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Situation models and retrieval interference: Pictures and words

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Previous studies have found that interference in long-term memory retrieval occurs when information cannot be integrated into a single situation model, but this interference is greatly reduced or absent when the information can be so integrated. The current study looked at the influence of presentation format—sentences or pictures—on this observed pattern. When sentences were used at memorisation and recognition, a spatial organisation was observed. In contrast, when pictures were used, a different pattern of results was observed. Specifically, there was an overall speed-up in response times, and consistent evidence of interference. Possible explanations for this difference were examined in a third experiment using pictures during learning, but sentences during recognition. The results from Experiment 3 were consistent with the organisation of information into situation models in long-term memory, even from pictures. This suggests that people do create situation models when learning pictures, but their recognition memory may be oriented around more "verbatim", surface-form memories of the pictures.

The two most popular stimuli formats in memory research are pictures and words. These two formats have different influences on memory. For example, the picture superiority effect shows that pictures are remembered better than words (Shepard, 1967; Snodgrass, Volvovitz, & Walfish, 1972), hypermnesia is more likely to be observed with pictures than words (Payne, 1987), and the left medial temporal lobe is more likely to be active during word recognition, whereas the right medial temporal lobe is more likely to be active during picture recognition (Papanicolaou, Simos, Castillo, Breier, Katz, & Wright, 2002). The aim of the current study is to look at the influence of these two formats on long-term memory organisation and retrieval, particularly at the situation model level (Johnson-Laird, 1983; Zwaan & Radvansky, 1998). It has been suggested that situation models can be created using pictures, and situation models can be used to generate mental images (Johnson-Laird, 1983; Radvansky & Zacks, 1997). This study examines how the format of information influences the use of situation models in memory.

To look at memory organisation and retrieval we used the *fan effect* paradigm (Anderson, 1974), in which retrieval time increases with an increase in the number of associations with a concept. Fan effects vary as a function of the degree to which information can be organised using situational, causal, or thematic relations (e.g., Myers, O'Brien, Balota, & Toyofuku, 1984; Radvansky & Zacks, 1991; Smith, Adams, & Schorr, 1978). We focus on how the organisation

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of information into situation models affects the fan effect. Previous research on situation models and the fan effect has shown that a fan effect is observed when a set of facts share elements, but is unlikely to be interpreted as referring to a common situation. In contrast, little to no fan effect is observed when facts refer to a single situation (see Radvansky, 1999a). One way to observe this is with facts about objects in locations, which is the focus of the current study.

The experimental paradigm we used reflects situation model organisation (Radvansky, Spieler & Zacks, 1993; Radvansky & Zacks, 1991). People first memorise a list of sentences about objects and locations in which there were one to three associations with each object and location. Using this associative structure we can derive two conditions of interest. For example, suppose Sentences 1–6 corresponded to a subset of the study materials.

1. The wastebasket is in the living room.
2. The wastebasket is in the kitchen.
3. The wastebasket is in the bathroom.
4. The picture is in the bedroom.
5. The storage chest is in the bedroom.
6. The stool is in the bedroom.

Sentences 1–3 correspond to the *Multiple Location* condition in which one object is associated with multiple rooms. According to situation model theory, because this information is unlikely to refer to a single situation, a separate model is created for each sentence. Then, during recognition, interference is experienced because the related but irrelevant models which also have that object interfere with the retrieval of the desired one, slowing down retrieval. In comparison, Sentences 4–6 correspond to the *Single Location* condition in which multiple objects are associated with a single room. Because it is possible to interpret these sentences as referring to one situation, this information can be integrated into a single model. During recognition, because there are no competing and irrelevant models, interference is reduced or is absent. This pattern, with interference in the Multiple Location condition, but not in the Single Location condition, has been observed repeatedly (Radvansky, 1998, 1999a, 1999b, 2005; Radvansky et al., 1993; Radvansky & Zacks, 1991; Radvansky, Zacks, & Hasher, 1996, 2005). Importantly, it is not affected by the order of the concepts in the sentences (Radvansky & Zacks, 1991; Radvansky et al., 1996), nor by whether definite or indefinite articles are used (Radvansky et al., 1993).

Situation models are mental simulations of described sets of circumstances, and these models bear a referential relation to the world. More currently, this line of thinking brings into play ideas about embodied cognition and the use of perceptual symbols (Barsalou, 1999; Glenberg, 1997; Wilson, 2002). A situation model is a representation where these characteristics would be expected to be seen more clearly. A situation model conveys an event in a real or possible world that a person could take some perceptual perspective on and possibly interact with. For example, for the sentence "The wagon is in the kitchen" one could create a situation model in which a mental image could be derived from a certain perspective (such as being near the sink area) and "see" a wagon on the floor by the kitchen sink.

Most of the research on the fan effect has used sentences. One exception is a study by Stopher and Kirsner (1981) in which people memorised either sentences or pictures that described a spatial relation with one object on top of another, such as "The clock is on the television". The results showed a fan effect with sentences, but not pictures. From these data, Stopher and Kirsner drew two conclusions. The first was that pictures and sentences are stored in memory using qualitatively different representations. The other was that people integrate information in the picture condition because the depicted scenes could be combined into a single situation, although it is not clear why they did not think this was possible for the sentences.

While the Stopher and Kirsner (1981) study provides some insight into memory retrieval using pictures and sentences, it has some serious limitations. First, they only looked at conditions where there were either one or two associations with a concept, so the ability to detect interference was hampered. Second, only 13–17 subjects were used per condition in the two experiments they reported, making it difficult to observe more subtle differences. Third, the pictures used were rather primitive. They essentially consisted of what amounted to impoverished line drawings of a pair of objects without any developed context (see Stopher & Kirsner, 1981, Figure 2). Thus, there was relatively little perceptual, semantic, and situational detail available. Finally, there was no attempt to assess mental organisation, which is the focus of our study.

It is worth pursuing further the issue of the role of stimulus format on memory and retrieval in the context of recent discussions about embodied cognition (Glenberg, 1997; Wilson, 2002) and perceptual symbols (Barsalou, 1999). While situation model theory does not demand these theoretical ideas, it does mesh well with them. Specifically, if a situation model is some form of an analogue, incomplete mental simulation of a real or possible world, then it is plausible to suggest that the situation model would be created using the same basic cognitive principles as are involved in perceptual experience. As such, one would expect that the pattern of results observed when language is used to be similar to that observed when pictures are used.

EXPERIMENT 1

The aim of Experiment 1 was to replicate previous research that has shown a differential fan effect, and to extend it to a somewhat different set of materials. Experiment 1 used sentences throughout. People memorised sentences about objects located in the rooms of a house. It was expected that the same pattern of results would be observed as has been seen previously, namely an interference effect for the Multiple Location condition, but not the Single Location condition.

Method

Subjects. A total of 36 native English speakers (29 female) were recruited from the subject pool at the University of Notre Dame and given partial class credit for their participation.

Materials. The 18 study sentences were derived from a set of object and location concepts combined in sentences of the form "The *object* is in the *location*", using an experimental design modelled on other studies (e.g., Radvansky et al., 1993). The primary difference here is that the objects were items that can be found in a house, and the locations were rooms in a house. The associative structure of the study list design, along with the names of the objects and locations, is shown in Figure 1 for a hypothetical subject. There were twice as many fan level 1 items, so that half of them could be randomly assigned to the Single Location condition and half to the Multiple Location condition, in order that a

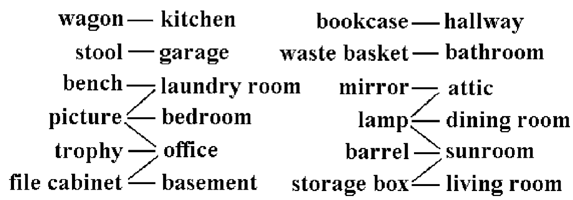

Figure 1. Associative structure between object and location concepts used in the study list design for the experiment. The object and room assignments in this figure are given for a hypothetical subject. For the actual study, the assignment of concepts to positions within this structure was randomised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

relatively straight-forward ANOVA could be done without repeating the same data in two cells of the design. A different random assignment of objects and locations to each condition was used for each person. During learning, people were explicitly told that the sentences referred to locations of objects in rooms of a home. For recognition, studied probes were the memorised sentences. Nonstudied probes were generated from re-pairings of objects and locations from within the same cell of the design. For example, if the studied sentences from the same cell were Sentences 7 and 8, the nonstudied sentences would be Sentences 9 and 10.

7. The storage box is in the living room.
8. The waste basket is in the bathroom.
9. The storage box is in the bathroom.
10. The waste basket is in the living room.

This method of generating nonstudied probes decreases the likelihood that plausibility judgements will be used rather than recognition decisions (Reder & Anderson, 1980). Because the same number of associations was involved for the concepts in the nonstudied sentences, they were assigned to Single and Multiple Location conditions, and were analysed as such.

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

The recognition test was timed and administered by computer. Each probe was presented eight times, for a total of 288 recognition trials. The left button on a computer mouse was pressed to indicate a studied sentence, and the right button to indicate a nonstudied sentence. People were told to respond as quickly and as accurately as possible. The order of recognition probes was randomised within each of eight blocks. If an incorrect response was made, feedback was given in the form of text that read either "*ERROR* STUDIED" or "*ERROR* NOT STUDIED", whichever was appropriate. Feedback was presented for 1 second. A set of 18 practice trials was given to familiarise people with using the mouse buttons. During practice the computer displayed either "STUDIED" or "NOT STUDIED", and the person pressed the appropriate button.

The response time data for correct responses were trimmed by removing response times less than 200 ms, and greater than 8000 ms. In addition, using Van Selst and Jolicoeur's (1994) criteria, the data trimmed are a function of the sample size for a person. This trimming procedure eliminated 4.4% of the data. Errors were also not included in the response time analysis.

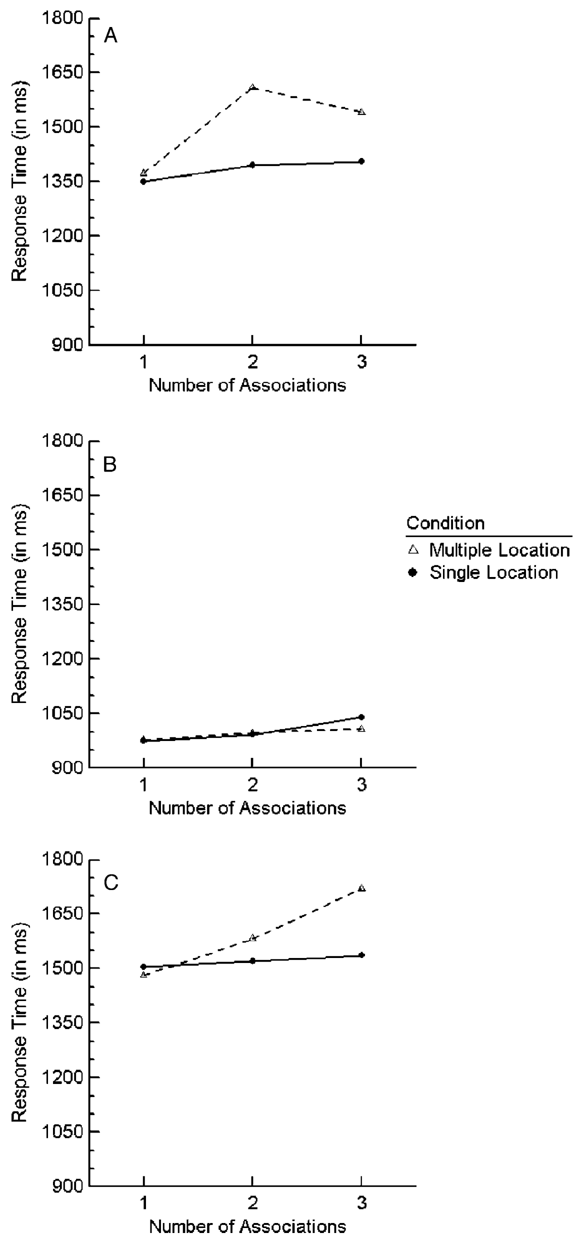

Figure 2. Response time results for Experiment 1 (A), Experiment 2 (B), and Experiment 3.

Results

Learning. People took 3 to 8 (M = 4.5; SD = 1.2) study–test cycles to memorise the sentences.

Response times. The response time data, shown in Figure 2A, were submitted to a 2 (Studied–Nonstudied) × 2 (Condition: Single Location vs Multiple Location) × 3 (Fan) repeated measures ANOVA. Of central interest, there was an effect of Condition, $F(1, 35) = 16.45$, $MSE = 101006$, $p < .001$, with people responding more slowly for the Multiple Location probes (M = 1508 ms) than to Single Location probes (M = 1384 ms). There was also an effect of Fan (fan level 1 = 1361, 2 = 1502, 3 = 1474 ms), $F(2, 70) = 7.83$, $MSE = 101889$, $p = .001$. Furthermore, the Condition × Fan interaction was significant, $F(2, 70) = 3.63$, $MSE = 91368$, $p = .03$. Simple effects tests showed that the fan effect was significant for the Multiple Location condition (fan level 1 = 1373, 2 = 1609, 3 = 1542 ms), $F(2, 70) = 11.40$, $MSE = 93495$, $p < .001$, but not for the Single Location condition (fan level 1 = 1350, 2 = 1396, 3 = 1406 ms), $F < 1$. This replicates previous research.

In addition to the results of primary interest, there was a significant effect of Studied–Non-

TABLE 1
Error proportions for the recognition tests

	Single Location			*Multiple Location*		
	1	*2*	*3*	*1*	*2*	*3*
Exp. 1: Sentence Memorisation – Sentence Recognition						
Studied	.04	.03	.03	.04	.05	.05
Nonstudied	.02	.03	.03	.03	.05	.05
Exp. 2: Picture Memorisation – Picture Recognition						
Studied	.06	.06	.09	.04	.04	.03
Nonstudied	.05	.06	.06	.05	.05	.02
Exp. 3: Picture Memorisation – Sentence Recognition						
Studied	.04	.05	.03	.04	.05	.06
Nonstudied	.04	.03	.05	.03	.07	.04

studied, $F(1, 35) = 55.89$, $MSE = 50376$, $p < .001$, with people responding faster to Studied probes ($M = 1365$ ms) than to Nonstudied probes ($M = 1527$ ms). Finally, there was also a marginally significant three-way interaction, $F(2, 70) = 2.88$, $MSE = 58833$, $p = .06$. Separate analyses of the Studied and Nonstudied probes revealed that the Condition $\times$ Fan interaction was marginally significant for the Studied probes, $F(2, 70) = 2.59$, $MSE = 61031$, $p = .08$, and was significant for the Nonstudied probes, $F(2, 70) = 3.85$, $MSE = 89170$, $p = .03$.

Error rates. People in Experiment 1 had a .04 error rate on the recognition test. The error rate data, shown in Table 1, were submitted to a 2 (Studied–Nonstudied) $\times$ 2 (Condition) $\times$ 3 (Fan) repeated measures ANOVA. There was a marginally significant effect of Condition, $F(1, 35) = 3.76$, $MSE = .007$, $p = .06$, with people being more accurately in the Single Location ($M = .03$ errors) than the Multiple Location condition ($M = .05$ errors). No other effects were significant.

Discussion

The results of Experiment 1 replicate the pattern of data observed in previous studies (e.g., Radvansky, 1999b; Radvansky & Zacks, 1991). A clear fan effect was observed when there were multiple locations associated with a single object. This is likely to be interpreted as multiple situations, and so each fact about the object is likely to be stored as a separate situation model in memory. These related, but irrelevant, models compete during retrieval, producing interference, and make retrieval more difficult. In contrast, no fan effect was observed when there were multiple objects in a single location. This is likely to be interpreted as a single situation in which several objects are occupying the common location as a single state-of-affairs. Because only a single model is created and stored in long-term memory, little to no retrieval interference is observed. Having replicated this basic pattern with this set of object and location concepts, we now sought to assess the effects of using pictures in Experiment 2.

EXPERIMENT 2

The aim of Experiment 2 was to assess the influence of using pictures rather than sentences. To this end we made pictures of the situations described in the Experiment 1 sentences. This was done using commercially available home-design software that allows one to create a layout of a home, place objects in the rooms, and make images of what the room would look like from various perspectives. These pictures were created so that if multiple objects were in a room, only one object was visible at a time. An example of a picture for "The wagon is in the kitchen" is shown in Figure 3.

If the pattern of response times observed in Experiment 1 reflects general situation comprehension, organisation, and retrieval process, as suggested by embodied cognition and perceptual symbol theories, then a similar pattern of results is expected. Alternatively, the pattern of data observed in Experiment 1 may be due to processes specific to verbal stimuli, or at least sentences of this type. For example, pictures may be coded in a highly perceptual form, which helps them to be remembered so well, consistent with the picture superiority effect. Because memory for pictures is so good, there is no need to integrate this information into situation models, which might be why no interference was observed by Stopher and Kirsner (1981).

Method

Subjects. A total of 36 native English speakers (17 female) were recruited from the subject pool at the University of Notre Dame and given partial class credit for their participation.

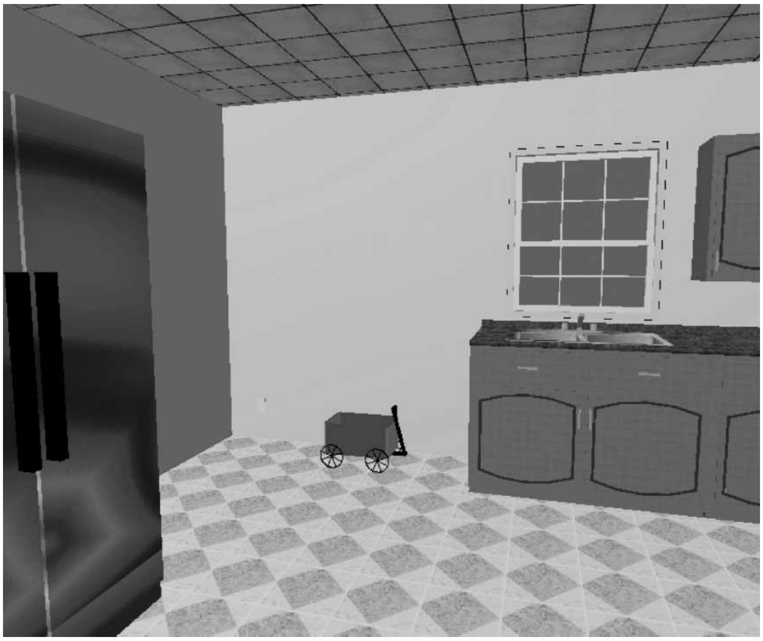

Figure 3. An example of one of the pictures used in Experiments 2 and 3.

Materials. The study pictures were derived from the sentences used in Experiment 1. For example, if one of the sentences for a given subject in Experiment 1 was ''The wastebasket is in the kitchen'', then a picture was created of a wastebasket in a kitchen for that subject number. Thus, the only difference between the materials used in Experiments 1 and 2 was that one set was sentences and the other pictures. The pictures were generated using the Broderbund Home Design software. A layout of a house was created. The rooms included a number of additional, irrelevant items to make the pictures more naturalistic. For example, light switches and power outlets were included, as well as diagnostic furniture that was not to be studied (e.g., a stove, refrigerator, and sink in the kitchen). To make each room distinct, the walls of each room were a different colour.

Within each room, three perspectives were defined. From these perspectives only one of the critical objects could be observed, and the other two (if they were present) could not be seen. If an object was in a given room, it was randomly assigned to one of these three perspectives. If there were more than one object in a room, each object was seen from a different perspective. An example of one of the pictures is shown in Figure 3. Nonstudied pictures were generated by having pictures of objects located in different rooms than the ones they had been studied in.

Procedure. The procedure for Experiment 2 was similar to Experiment 1 except for two changes. First, pictures were used instead of words. Second, because it was not practical to use a recall test during memorisation, forced choice recognition was used. A larger picture of either a single object or an entire empty room was shown along with pictures of all 12 of the rooms or objects. The task was to select the one to three rooms or objects associated with the object or room shown in the larger picture. If incorrect selections were made, then the correct items were highlighted during feedback. After learning, a recognition test was given using pictures. The response time trimming procedure eliminated 4.0% of the recognition data.

Results

Learning. People took 2–11 ($M = 4.4$; $SD = 1.4$) study–test cycles to memorise the study pictures.

Response times. The response time data, summarised in Figure 2B, were submitted to a 2 (Studied–Nonstudied) $\times$ 2 (Condition: Single Location vs Multiple Location) $\times$ 3 (Fan) repeated measures ANOVA. Of more central interest, there was a main effect of Fan, $F(2,\ 70) = 4.26$, $MSE = 19534$, $p = .02$, with response time increasing with an increased number of associations (fan level 1 = 976, 2 = 994, 3 = 1024 ms). Importantly, neither the main effect of Condition nor the Condition × Fan interaction was significant, both $F\text{s} < 1$. Thus, the pattern of retrieval times observed in Experiment 1 was not replicated when pictures were used.

In addition to the results of primary interest, there was also a significant effect of Studied–Nonstudied, $F(1, 35) = 4.97$, $MSE = 29168$, $p = .03$, with people responding faster to Studied probes ($M = 980$ ms) than to Nonstudied probes ($M = 1016$ ms).

Error rates. People in Experiment 2 had an error rate of .05 on the recognition test. The error rate data, shown in Table 1, were submitted to a 2 (Studied–Nonstudied) × 2 (Condition) × 3 (Fan) repeated measures ANOVA. None of the effects was significant, all $p\text{s} > .10$.

Discussion

The results of Experiment 2 stand in stark contrast to those of Experiment 1. Specifically, there was a clear difference in the fan effects in the Single and Multiple Location conditions of Experiment 1, but not in Experiment 2. This was supported by an additional ANOVA that used Experiment as a between-subjects variable, revealing a significant Experiment × Condition × Fan interaction, $F(2, 140) = 3.186$, $MSE = 54964$, $p = .04$. Moreover, people responded faster to the memory probes in Experiment 2, $F(1, 70) = 59.79$, $MSE = 725065$, $p < .001$. Finally, although a fan effect was observed in Experiment 2, it was smaller in magnitude compared to Experiment 1, $F(2, 140) = 4.51$, $MSE = 60711$, $p = .01$. This reduced fan effect for picture stimuli is similar to the results reported by Stopher and Kirsner (1981). However, we were able to observe some interference, whereas they observed none. The current study had a larger number of associations with a concept and used more subjects, which allowed us to see a significant fan effect.

So, why was this pattern of results observed? The increase in response speed corresponds to the general ease with which pictures are processed, relative to language. The fan effect that is observed is due to competing memory traces that share common objects or locations. However, the generally smaller magnitude of this fan effect ($M = 24$ ms increase per fan level) relative to that observed in Experiment 1 overall ($M = 57$ ms increase per fan level), let alone the Multiple Location condition ($M = 85$ ms increase per fan level) suggests that the difficulty people were experiencing with pictures was not as great, and perhaps may have been of a different quality.

Of greatest importance here is the absence of a difference in the fan effects of the Single and Multiple location conditions. There are two immediately obvious ways to interpret this outcome. First, the pattern of results in Experiment 2 suggests that people were not organising information into situation models, as was suggested for the sentences used in Experiment 1. Instead, this pattern is only observed when people are memorising text. When presented with pictures, other cognitive processes come into play that do not involve organisation based on events and situations. For example, people may be storing a memory trace of each picture separately, and not bothering to integrate at all.

The second possibility is that people were creating location-based situation models, and these were stored in memory. However, because of the superior perceptual memory for pictures, people could quickly make recognition judgements based on the surface characteristics of the image, rather than using a more elaborate and complex situation model. Thus, situation models were created and stored in memory, but did not play a large role during retrieval because more "verbatim" representations were available for the pictures, and could be used easily, than is the case with sentences. This also helps to explain why a (small) general fan effect was observed. Specifically, because people are using a surface form representation, rather than a situation model, memory traces for each picture would be stored separately, thereby opening the window for interference to be observed in both the Single and Multiple Location conditions.

EXPERIMENT 3

The aim of Experiment 3 was to assess whether the results of Experiment 2 were due to a failure to create location-based situation models during learning or to the use of a detailed surface form (perceptual) memory of the pictures outpacing the retrieval of any situation models that may have been created. This was done by first having people memorise pictures as in Experiment 2, but then giving them sentences as recognition probes. In this way, the perceptual information from the picture is not available. However, because the information has already been memorised, if there already is an organisation around the locations, then this should be observed.

Method

Subjects. A total of 36 native English speakers (18 female) were recruited from the subject pool at the University of Notre Dame and given partial class credit for their participation.

Materials and procedure. The pictures used during memorisation were those used in Experiment 2, and the recognition probe sentences were those used in Experiment 1. The memorisation period was like that of Experiment 2 and the recognition test was like that of Experiment 1. The only new addition was that, prior to memorisation, people were shown pictures of the rooms without any of the critical objects in them, and from a new view, and pictures of the objects on a neutral background. These were the same pictures used during the test portion of the study period. Each of these pictures was presented in a random order along with the name of the room or object. This was done so that any verbal labels people would apply to the pictures would correspond to the same labels used during recognition. Note that these verbal labels were not present during the learning phase. The response time trimming procedure eliminated 4.2% of the data.

Results

Learning. People took 2–9 ($M = 4.3$; $SD = 1.5$) study–test cycles to memorise the pictures.

Response times. The response time data are summarised in Figure 2C. These data were submitted to a 2 (Studied–Nonstudied) $\times$ 2 (Condition: Single Location vs Multiple Location) $\times$ 3 (Fan) repeated measures ANOVA. Of more central interest, there was a main effect of Condition, $F(1, 35) = 6.03$, $MSE = 98714$, $p = .02$, with people responding more slowly for the Multiple Location probes ($M = 1594$ ms) than to Single Location probes ($M = 1520$ ms). There was also a main effect of Fan, $F(2, 70) = 8.71$, $MSE = 76215$, $p < .001$, with response time increasing with an increased number of associations (fan level 1 = 1493, 2 = 1551, 3 = 1628 ms). Importantly, the Condition $\times$ Fan interaction was significant, $F(2, 70) = 4.36$, $MSE = 90943$, $p = .02$. Simple effects tests showed that the Fan effect was significant for the Multiple Location condition (fan level 1 = 1481, 2 = 1587, 3 = 1720 ms), $F(2, 70) = 10.56$, $MSE = 98705$, $p < .001$, but not for the Single Location condition (fan level 1 = 1505, 2 = 1520, 3 = 1536 ms), $F < 1$. Thus there is evidence for a location-based organisation.

In addition to the results of primary interest, there was a significant effect of Studied–Nonstudied, $F(1, 35) = 26.34$, $MSE = 40182$, $p < .001$, with people responding faster to Studied probes ($M = 1508$ ms) than to Nonstudied probes ($M = 1607$ ms). There was also a significant Studied–Nonstudied $\times$ Fan interaction, $F(2, 70) = 4.52$, $MSE = 28451$, $p = .01$. The fan effect was smaller for the Studied probes (fan level 1 = 1477, 2 = 1479, 3 = 1568 ms) than the Nonstudied probes (fan level 1 = 1509, 2 = 1623, 3 = 1688 ms), although it was significant for both, $F(2, 70) = 3.70$, $MSE = 52539$, $p = .03$, and $F(2, 70) = 11.47$, $MSE = 52127$, $p < .001$, respectively.

Error rates. People in Experiment 3 had an error rate of .04 on the recognition test. The error rate data, shown in Table 1, were submitted to a 2 (Studied–Nonstudied) $\times$ 2 (Condition) $\times$ 3 (Fan) repeated measures ANOVA. None of the effects was significant, except for the three-way interaction. Looking at the pattern of means, there is no clear interpretation of this interaction and it seems to likely reflect a random variation in the error rates.

Discussion

The results of Experiment 3 showed a differential fan effect, which is consistent with a location-based organisation. As such, these results are more consistent with the idea that people were creating room-based situation models during memorisation, and that when people were not able to use the large amount of perceptual detail in the pictures from their surface-form memories, they fell back on more abstract representations, such as their situation models. These data are inconsistent with the idea that the encoding of the information in either sentence or picture form led to differential organisation of the information in memory.

GENERAL DISCUSSION

Three experiments are reported here that explored the influence of stimulus format on the organisation of information in memory and the subsequent retrieval of that information. When only sentences were used (Experiment 1), a pattern of response times consistent with a room-based organisation was observed. However, when only pictures were used (Experiment 2), a different pattern of results emerged in which there was some general interference, but no evidence of organisation. To provide insight into this finding, in Experiment 3 it was observed that when people memorised pictures and then took a recognition test using sentences, then the pattern of data consistent with a room-based organisation re-emerged.[1]

The explanation for this pattern of data is that when people are given perceptually impoverished situational information, such as a list of sentences, they rely on their situation models to make memory decisions. In contrast, when people were given perceptually rich information, in the form of pictures, recognition is more influenced by those representations. Thus, individual memories of each picture were stored more independently, and not integrated as is the case with situation models. There was less need to use the situation models, and so the organisational structure was not observed. However, when the retrieval conditions were altered so that using memories for pictures was not a viable alternative, the previously observed situation model organisations were seen again. This supports the idea in situation model theory that situation models can be created using any type of information, but that these models are not always used. In circumstances where other representational forms are more apt, such as the surface form, then those memories will be used instead (e.g., Johnson-Laird, 1983; Zwaan, 1994).

The current results also have implications for theories of embodied cognition and perceptual symbols (Barsalou, 1999; Glenberg, 1997; Wilson, 2002). These theories assume that the primary representational form of information in memory is based on our interactions with the world, which are largely perceptual. As such, representations of language are thought to be based on perceptual primitives and are structured to capture perceptual qualities, such as orientation, even when not required by the language process itself. On the one hand, the results of the current experiments could be argued to provide evidence that is inconsistent with these theories. Specifically, the format in which the information is presented has a powerful influence on the observed pattern of data.

However, on the other hand, there is also a great deal of evidence to suggest that the mental representations being used in all cases are derived from our interactions with the world, and not some abstract, amodal representation, like a propositional network. The use of perceptual representations is clear when pictures are used exclusively. When sentences are involved, there is evidence of an interactional component in the fact that the organisation that is observed is location-based, which is consistent with our interactions with the world (i.e., we can find multiple objects in one place as part of a coherent situation, but not a single object in multiple places). Thus, there may still be different levels of representation, such as a surface form and situation model level, that are involved in memory, and it is possible that they may both be derived from a common underlying perceptual symbol vocabulary.

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[1] We also did a fourth experiment in which 43 people were presented with sentences at memorisation and pictures at recognition. The response times revealed evidence of a location-based organisation, but not as clearly as in Experiments 1 and 3. There was a significant effect of Condition, $F(1, 42) = 8.35$, $MSE = 184888$, $p = .006$, but the Condition × Fan interaction did not reach significance, $F(2, 84) = 1.33$, $MSE = 196553$, $p = .27$. We believe that people created location-based situation models during memorisation and, even though they had been given example pictures of the rooms and objects, they probably formed images in their mind that differed from the pictures seen at recognition. As such, the variability caused by the format switch and the mismatch with previously generated images caused there to be greater variability in responding and also produced results different from Experiment 2.

	Single Location			*Multiple Location*		
	1	2	3	1	2	3
Studied	1446	1479	1448	1445	1584	1530
Nonstudied	1447	1559	1677	1487	1751	1917

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