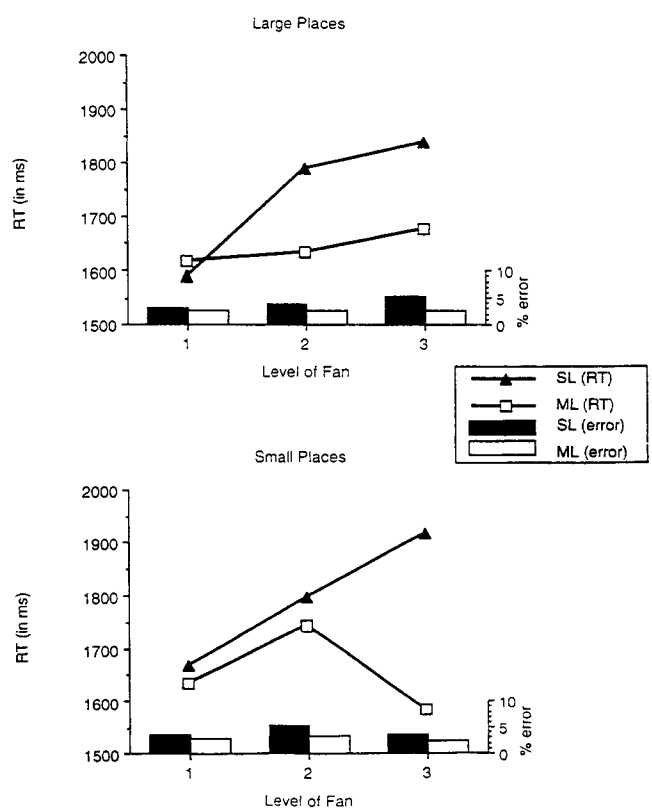

Figure 9. Comparison of the reaction times (RTs) and error rates for the single location (SL) and multiple location (ML) conditions for each of the location size conditions in Experiment 6.

seen in Figure 9, this was not the fan effect pattern that would normally be expected. We have no immediate explanation for this result, but, given the results of Experiment 5, it is likely an anomaly in part due to the smaller number of observations per cell. In spite of this, a clear person-based organization was present for both the small and large locations. This was especially important for the large locations, which failed to show a person-based organization in Experiments 3 and 4.

The RT data were submitted to a 2 (location type) × 2 (studied–nonstudied) × 2 (SL–ML) × 3 (fan) repeated measures ANOVA. The main effect of SL–ML and the SL–ML × Fan interactions reached significance, $F(1, 47) = 19.05$, $MS_e = 214{,}996$, and $F(2, 94) = 10.23$, $MS_e = 139{,}902$, respectively. Simple effects tests showed that the fan effect was significant for the SL condition, $F(2, 94) = 14.35$, $MS_e = 224{,}087$, but not for the ML condition, $F(2, 94) = 1.65$, $MS_e = 152{,}093$. Neither the main effect of location type nor the Location Type SL–ML interaction reached significance, $F(1, 47) = 1.88$, $MS_e = 168{,}495$, and $F(1, 47) = 1.11$, $MS_e = 116{,}054$, respectively. However, the Location Type × SL–ML × Fan interaction did reach significance, $F(2, 94) = 3.51$, $MS_e = 127{,}568$. The SL fan effect was present for both location types, $F(2, 94) = 8.27$, $MS_e = 179{,}756$, and $F(2, 94) = 12.64$, $MS_e = 142{,}590$, for small and large locations, respectively. The ML condition fan effect was not significant for the large locations ($F < 1$), but (as suggested earlier) it was significant for the small locations, $F(2, 94) = 3.53$, $MS_e = 182{,}055$. In addition to these effects, the SL–ML difference was greater for the nonstudied probes (1,867 and 1,711 ms) than the studied probes (1,668 and 1,586 ms), $F(1, 47) = 5.64$, $MS_e = 68{,}954$.

Errors. The error-rate pattern was similar to that of the RT data in showing a person-based organization. There were more errors made in the SL condition than in the ML condition. There was a significant SL–ML difference, $F(1, 47) = 5.19$, $MS_e = 94$. In addition, the Location Type × Studied–Nonstudied interaction was significant, $F(1, 47) = 6.60$, $MS_e = 47$. For small places there was no difference in the error rate for studied (3.8%) and the nonstudied (3.2%) probes, $F(1, 47) = 1.36$, $MS_e = 45$, whereas for the large places, the studied probes produced fewer errors (2.6%) than the nonstudied probes (4.1%), $F(1, 47) = 3.50$, $MS_e = 84$, $p < .07$. Although there is no simple explanation for this interaction, the overall error rate was so low that it probably does not imply any important consequences for the interpretation of the RT data.

Discussion

Experiments 5 and 6 demonstrated that a person-based organization can be made more prominent than a location-based organization if the location-based organization is made less plausible. This was done by including small places in the set of facts to make the situation of several people being contained in the same place unlikely. Experiment 6 further showed that the places mentioned in the sentences do not have to be small places exclusively. Rather, they only need to be present in sufficient number to lead subjects to be less willing to use a location-based organization in general.

General Discussion

The present set of experiments explored a number of factors that could possibly have an impact on the mental model organization. The first factor investigated was based on the notion that the organization of mental models may be influenced by whether the sentential subjects (either people or objects) and locations were marked with definite or indefinite articles. If this were true, then in those cases in which there was an asymmetry, such that one concept was definitely marked and the other was indefinitely marked, the concept paired with a definite article would be treated as given information (Haviland & Clark, 1974) and therefore would serve as the basis for organizing a mental model. The results of three experiments (Experiments 1, 2, and 4) using three different concept types failed to show any effects, suggesting that the organization of mental models is not easily influenced by such information. It should be noted that the current experiments required subjects to commit to memory information outside of the realm of a normal discourse situation. There is other evidence that article definiteness does have an impact on the organization of information when the information is presented within the context of a coherent discourse (Gernsbacher, 1991; Murphy, 1984).

The transportability of the object was the second factor that we considered to be potentially influencing the organization of the information into either location- or object-based mental models. With nontransportable objects, location-based organization was thought to be more plausible because these sorts of objects rarely move from place to place. With transportable objects, however, either a location- or object-based organization is possible. Subjects could construe the described situations as courses of events in which an object is moved from place to place, rather than as states of affairs (Barwise & Perry, 1983) in which the object remains stationary in the location, and construct their mental models accordingly. Like the manipulation of definite and indefinite articles, we found that this did not affect the organization (Experiments 1 and 2). Subjects treated both transportable and nontransportable object cases as state-of-affairs situations.

A third factor that we tested was the animacy of the nonlocation concept. All of the previous investigations relied on inanimate entities in the study sentences. The inclusion of animate entities may have an impact on the interpretation of the type of situation being described and hence on the organization of the mental models. This notion was tested by altering the memorized items to include people rather than objects. An important point here is that in the Radvansky and Zacks (1991) experiments, animacy and location information were consistent with one another in terms of how they could be used to determine the organization of the mental models. The inclusion of the location concept allowed for a location-based organization for obvious reasons, and the inanimate objects might have further reinforced this interpretation because the objects cannot

move from place to place on their own but are confined to a single location.

However, by pairing animate rather than inanimate concepts with the locations, the animacy and location information were in competition with respect to the possible types of situations that each could be used to describe. The potential for creating spatial mental models was present by virtue of the locations mentioned. The people were described as being in various locations that each could be considered to be a separate state of affairs. The potential for creating nonspatial mental models was present by virtue of the fact that people are not necessarily confined to being contained in a single location but can and do voluntarily move from place to place. It is the voluntary and purposeful nature of movement across several locations that separates animate concepts from the transportable objects. Therefore, a set of sentences about a person being in several places can be taken to describe either a single person in several situations, a different state of affairs at each of the different locations, or a single situation consisting of a course of events about a person moving from place to place. When considered in conjunction with other research on mental models involving both spatial properties and an animate concept (Franklin & Tversky, 1990; Glenberg et al., 1987; Morrow et al., 1989, 1987), it seemed likely that the animate concepts would be chosen as the basis for the organization of the mental models.

Experiments 3 and 4 showed weak evidence of a person-based organization, although the results seem more representative of a case in which both person- and location-based organizations are used to some extent (Sedikides & Ostrom, 1988). The most important accomplishment of these experiments was the demonstration that the inclusion of an animate sentence subject produced results that were considerably different from previous experiments in which clear location-based organizations had monopolized the result patterns.

The fourth factor investigated was whether a change in the functional relation between the two entities would affect the organization of the information. Experiments 5 and 6 provided evidence for this and also supported the idea of mixed organizational strategies in Experiments 3 and 4 by making a location-based interpretation less plausible by the inclusion of small places that typically contain only a single person. When the studied facts contained small places, subjects organized their mental models in a person-based fashion (Experiment 5), even when large places were also included in the study list (Experiment 6). These two experiments provided a clear demonstration that animate concepts can serve as the basis for organizing mental models even when the possibility for a location-based organization is present.

The present set of experiments can be compared with those of Anderson (1974), who also reported a set of fan effect experiments involving person–location sentences. He obtained results highly similar to those of our Experiment 3. He used indefinite articles rather than the definite articles of Experiment 3, but this probably had no effect (cf. our Experiment 4). Specifically, Anderson found fan effects for what corresponded to both the SL and ML conditions. Although we do not have access to the actual materials used by Anderson, all of the locations appear to have been large ones that typically could contain several people at one time. Therefore, it may be the case that the animate person concepts and the location concepts were equivalently plausible as a foundation for organizing the facts. As a result, both person- and location-based representations could have been created by the subjects, thus obscuring the use of mental model representations.

The findings of the present set of experiments provide further evidence of what sorts of information are used to organize mental model representations. When possible, information is organized with reference to what possible situations are being described. The determination of the type of situation being described is based on the functional relation of the elements to one another in the real world. When presented with sets of facts about inanimate objects being in locations, the relation used by subjects was that of containment, and location-based organizations of the mental models abounded. A clear nonlocation-based organization was not found until the location-based relation was challenged so that containment was not the only relation involved. At a minimum, the mental model view provides the researcher with a heuristic device for considering how information will be represented and processed by subjects on the basis of the functional relation among the presented concepts.

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Appendix A

List of Objects and Locations Used in Experiments 1 and 2

Nontransportable Objects	Transportable Objects	Locations
Big desk	Black umbrella	Airport
Bulletin board	Blue backpack	Barbershop
Ceiling fan	Briefcase	Car dealership
Cola machine	Coffee maker	City hall
Display case	Fire extinguisher	Cocktail lounge
Exit sign	Flashlight	Ice cream parlor
File cabinet	Manilla envelope	High school
Marble bench	Newspaper	Hotel
Oak table	Portable radio	Laundromat
Pay phone	Thermos	Movie theatre
Revolving door	Wastebasket	Office building
Water fountain	Wooden cane	Public library

(*Appendixes continue on next page*)

Appendix B

Design Used for Combining Subjects and Predicates in the Generation of the Study Lists

Italicized items were the ones presented during the recognition test (except Experiment 3, in which all items were presented). Items with a superscript "SL" (single location) constituted the SL condition and items with a superscript "ML" constituted the ML (multiple location) condition. The lowercase letters indicate nonlocation concepts (e.g., cola machine or architect) and the uppercase letters indicate location concepts (e.g., hotel or phone booth). Each combination of a lower- and an uppercase letter represents a different study sentence (e.g., if a = "cola machine" and A = "hotel," then the resulting sentence would be "The cola machine is in the hotel").

		Location fan		
		1	2	3
	1	$a\mathrm{A}^{\mathrm{SL}}$ $b\mathrm{B}^{\mathrm{SL}}$	$e\mathrm{E}^{\mathrm{SL}}$	$g\mathrm{G}^{\mathrm{SL}}$
		$c\mathrm{C}$ $d\mathrm{D}^{\mathrm{ML}}$	$f\mathrm{F}^{\mathrm{SL}}$	$h\mathrm{H}^{\mathrm{SL}}$
Subject fan	2	$i\mathrm{I}^{\mathrm{ML}}$	—	$i\mathrm{G}$
		$j\mathrm{J}^{\mathrm{ML}}$	—	$j\mathrm{H}$
	3	$k\mathrm{K}^{\mathrm{ML}}$	$k\mathrm{E}$	$k\mathrm{G}$
		$l\mathrm{L}^{\mathrm{ML}}$	$l\mathrm{F}$	$l\mathrm{H}$

Appendix C

List of Occupations and Locations Used in Experiment 3

People	Large Places	Small Places
Architect	Airport	Back room's tanning bed
Banker	Barbershop	Blue and yellow kayak
Carpenter	Car dealership	Dark confessional
Engineer	City hall	Greyhound bus's bathroom
Farmer	Cocktail lounge	Nearest voting booth
Grocer	Ice cream parlor	New car's driver's seat
Janitor	High school	Old tire swing
Mechanic	Hotel	Operating table
Plumber	Laundromat	Ornate throne
Salesman	Movie theatre	Store's dressing room
Teacher	Office building	Telephone booth
Writer	Public library	Witness stand

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