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The Effect of Item and Relational Processing on Incidental Long-Term Memory for Order

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Abstract

While stimulus similarity and levels of processing are often manipulated in long-term episodic tasks that test item memory, little attention has been paid to how these variables affect long-term memory for temporal order. The effects of these variables on order memory was tested using a task that required the reconstruction of the initial presentation order of short lists after a filled delay. Initial learning of the lists always involved incidental processing procedures ranging from low-level item processes to high-level relational processes. In all experiments, changes in stimulus similarity and processing tasks had similar effects on order memory to the effects found in tasks involving long-term item memory. An interpretation of the data was proposed, based upon the joint contribution of distinctive item and relational processing, and poor encoding of order information with shallow processing. It was concluded that item information must play a significant role in the long-term order reconstruction task.

The Effect of Item and Relational Processing on Incidental Long-Term Memory for Order

Two of the most frequent manipulations of performance in long-term episodic memory tasks have been those involving stimulus similarity and levels of processing. Moreover, the interaction of these variables has been crucial in the development of models of how organisation and distinctiveness influence many facets of memory performance (Einstein & Hunt, 1980; see Hunt & McDaniel, 1993 for a review). However, in the area of long-term memory for temporal order, little attention has been paid to these variables. Though there is some research on similarity and order (Baddeley 1966; Greene & Crowder, 1984), and a small amount on incidental learning and order (Jackson, Michon, Boonstra, De Jonge, & De Velde Harsenhorst, 1986; Naveh-Benjamin, 1990), only the work of Nairne has examined the interaction of similarity and incidental learning (Nairne, 1990; Nairne & Neumann, 1993).

The current experiments are aimed at adding to both the empirical data base of long-term memory for order and our theoretical understanding of long-term order effects. Specifically, we aim to demonstrate that long-term episodic tasks involving memory for temporal order are affected by manipulations of stimulus similarity and type of orienting task in much the same way as tasks involving long-term episodic memory for items.

Similarity and Memory for Order

Currently, most of the research into similarity effects has focused on two types of similarity: phonemic similarity, where list items have similar sound characteristics; or semantic similarity, where list items either come from the same taxonomic category, or are synonyms of each other.

Most of the research involving similarity and memory for temporal order has involved short-term serial recall tasks. For example, in a short-term order reconstruction task, Crowder (1979, Experiment 3) first had his subjects study a series of semantically similar or semantically dissimilar lists for serial recall. Following the presentation of each list, subjects were given the list items in a new random order and were required to reconstruct the original study order of the list. The rationale for using a reconstruction task was that reconstruction was seen to be a relatively pure test of order memory. That is, because the items were presented at the time of testing, the reconstruction task measured only memory for the order of the items. The results indicated that subjects were better at regenerating the study order of the dissimilar lists than the similar lists. However, after all the lists had been presented and tested for order reconstruction, a final free recall of all items was requested. This free recall test was assumed to reflect access to item memory rather than order memory. Here the pattern of performance was reversed in that more items from the similar lists were recalled than the dissimilar lists. The free recall data are typical of the finding that similarity facilitates item recall. This study is interesting not only because it is a good example of the standard adverse effect of similarity upon short-term ordered recall, but also because Nairne has modified this procedure to develop a long-term order reconstruction task in which reverse similarity effects have been observed. That is, similarity enhanced long-term memory for order (Nairne, 1990; Nairne & Neumann, 1993), not just long-term item memory. It is to these discrepant long-term findings that we now turn.

Nairne's primary interest involved the effects that both semantic similarity (Nairne, 1990) and phonemic similarity (Nairne & Neumann, 1993) would have on the incidental learning of memory for order. In these experiments order memory was again tested via a reconstruction task but the learning phase differed from the typical short-term procedures outlined above. Firstly, subjects were shown five- or six-item lists of similar or dissimilar words, but were only shown three or four lists of each type. Thus, the experiment involved only six or eight trials, not the thirty or forty that are typically utilised in the short-term domain. The presentation rate was a little slower (2.5 sec. as compared to 1.0 sec. in normal serial recall tasks) and subjects learned the items in an incidental fashion by rating each word for pleasantness.

Finally, no immediate memory test was given after each list. Instead, following a ten minute distractor task, subjects were supplied with the original lists of items in the original order of list presentation, but with the items within each list in a new, random order. Subjects were required to reconstruct the original order of the items within each of the lists.

There are three important features of Nairne's results. Firstly, subjects were able to reconstruct the order of the original lists at greater-than-chance levels. Secondly, serial position effects were manifest in a bowed serial position curve, with the order of primacy and recency items being well recalled. Thirdly, reconstruction performance was better for the lists that contained words from the same taxonomic or rhyming categories than for the corresponding uncategorized lists. This last finding is in direct contrast to performance in the short-term task and requires explanation.

While there are many procedural similarities between the short-term and long-term versions of the reconstruction task there are clear differences (e.g. retention intervals). However we are primarily concerned with the differences in encoding operations with a particular focus on levels of processing differences[1]. Within the traditional levels perspective, low-level processing is probably being used in the short-term task, in that maintenance rehearsal appears to be the preferred strategy for preserving short-term memory for order (Baddeley, 1990). In the long-term task, however, rating items for pleasantness is a prototypic deep level process and is thus deemed to produce more elaborate encoding of the items. Thus, it might be that similarity hurts performance when low-level processing is involved but helps when higher level processing is utilized. Of course, it might be the fact that the similarity effects in the short-term task are being driven primarily by some transient factor that is dominant in the short-term domain but has little impact in the long-term domain.

The interaction of similarity with low-level processing is further complicated by one of the Nairne and Neumann (1993) studies. In their experiments that looked at the effects of phonemic similarity on long-term order memory, the processing task involved making pleasantness judgements on the sounds of the words. The question here is whether rating for pleasantness of sound is a deep or shallow processing task. Rating for pleasantness suggests increased levels of elaboration but the focus on non-semantic characteristics suggests encoding of low-level features, provided that their ratings of sound were not affected by the meaning of the word. Given that Nairne and Neumann found that phonemic similarity facilitated performance, the results might indicate that similarity also enhances performance when low-level incidental processing occurs.

From a straight theoretical perspective it is possible to come to another conclusion. If subjects are processing low-level features of the stimuli, by definition they should not be encoding high-level features like the fact that all the items come from the same taxonomic category. To the extent that the semantic attributes of the items are not encoded when low-level encoding processes are utilized, it seems plausible to expect that similarity might have no noticeable effect upon performance. This prediction, while theoretically sound, is at odds with empirical evidence that indicates that semantic attributes still affect performance after low-level processing (Hunt, Elliot & Spence, 1979; Nelson, Walling & McEvoy, 1979; Till & Jenkins, 1973).

The discussion above is intended to highlight the fact that both data and theory can produce different expectations concerning the interaction of similarity with low-level processing tasks. There are instances where similarity facilitates memory, there are instances where it impedes memory and theoretical considerations would lead one to believe that it should have no effect. These predictions are highly dependent in how one interprets the processing involved, particularly in the order reconstruction task. In none of the reconstruction studies reviewed have the more prototypic, low-level, incidental learning tasks been utilized. The first three experiments attempted to resolve some of the ambiguity by testing order reconstruction after incidental learning involving prototypic high-level or low-level encoding tasks. We expected to replicate

Nairne's findings with high-level processing but were less sure about what would happen with the low-level task.

Before proceeding to the first experiment we would like to comment upon one fundamental issue that has not been addressed to date. The assumption has been that the reconstruction task is a test of order memory. That is, the task requires memory for the relationships between items, not memory for the items themselves, yet both the high-level and low-level rating tasks have the processing of item characteristics as their prime focus. The problem is twofold: How does differential processing of item characteristics produce differences in relational information, and how would relational processing affect incidental memory for order? The distinction between item and relational information lies at the heart of many of the organisational and distinctiveness effects that pervade many aspects of human memory (Hunt & McDaniel, 1993). The final experiment adapts the work of Einstein and Hunt (1980) to look at the interaction of similarity, item processing and relational processing on the order reconstruction task. The Einstein and Hunt data indicate that similarity effects are not equivalent for item and relational processing when it comes to item memory. We wondered, given that Nairne's results look very much like standard item memory effects, even though the test is supposedly an ordered memory test, that we might find the same interaction of similarity with relational and item processing that Einstein and Hunt have shown.

Experiment 1

The first experiment examined the effects of depth of processing manipulations and semantic similarity on Nairne's reconstruction task. The pleasantness ratings task employed by Nairne (1990) is regarded as a deep processing task. This raises the question of whether or not order information might also be influenced by the type of incidental learning task utilised and more importantly how similarity would interact with level.

With regards to order memory, depth-of-processing manipulations do have an influence on overall performance (Jackson et al., 1986; Naveh-Benjamin, 1990). For example, Naveh-Benjamin (1990) presented a 20-item list to subjects who either rated the cost of each item (deep processing) or generated a rhyme of each item. At test subjects were presented with a list of the 20 item and were required to place the items in the original study order. Subjects who had rated the cost of items were more able to reconstruct the study order than those who had generated rhymes.

With regards to similarity and order information Nairne's (1990; Nairne & Neumann, 1993) experiments have shown how similarity affects memory for temporal order under deep incidental learning. However, it is not at all clear how similarity interacts with low-level incidental learning to affect memory for temporal order. In the current experiment we expected to replicate Nairne's (1990) findings by demonstrating the facilitative effects of semantic similarity under the pleasantness rating task that Nairne utilised. We also expected to find a depth effect with performance on the pleasantness rating task producing better memory for order than that obtained when subjects were asked to state whether each item contained either of the letters "b" or "m", our low-level processing task. This part of the experiment was largely exploratory given considerations outlined in the general introduction.

Method

Subjects. Ninety students enrolled in an introductory level Psychology course at the University of Southern Queensland participated in this experiment for course credit. Experimental sessions were conducted in groups of six to 10 subjects. Forty-five subjects participated in the pleasantness rating condition: 45 participated in the letter detection condition.

Materials. The items used in the experiment were selected from the University of South Florida Category Norms (McEvoy & Nelson, 1982). Six monosyllabic, concrete nouns were selected from each of the following categories: PART OF THE BODY, FARM ANIMAL, TYPE OF FURNITURE, COLOUR, ARTICLE OF

CLOTHING, TYPE OF TREE, FORM OF TRANSPORT, ALCOHOLIC BEVERAGE, and WEAPON.

Each subject was presented with six six-item lists. For three of the lists the items in each list came from the same taxonomic category and were randomly assigned to the six serial positions. The other three lists were created by randomly assigning one instance from each of the remaining six taxonomic categories to each list. To counterbalance possible materials effects, three replications of this procedure were conducted to ensure that the instances of each category were tested in a similar list and in a dissimilar list. Within each replication the order of the six trials was randomised.

At test, subjects were presented with a single sheet which contained the trials from the study phase in their original order. However, within each trial, the items were randomly reordered and placed above six response spaces.

Procedure. Each trial began with the word "READY" appearing on a Macintosh computer screen. The list items were then individually presented at a 2.5 sec. rate and the trial finished with a 5.0 sec. blank delay. Following Nairne's lead, the instructions made no reference to any reason for grouping the items in this way.

Depending upon which incidental learning condition subjects were assigned to, subjects were requested to perform a pleasantness rating task or a letter detection task. Each subject was given a rating sheet, which contained six response blanks for each of the experimental lists. For the pleasantness task, subjects were asked to make rapid pleasantness ratings on each word in the list using a scale from one (Unpleasant) to three (Pleasant). In the letter detection task subjects were required to determine whether or not the word contained either of the letters "b" or "m". Thus for each word they produced a yes/no decision. In both the tasks, subjects wrote their response to each word directly after the presentation of that word, and were asked to make their decision as quickly as possible after the presentation of each word. Neither of the experimental groups were informed of the purpose of their respective tasks.

After the presentation of all six lists, a distractor task was given to both experimental groups, which involved finding words hidden in a matrix of letters. This task continued for 10 min., after which subjects were given the order reconstruction test. Subjects were informed of the changes to the order of the items in each list, and that their task was to write the words in the exact order of original presentation. They were given as much time as they required to complete the task.

Results and Discussion

The data concerning order reconstruction are summarised in Figure 1 as a function of serial position and stimulus similarity. The facilitative effects of similarity on order recall in the pleasantness rating task appear to have been replicated, a depth effect is present, and the similarity effect has been attenuated under letter detection conditions.

Insert Figure 1 about here

The initial analysis of the results in Figure 1 involved a 2*2*6 mixed design ANOVA, with learning task (pleasantness vs. letter detection) as the between-subjects variable, and with similarity (similar vs. dissimilar) and serial position (six levels) as within-subjects variables. In this and all subsequent analyses, alpha was set at .05. The results of this analysis indicated that performance was better on the pleasantness task than on the letter detection task, F (1, 88) = 86.53; MSE = .241, similar lists were better recalled than dissimilar lists, F (1, 88) = 7.12; MSE = .142, and there were reliable serial position effects, F (5, 440) = 42.94; MSE = .05. Of primary concern, however, was the presence of a task by similarity interaction, F (1, 88) = 5.75; MSE = .142. Simple main effects indicated that for the pleasantness rating task, recall was better for the similar lists than the dissimilar lists, F (1, 44) = 9.54; MSE = .190, but that for the letter detection task similarity had no effect.

The patterns of performance depicted in Figure 1 are as expected. We replicate Nairne's (1990) findings in the pleasantness task. That is, levels of performance are reasonably high even after a 10 minute retention interval, there is pronounced primacy and recency in both the similar and dissimilar conditions and there is a substantial similarity effect with similar items being better recalled than the dissimilar items. We also replicate the findings that order information is susceptible to levels of processing manipulations (Jackson, et al., 1986; Naveh-Benjamin, 1990) in that overall levels of ordered recall were better in the pleasantness rating task than for the letter detection task. What is new in the current experiment is that the similarity effect evident with high-level processing has been eliminated with low-level processing. In the next experiment we explore the generality of the effect.

Experiment 2

Nairne and Neumann (1993, Exp. 1) demonstrated that the beneficial effects of similarity in the order reconstruction task was not limited to semantic similarity, but generalised to phonemic similarity. Using the Nairne (1990) methodology, they had subjects rate lists of phonemically similar or phonemically dissimilar words for the pleasantness of the sound of the word. They found that phonemic similarity also facilitated ordered recall in the reconstruction task. This result was surprising, given the large data base indicating the detrimental effects of phonemic similarity in short-term ordered recall. Furthermore, as mentioned earlier, there is some doubt as to the level of processing that is being manipulated by having subject rate the pleasantness of the sound of words. The first aim of the current experiment was to attempt to replicate the facilitative effects of phonemic similarity using the standard rating for semantic pleasantness technique.

The second aim of the experiment was to replicate the levels of processing effect and the interaction of similarity and levels that were evident in the first experiment. Thus, once again subjects studied three lists containing similar items and three lists containing dissimilar items and their ability to reconstruct the order of the lists was tested. To the extent that Nairne and Neumann results are reliable, we expected to find the identical pattern of results that were present in the first experiment.

Method

Subjects. Ninety first year undergraduate students participated in this experiment for course credit. Experimental sessions were conducted in groups of six to 10 subjects. Forty-five subjects participated in the pleasantness rating condition: 45 participated in the letter detection condition.

Materials. The items used in the experiment were selected from the University of South Florida Rhyme Category Norms (Walling, McEvoy, Oth, & Nelson, unpublished manuscript). Six monosyllabic, concrete nouns were selected from each of the following rhyme categories: OCK, ILL, ALE, ING, EET, EEL, AIN, OAL, and UNK. The number, construction and organisation of the lists were identical to that in Experiment 1.

Procedure. The procedure in the current experiment was exactly the same as for Experiment 1. This resulted in a slight modification to the procedure used by Nairne and Neumann (1993). Their subjects rated pleasantness for sound, whereas the subjects in the current experiment were instructed simply to rate the pleasantness of the word.

Results and Discussion

The results are summarised in Figure 2. The main features of the first experiment appear to be present in the current data. Phonemic similarity facilitates order recall in the pleasantness rating task, a depth effect is present although it seems to be weaker than in the first experiment, and the similarity effect is again attenuated in the letter detection task.

Insert Figure 2 about here

An overall ANOVA with the same design specifications as Experiment 1 confirmed that performance was better on the pleasantness task than on the letter detection task, F (1, 88) = 22.95; MSE = .162, similar lists were better recalled than dissimilar lists, F (1, 88) = 7.69; MSE = .123, and there were reliable serial position effects, F (5, 440) = 18.49; MSE = .067, with primacy and recency portions of the serial position curve being better recalled. Of the possible interactions, serial position interacted with the type of task, F (5, 440) = 18.49; MSE = .067, and, more importantly, the task by similarity interaction was only marginal, F (1, 88) = 3.00; MSE = .123, p. = .08.

Simple main effects of the position by task interaction, indicated that there were reliable serial position effects for the high-level condition, F (5, 220) = 30.1; MSE = .070., but not for the low-level condition. That is, the serial position curve is basically flat. Simple main effects analysis of the task by similarity interaction indicated that similarity effects were present under pleasantness rating, F (1, 44) = 7.14; MSE = .175, but not under letter detection conditions.

The results again indicate that memory for order, like item memory, is quite good when high-level processing is induced but not very good when low-level processing is required. The data also confirm that the facilitative effect of similarity on long-term order memory generalises to phonemic similarity under deep processing conditions. It would appear that the type of pleasantness rating, be it rating for the pleasantness of the sound or for semantic pleasantness, is immaterial in producing the similarity effect. There are differences, however, in the absolute levels of performance across the two experiments. The superior recall of semantically similar over phonemically similar lists may be due simply to differing subject characteristics. It might be the fact that semantic features serve as better retreival cues than do phonemic features, although there is evidence in the long-term domain that both are equally effective (Nelson et al., 1979). The difference might also be due to transfer appropriate processing effects in that rating for semantic pleasantness should produce a closer match with semantic attributes than sound attributes. What ever the explanation phonemic similarity still facilitates performance on the reconstruction task after deep processing. In contrast, under shallow processing conditions, order memory does not seem to be influenced in any way by the similarity of the items in the list.

The pattern of results across the first two experiments is virtually identical. However there are some methodological considerations that warrant inspection. Performance in the letter rating condition is quite poor, especially in Experiment 2. The lack of similarity effects in this condition may simply reflect floor effects. Furthermore, it has been suggested that differences in performance between deep and shallow incidental conditions are not due to different depths of processing, but rather that these differences are due to the pleasantness rating task involving whole word processing, whereas the letter detection task may not (Lewandowsky & Hockley, 1987). Consequently, it has been argued that making rhyme judgements, for example, is a more appropriate low-level learning task. While, the logic of the argument cannot be faulted, the empirical data would tend to suggest that the letter detection and rhyme judgement tasks produce similar effects. For example, Jackson et al. (1986) examined order memory using the letter detection task and Naveh-Benjamin (1990) utilised the rhyming task. Both studies indicated that order reconstruction in these conditions was substantially poorer than when high-level learning tasks were used, though neither of them varied stimulus similarity. Therefore, the next experiment was designed to address these concerns in the current experimental context.

Experiment 3

If the pattern of performance observed in the first two experiments is not due to the surface characteristics of the task employed, it should be possible to change several aspects of the experimental procedure and still observe the same pattern of performance. In the current experiment, we replicated Experiment 1 with the following changes. We changed the materials by choosing from a different set of taxonomic categories. To deal with the issue of floor effects we decreased the length of the list from six items to five items and we decreased the retention interval from ten minutes to two minutes. Nairne (1990) demonstrated that such a change in retention interval does facilitate order recall in this task. We also changed the incidental learning tasks. The high-level task involved subjects making yes/no decisions on whether or not the items on the list made sense when they were inserted into a specified sentence. The low-level task was the rhyme judgement task in which participants were asked if each item on the list rhymed with a predetermined word. These particular level manipulations were chosen because they were similar to those used in Craik and Tulving's (1975) seminal level-of-processing paper.

In all other respects the current task was identical to previous tasks. To the extent that these surface changes were not a critical determinant of order memory, we expected to observe the same pattern of performance as obtained in the first two experiments.

Method

Subjects. Sixty undergraduate students from the University of Southern Queensland participated for course credit. Thirty subjects were randomly assigned to the sentence frame learning condition and 30 were assigned to the rhyme judgement condition.

Materials. Five exemplars from nine different categories to those used in Experiment 1 were selected from the South Florida category norms. The categories chosen were WEAPON, RELATIVE, CRIME, CHEMICAL ELEMENT, FRUIT, PART OF A TREE, COLOUR, GARDENING IMPLEMENT, and MEMBER OF ROYALTY. The number, organisation and construction of the lists was identical to that used in Experiment 1, with two exceptions. Firstly, each list consisted of five items instead of six. This necessitated a different procedure for the construction of dissimilar lists. For each of these, five categories were randomly chosen, and one item from each of those categories was randomly selected, without replacement, to be a member of that list. This procedure was then repeated for the construction of the other two dissimilar lists. Counterbalancing considerations again necessitated the construction of three sets of lists.

Procedure. The major change to the experimental procedure involved the adoption of two different incidental learning tasks. For the sentence frame task, one item in each list was selected to be the target and a meaningful sentence was constructed that included that word. Thus in the case of the items from the category Chemical Elements, the sentence "A Midas touch turns everything to _____" was created. Of the selected instances for this category (ie. zinc, iron, carbon, gold and sulphur) only gold produced an appropriate completion. Likewise, for the rhyme judgement task one item in each list rhymed with the cue word (eg. Rhymes with mink). Thus, for both types of task, the ratings on each trial resulted in one yes response and four no responses.

The actual rating sheet that was used in the learning phase of the experiment involved the sentence frame or the rhyming word presented above five numbered spaces in which the subjects inserted their judgement for each item. Instructions indicated that at the beginning of each trial they were to look at the sentence frame (or the rhyme cue) and then to judge if each of the following words in the list fitted into the sentence (or rhymed with the cue) and to write down a yes or no response for each word.

The other change involved a reduction in retention interval. The word search task was still used but work on the task ceased after two minutes instead of ten.

Results and Discussion

The results are summarised in Figure 3. It appears here that, despite the methodological changes made in the current experiment resulting in higher levels of performance, overall patterns of performance are similar to those observed in Experiments 1 and 2. That is, a depth effect is once again evident, and similarity facilitates order recall in the sentence frame task, but has little effect on order recall in the rhyme judgement task.

Insert Figure 3 about here

An overall ANOVA with the same design specifications as Experiments 1 and 2, but with five, rather than six, levels of serial position, confirmed that performance was better on the sentence frame task than on the rhyme judgement task, $\underline{F}$ (1, 58) = 25.25; $\underline{MSE}$ = 1.885, similar lists were better recalled than dissimilar lists, $\underline{F}$ (1, 58) = 7.48; $\underline{MSE}$ = .807, and there were reliable serial position effects, $\underline{F}$ (4, 232) = 19.18; $\underline{MSE}$ = .481.

Of the possible interactions, serial position interacted with the type of task, $\underline{F}$ (4, 232) = 2.47; $\underline{MSE}$ = .481, similarity interacted with serial position, $\underline{F}$ (4, 232) = 4.65; $\underline{MSE}$ = .504, and, importantly, type of task interacted with similarity, $\underline{F}$ (1, 58) = 15.63; $\underline{MSE}$ = .807.

Subsequent simple main effect analyses indicated that for the sentence frame task, recall was better for the similar lists than the dissimilar lists, $\underline{F}$ (1, 29) = 19.81; but there were no overall advantages for similar over dissimilar lists in the rhyme judgement task. Furthermore, serial position effects were stronger in the high-level processing task , $\underline{F}$ (4, 116) = 18.46; $\underline{MSE}$ = .456, than in the rhyme judgement task although the latter were still reliable, $\underline{F}$ (4, 116) = 3.93; $\underline{MSE}$ = .506.

The results of the first three experiments are quite consistent. We replicate Nairne's (1990; Nairne & Neumann, 1993) findings that both semantic and phonemic similarity facilitate reconstruction of order under deep incidental learning. The results are also consistent in showing that, with shallow orienting tasks, memory for order is poor and similarity has virtually no effect upon performance. As yet we have not addressed explanations or implications of these results. We do so now.

As noted previously, the facilitative effects of similarity on order that are observed under high-level processing, are at odds with much of the other literature on temporal order which generally indicates a detrimental effect of similarity (Baddeley, 1966; Conrad & Hull, 1964; Crowder, 1979; Greene & Crowder, 1984, Murdock & Vom Saal, 1967). One straightforward way of explaining these results would be to assume that the processes involved in the long-term reconstruction task are very different to those involved in the short-term domain. Performance on the low-level task is informative here because if one accepts that maintenance rehearsal and the incidental learning tasks used in the current experiments all induce low-level processing then one might expect to observe the detrimental effects of similarity in the current experiments. The fact that the incidental tasks do not produce the same effects as maintenance rehearsal suggests that encoding processes are not equivalent across the two domains. Thus, there is the distinct possibility that the differences between short- and long-term domains is due to the fact that different processes are involved. There are a number of caveats to accepting this conclusion, however, because there are some similarities in performance across the two domains. The most important of these is the distribution of order errors.

In short-term serial recall a large proportion of errors involve the systematic transposition of items within a list. That is, transpositions amongst near neighbours in the list are more likely than transpositions among remote neighbours. When the responses for a particular serial position are plotted graphically, the frequency of responses peaks at the correct position and declines gradually as the distance from the correct serial position increases (Estes, 1972; Lee & Estes, 1977; 1981). Exactly the same pattern of transposition errors is found in the reconstruction task and this pattern is not due to some type of short-term memory residual (Nairne, 1990; 1992). Thus, there are some critical similarities between the reconstruction task and more traditional short-term serial recall tasks.

The absence of similarity effects under low-level processing is to some extent troublesome. Although the results are precisely what one would expect from a levels of processing approach that asserted that encoding processes are the only important determinant of memory, we noted earlier that there was substantial empirical evidence to suggest that semantic attributes of the study material could still influence recall even under low-level orienting tasks (Hunt et al, 1979; Nelson et al., 1979; Till & Jenkins, 1973). In the current experiments this is clearly not the case. Furthermore, if one accepts the proposition that semantic effects under low-level processing are due to retrieval factors (Nelson. et al., 1979), then the results suggest that retrieval factors are not having a strong impact on performance under low-level processing conditions.

The results at this point are very similar to those obtained in experiments that typically require item memory instead of order memory, which is not all that surprising given that the manipulations involve differential item processing. In the next experiment we want to see how relational processing affects performance on the reconstruction task. Here Hunt, Einstein, and McDaniel's (Einstein & Hunt, 1980; Hunt & Einstein, 1981; Hunt & McDaniel, 1993) work on item and relational processing and its effects on memory are relevant. In particular, two experiments conducted by Einstein and Hunt (1980).

In their first experiment, Einstein and Hunt tested recall of related words (ie. lists of words from the same taxonomic categories) under different incidental learning situations. For their experimental procedure, subjects either performed relational or individual-item processing, or a combination of the two types of processing, on each list. The relational task was either semantic (sorting by category) or non-semantic (sorting by first letter). Likewise, the individual-item processing task was either semantic (pleasantness rating) or non-semantic (rhyme rating). Hunt and Einstein demonstrated that the effects of item and relational processing were additive, in that together they produced higher levels of overall free recall than either type of processing alone.

In their second experiment, Einstein and Hunt looked at the interaction of relational and individual-item processing with list structure. They had subjects perform either a semantic individual-item processing task (rating words for pleasantness), or a semantic relational processing task (sorting words into categories) on a list of words that differed in their level of semantic relatedness. The items in the lists were either highly similar (ie., consisting of similar items from common taxonomic categories, such as "Musical Instruments"), or weakly related (ie., essentially items grouped into non-obvious categories, such as "Things that are Green"). After a one-minute distractor task, subjects were given a free recall test. They found that similar items were better recalled than dissimilar items following item-specific encoding. Conversely, recall of dissimilar items was better than recall of similar items following relational processing.

In explaining these results, Einstein and Hunt assumed that there was strong relational information inherent in similar words, and strong individual-item information inherent in dissimilar words. Consequently, the similar words benefited more from item processing than further relational processing and the dissimilar words benefited more from relational processing than additional item processing.

While the item-relational processing explanation was based on experiments measuring item memory, the similarity in surface characteristics between the pleasantness rating condition of Einstein and Hunt's (1980) second experiment and the pleasantness rating task in the reconstruction experiments reported in this paper and by Nairne (1990) suggests that the explanation might transfer to memory for order. Thus, the pleasantness-rating task could be seen to promote item-specific encoding which is most beneficial for items possessing strong relational information (ie. the similar lists). Providing additional item processing for the dissimilar words which presumably already have fairly distinctive item information, would be superfluous. Thus, a possible alternative explanation for the facilitative effect of similarity on long-term memory for order involves the additive effects of item and relational information. Moreover, if there is correspondence between the two domains, one might expect to find dissimilar words being better recalled in the order reconstruction task when relational processing is required. The final experiment to be reported sought to confirm such a correspondence.

Experiment 4

In this experiment, we examined the correspondence between Einstein and Hunt's results and performance on the reconstruction task, again utilising high-level and low-level item processing tasks but adding a relational information orienting task. Furthermore, the materials in the current experiment were selected to be more like those used in the Einstein and Hunt's experiments. That is, all the list involved items from the same category. Similarity and dissimilarity under these conditions reflect whether or not a particular category is more or less obvious. The expectation was that we would replicate the results of Experiments 1, 2, and 3 by showing a facilitative effect of similarity under the deep processing condition and an absence of any similarity effect under the shallow condition. We also expected to find that under the relational processing condition, the dissimilar lists would be better remembered than the similar lists.

An additional consideration was the possibility that subjects may have noticed the relational structure in the dissimilar lists if the similar lists were presented before the dissimilar lists. To examine this effect, the dissimilar lists were blocked and the order was counterbalanced across subjects. To the extent that subjects in the condition where similar lists preceded dissimilar list did note the relational structure of the lists, we expected the similarity effect on the deep orienting task to be attenuated. That is, both lists would have equivalent relational and item processing: the similar lists would benefit from increased item processing and the dissimilar lists would benefit from the increased relational processing that results from seeing that the items come from the same category.

Method

Subjects. The sample consisted of 90 participants, the majority of whom were undergraduate students participating for course credit. Thirty subjects were other undergraduate students or volunteers from the community who participated in return for a ticket in a cash lottery. On the basis of sign-up times, subjects were assigned to one of three conditions: relational processing (n = 30), deep individual-item processing (n = 30), or shallow individual-item processing (n = 30). Sessions were conducted in groups of three to five.

Materials. Five items from each of the four obvious taxonomic categories and five items from each of the less obvious categories served as the materials for the similar and dissimilar trials respectively. The similar words were drawn from the Battig and Montague (1969) norms, and included five items from each of four of the taxonomic categories used by Einstein and Hunt (1980) (PARTS OF THE BODY, MUSICAL INSTRUMENTS, INSECTS, and FRUITS). The dissimilar words were generated by the experimenters, and included five items from each of Einstein and Hunt's four broad categories (THINGS THAT ARE GREEN, LIQUIDS, THINGS MADE OF WOOD, and THINGS WOMEN WEAR). The items were chosen with the expectation that the relational nature of the broad categories would be less obvious than that of the taxonomic categories.

The use of these materials necessitated some changes to the procedure involved in the earlier experiments. Firstly, in the previous experiments, items on a particular dissimilar list were selected from different taxonomic categories. In the current experiment, the items in each dissimilar list were from the same category. Thus, one of the dissimilar lists might have involved all the items from the category THINGS MADE OF WOOD. This change meant that similarity in this experiment was based primarily upon the status of the category, because for both similar lists and dissimilar lists, the items came from the one category. That is, similarity was determined by whether or not the category was an obvious, familiar, and readily recognised one. This change probably weakened the manipulation of similarity to some extent, but was required to examine the effects of item-information differences under the relational processing condition.

A second change involved an increase in the number of study trials. In the early experiments reported here, subjects studied three similar and three dissimilar lists. In the current experiment, subjects studied four of each type.

A third change involved the order of presentation of the lists. Half the subjects studied the dissimilar lists before the similar lists, and half studied the similar lists before the dissimilar lists.

Procedure. The experimental procedure closely followed that used in the earlier experiments exploring the temporal order reconstruction task. However, we again made some changes to the orienting tasks. In the pleasantness rating task, a five point pleasantness rating task was used instead of the three point scale used earlier. In the shallow processing condition subjects counted the number of letters in each item. In the sorting condition, subjects were provided with a list of category labels and were asked to write down the category label of each item. In effect, students produced the same response for each item on a particular trial. The filled retention interval was two minutes in length.

Results and Discussion

The results of the different orienting tasks are summarised in Figure 4. The main features of Experiments 1, 2 and 3 appear to be present in the current data. That is, similarity facilitates order recall in the deep item-processing task but has no effect in the shallow item-processing task. It also appears that dissimilar items are better recalled than the similar items in the sorting task.

Insert Figure 4 about here

The initial analysis involved a 3*2*5 mixed design ANOVA with orientation task as a between-subjects variable and similarity and serial position as within-subject variables. There were reliable effects of the orienting task, F (2, 87) = 45.69, MSE = .285, in which Newman-Keuls comparisons indicated that pleasantness rating produced (M = .70) significantly better recall than sorting (M = .52) which in turn produced better learning than counting (M = .28). There were reliable effects of serial position, F (4, 348) = 21.96, MSE = .041, and serial position interacted with orienting task, F (8, 348) = 5.29, MSE = .041. More importantly, there was no overall effect of similarity, F (1, 87) = 2.77, MSE = .093, but the interaction of similarity and orienting task was reliable, F (1, 87) = 8.13, MSE = .093. Given this interaction, we examined similarity effects in each of the orienting conditions, and in this analysis, we added the between-subjects variable of list order (first block vs. second block).

When subjects rated items for pleasantness, there was an overall advantage for similar items over dissimilar items, F (1, 29) = 5.96, MSE = .084, although this interacted with list order. When the dissimilar lists preceded the similar lists, the effect of similarity was very robust, F (1, 14) = 11.86, MSE = .078, but when the similar lists preceded the dissimilar lists, performance was equivalent in the two conditions, F (1, 14) = .03, MSE = .066.

When subjects counted the number of letters in the word, there was no difference in recall between similar and dissimilar lists, F (1, 29) = 2.52, MSE = .095. Similarity did not interact with list order.

In the sorting task, dissimilar words were better recalled than similar words, F (1, 29) = 8.86, MSE = .158. Again, similarity did not interact with list order.

The pattern of results obtained here bear a strong resemblance not only to the order recall results of Experiments 1, 2, and 3, but they also bear a strong resemblance to the item recall results of Einstein and Hunt's (1980) results. In short, there appears to be a strong correspondence between performance on the temporal order reconstruction task and an item recall task, and so it seems plausible to look at serial order reconstruction from the point of view of the interaction of relational and item processing. We will develop this argument in the general discussion. For now we would like to assert that the interaction observed between similarity and list order in the pleasantness rating condition is consistent with these notions. The argument would be that when the dissimilar lists are presented first, participants do not notice the structural relationship between the items, that is that blood, oil, ink, wine and petrol are all liquids. Thus, at the end of the orienting task, similar and dissimilar lists have equivalent item information but the similar lists benefit from the relational information. We assume that presenting the similar lists first sensitizes subjects to the relational features of all the lists. Seeing earlier lists of musical instruments, insects, fruits, and body parts, sets the scene for subjects to notice the links between the items in the dissimilar lists. If this happens, then, at the termination of processing, both the dissimilar and similar lists should enjoy the benefits of relational and item processing. This explanation is supported to the extent that performance on the similar lists is the same irrespective of the order of the lists and that the dissimilar lists when studied second are remembered as well as the similar lists. This suggests that the dissimilar lists have also received some relational processing.

General Discussion

The effects of similarity and orienting task upon serial order appear to be quite consistent across the four experiments that have examined order reconstruction. Deep processing results in higher levels of order recall than shallow processing. This replicates other research on memory for temporal order (Naveh-Benjamin, 1990). Similarity, be it semantic similarity or phonemic similarity, enhances order recall when deep item processing tasks are utilised. This replicates the work of Nairne (Nairne, 1990; Nairne & Neumann, 1993).

There are two novel findings in the four reconstruction experiments of this paper. Firstly, similarity has no effect upon ordered recall when shallow orienting tasks are used. Secondly, the results of Experiment 4 show that, when a relational processing task is performed, dissimilarity amongst the items in the list facilitates ordered recall.

These results raise a number of issues. For a start, how is the absence of similarity effects in the shallow condition to be understood. It might be that the maintenance of order information requires processing at the word level and that our low-level tasks of counting the number of letters in the word, or searching for specific letters in each word, does not involve whole word processing. It might be the case that we are simply observing floor effects, or it might be the case that order information is poorly registered under shallow processing conditions.

With regards to the orienting tasks involved, we have utilised three different shallow tasks; letter search, letter counting and rhyme judgement. While the first two of these tasks probably may not require whole word processing, the last does. Given the lack of similarity effects across the three shallow conditions, plus a consistent pattern across the two different deep processing tasks, we are inclined to think that the lack of similarity effects are not specific to the particular orientation task used.

Although performance after shallow processing is quite poor, there are signs that we are not on floor in some of the experiments. Thus, in Experiment 1, the serial position curve is slightly bowed, so for at least the primacy and recency portions it is reasonable to assume that we are off floor. In Experiments 3 and 4, where list length and retention interval both been shortened, performance is superior to that in Experiments 1 and 2, yet virtually the same pattern of performance is observed. Floor effects do not seem to be a complete explanation for the lack of similarity effects.

We think that there are two sources of information that suggest that the data reflect the fact that shallow processing simply produces poor order information. We mentioned earlier that in serial recall tasks where there are reasonable levels of learning, transposition errors are most prevalent amongst neighbouring items. One might assume that, if performance was on floor, or if item information was totally absent, the pattern of transposition errors should be quite random. In Figure 5, we present the response gradients for the shallow condition in Experiment 4, which are representative of the equivalent conditions in the other experiments. The essential features of normal order memory are preserved but the gradients are flatter than normal. In fact, the current performance as reflected by the absolute levels of performance and the gradient of the response curves is roughly equivalent to that obtained when memory for order after deep processing is tested after a 24-hour delay (Nairne, 1992). In short, we think the data indicate that memory for order is hard to retrieve under shallow processing conditions.

Insert Figure 5 about here

While we have very low-levels of order information under low-level encoding operations, in the other conditions order memory is quite good. In these instances it appears as though performance can be understood in terms of the joint contribution of distinctive item processing and relational processing.

In proposing an explanation in terms of relational and item processing, we first assume, as have Einstein and Hunt (1980), that good relational information but relatively poor distinctive item information is present in lists that are made up of items from the one category. In contrast, the lists consisting of items from different categories have relatively good distinctive item information but lack any relational information. Secondly, we assume that the pleasantness rating task produces changes to item distinctiveness but not to relational information whereas the sorting task produces changes in relational information but not item distinctiveness. With these assumptions performance emerges as the joint effects of inherent features of the material being studied and the processing being employed. Performance is optimal in the situation where both relational information and item distinctiveness are maximised. Thus, in the pleasantness rating task, good relational information inherent in the similar list is supplemented by increasing the distinctiveness of the similar items. Additional item processing of the already distinctive items in the dissimilar list is seen to be somewhat superfluous. Conversely, the act of sorting increases the level of relational information of the dissimilar lists to that of the similar lists. The inherent distinctiveness of the dissimilar items ensures that they are better recalled.

The strong correspondence between the current studies and those of Einstein and Hunt suggests that performance on the order reconstruction task is influenced by the same processes that underlie some of the features associated with hypermnesia, the generation effect in free recall, understanding prose, and self-referent encoding (Hunt & McDaniel, 1993). However, this correspondence is problematic at other levels. For instance, the current experiments have little to offer for the explanation of why in most other situations similarity has a deleterious effect upon performance. In the current experiments the only time we demonstrated the traditional detrimental effects of similarity was in the sorting condition. An explanation in terms of equivalent relational processing but different levels of distinctiveness might explain performance in the reconstruction task but such an explanation would not hold in the typical short-term task where the similar items would by this account have superior relational information to the dissimilar items and hence should be better recalled.

The results are also problematic in that, to the extent that the reconstruction task reflects a pure test of order memory, it would seem that order memory is quite similar to item memory. This is at odds with most models of short-term recall in which order and item information is represented by quite separate and distinct mechanisms (Drewnowski, 1980; Nairne, 1988; Shiffrin & Cook, 1978), or if the same processes are involved, item information is lost due to perturbations in order information (Estes, 1972; Lee & Estes, 1977;1981). Of course, one reason why order information might look like item information in the current task is that it is not a pure test of order information. There are already some indications that this might not be so. For example, Whiteman, Nairne and Serra (1994) argued that, in the reconstruction task, all subjects were required to do was to make an appropriate recognition decision since all the items were present. Consequently, given the standard findings in recognition that low frequency words are better recognised than high frequency words, they expected to observe the same effect in the recall task. They did not. It would thus appear that the reconstruction task is not a straight forward recognition task.

At the theoretical level there are models that would specify that item information would have to be retrieved in the reconstruction task. For instance, Chappell and Humphreys (1994) have proposed a retrieval model of memory that involves the generation of a target through the intersection of multiple cues. The output of the intersection is usually noisy and a clean-up process is required to make a response. In applying this model to the current task, say trying to place one of the items in the third serial position, the subject would have to first find the intersection of the cue representing serial position three and the cue that would elicit the items on that list. The position cue would elicit all items in the experiment that appeared in the third serial position (order information) and the list cue would elicit all the items on the list (item information). The intersection would specify a representation that hopefully would look something like the representation of the target item. Note that in this explanation for the intersection to take place both order information and item information have to be retrieved, and that producing a response involves the confluence of item and order information. The provision of the list items might facilitate cleaning up the noisy output of the intersection, but the task is primarily one in which item information has to be retrieved. From this perspective, it is not surprising that the factors that influence item information are also having the same effect upon the reconstruction task.

We started this paper by commenting that there was little information available concerning the effects of similarity and incidental learning on long-term memory for order. We can now say that performance on the long-term order reconstruction task that Nairne (1990) developed has much in common with performance on other long-term tasks that have measured item memory. Long-term order performance appears to covary in a principled manner with manipulations of relational and item distinctiveness processing. To this extent, performance on this task appears to have much more in common with other long-term memory tasks that with more traditional short-term serial order tasks. However, there are obvious overlaps in the two domains, particularly with the pattern of transposition errors observed. What may be happening is that the reconstruction task is not a pure test of order memory and that in fact item information must be retrieved. If so, what we are observing in the current set of experiments are the effects of variables that have a large impact upon item information but very little impact upon pure memory for order.

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Footnotes

1. The levels of processing theory proposed by Craik and Lockhart (1972) regards the storage of information in long-term memory as being a consequence of the processes adopted in the learning stage. According to the theory, cognitive process can range in complexity. The "deeper" or more complex the processing the more likely it is that a stimulus item will be remembered. Although the theoretical aspects of the procedure have been criticised (Baddeley; 1978; Morris, Bransford & Franks, 1977; Nelson et al. 1979), the effects of depth of processing manipulations are easily replicated and clearly demonstrate that item recall is sensitive to encoding processes. For expository convenience we will refer to high-level or low-level orienting tasks although we are not wedded to the theoretical underpinnings of these terms.

Figure Captions

Figure 1. Order reconstruction performance in Experiment 1 as a function of orienting task, serial position and stimulus similarity.

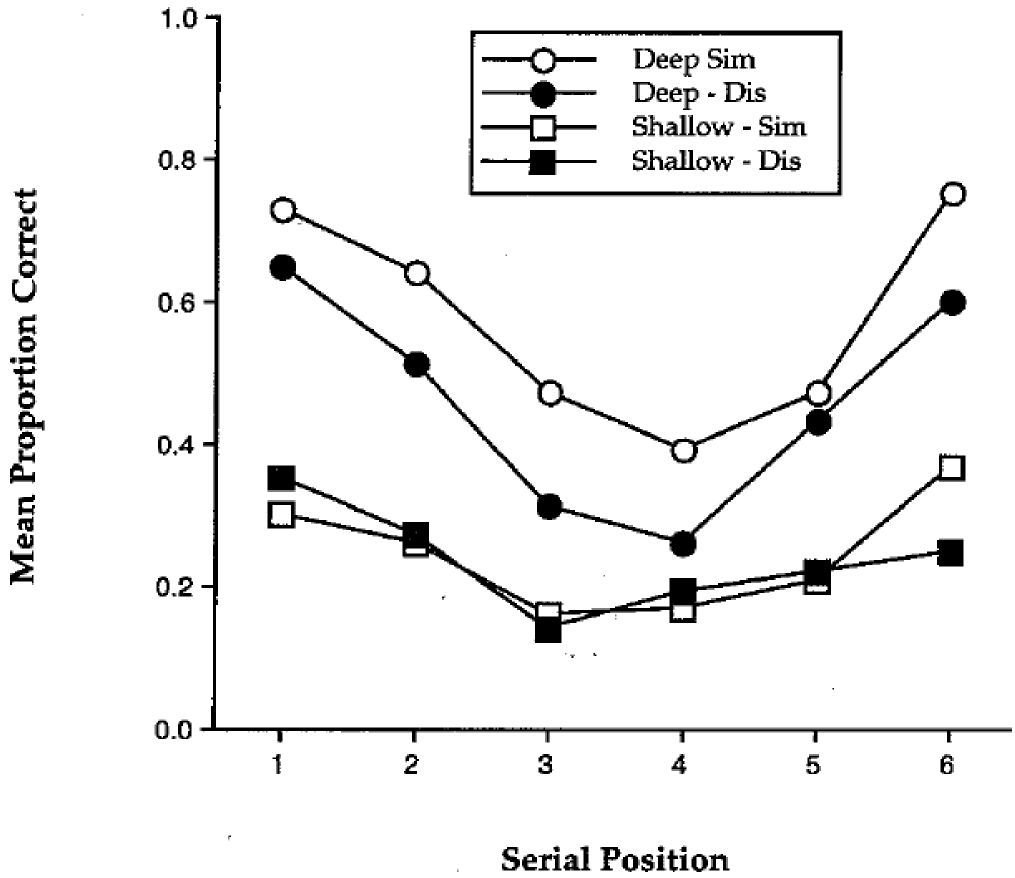
Figure 2. Order reconstruction performance in Experiment 2 as a function of orienting task, serial position and stimulus similarity.

Figure 3. Order reconstruction performance in Experiment 3 as a function of orienting task, serial position and stimulus similarity.

Figure 4. Order reconstruction performance in Experiment 4 as a function of orienting task, serial position and stimulus similarity. Top panel: sorting task; middle panel: pleasantness rating; bottom panel: letter counting.

Figure 5. Response gradients for the letter counting condition of Experiment 4. Serial positions 1 and 2 are displayed in the top row; positions 3 and 4 are presented in the middle row and position 5 is presented in the bottom row.

Fig 1.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Deep - Dis
Shallow - Sim
Shallow - Dis
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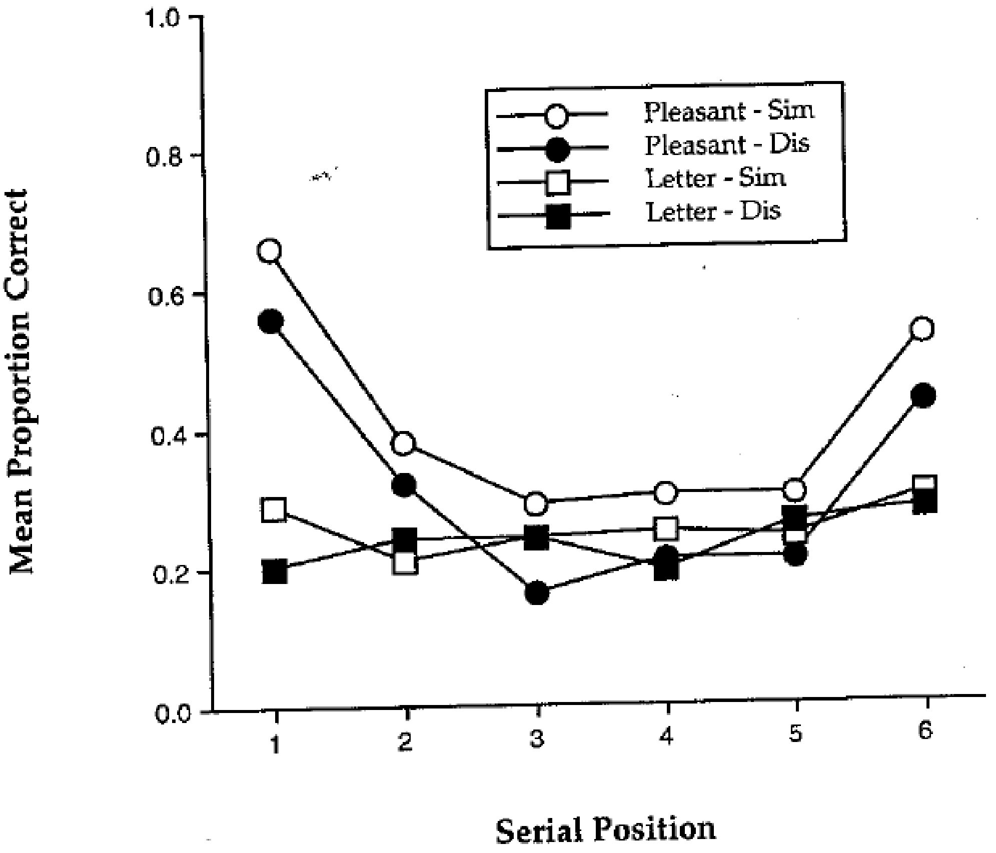
2
3
4
5
6
Serial Position

Fig 2.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0.6
0.4
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Letter - Sim
Letter - Dis
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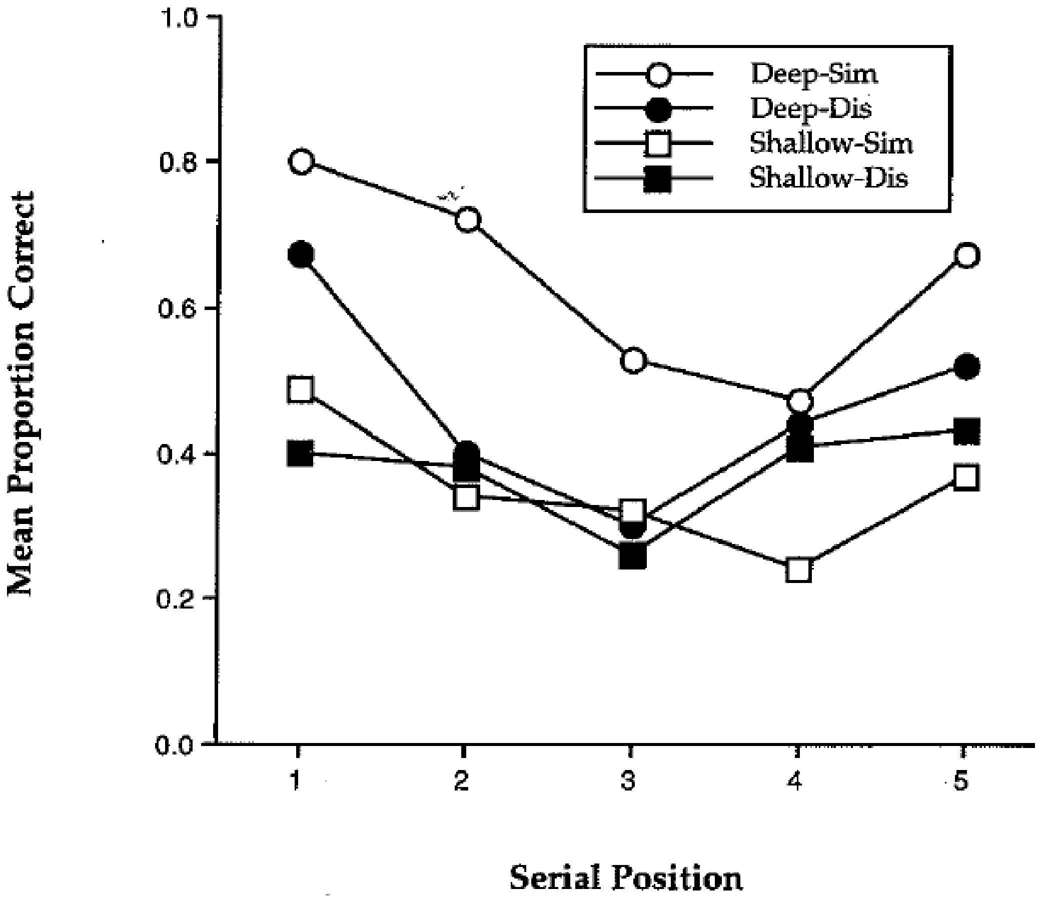
5
6
Serial Position

Fig 3.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0.6
0.4
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2
3
4
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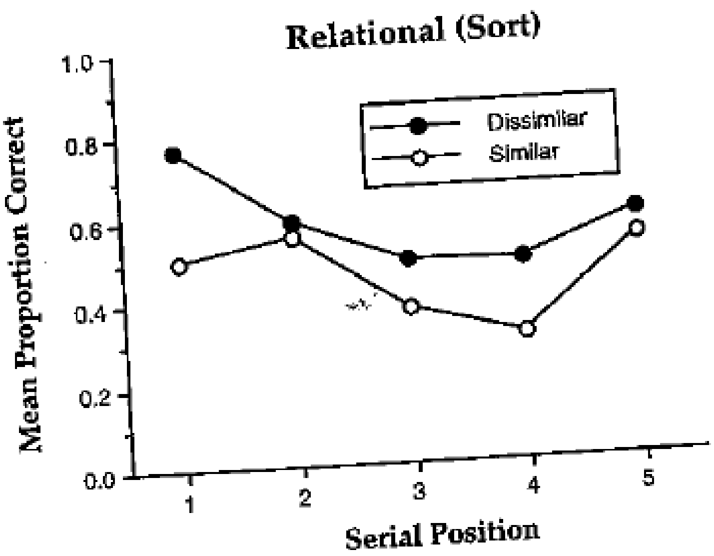
Serial Position
Deep-Sim
Deep-Dis
Shallow-Sim
Shallow-Dis

Fig 4.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Dissimilar
Similar
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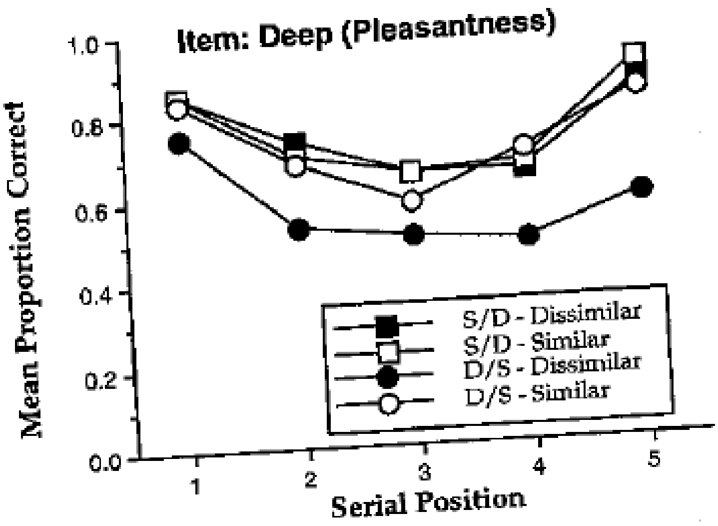
2
3
4
5
Serial Position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S/D - Similar
D/S - Dissimilar
D/S - Similar
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2
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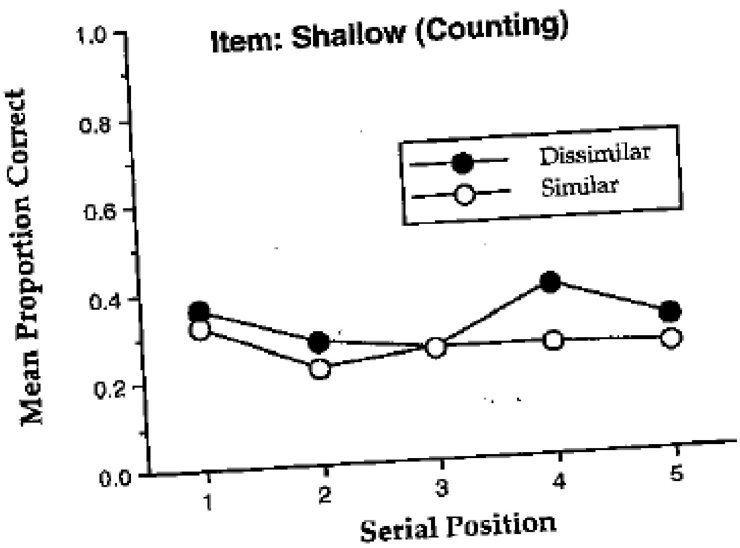
Serial Position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Dissimilar
Similar
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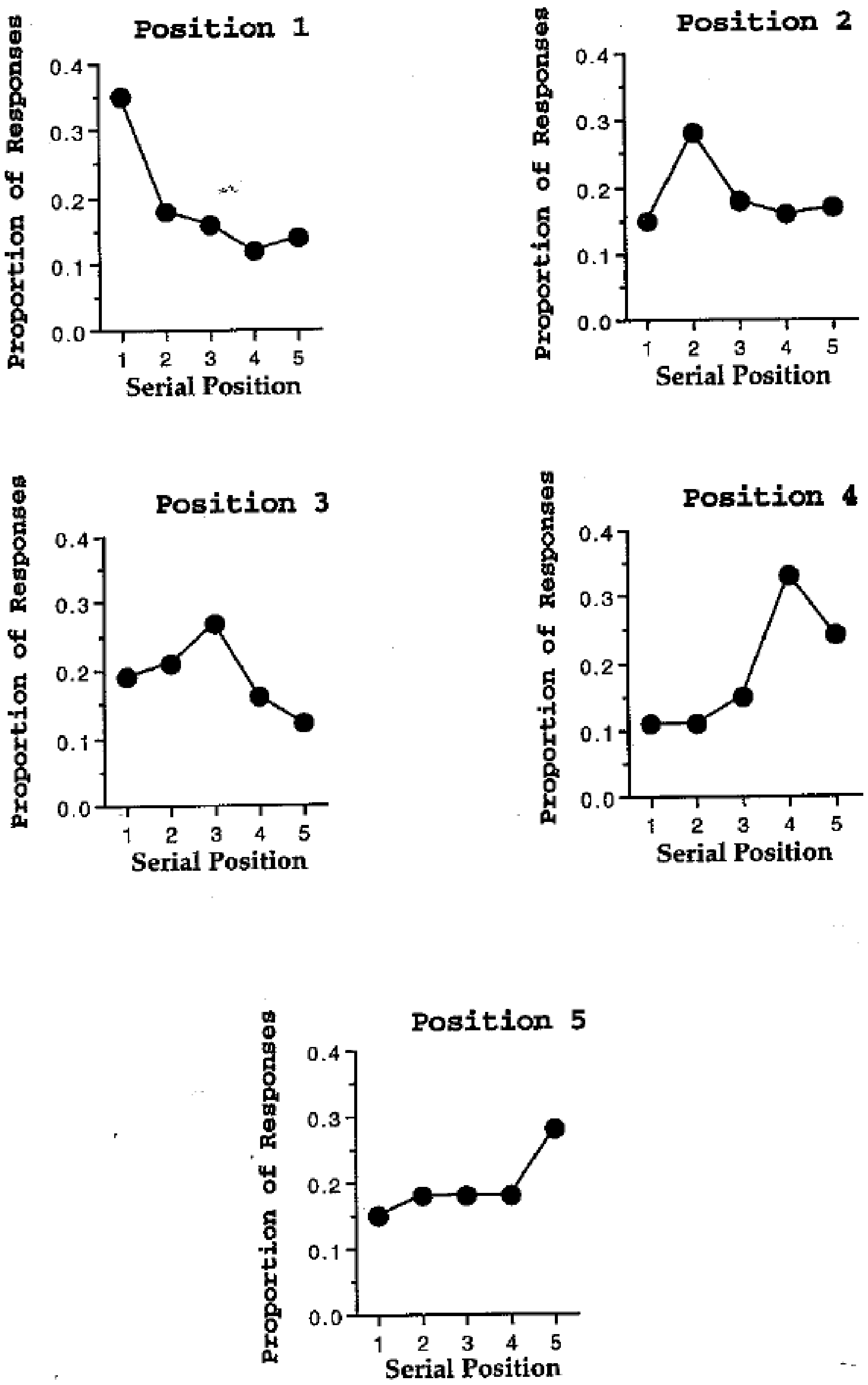
1
2
3
4
5
Serial Position

Fig 5.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Proportion of Responses
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0.3
0.2
0.1
0.0
1 2 3 4 5
Serial Position
Position 2
Proportion of Responses
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0.3
0.2
0.1
0.0
1 2 3 4 5
Serial Position
Position 3
Proportion of Responses
0.4
0.3
0.2
0.1
0.0
1 2 3 4 5
Serial Position
Position 4
Proportion of Responses
0.4
0.3
0.2
0.1
0.0
1 2 3 4 5
Serial Position
Position 5
Proportion of Responses
0.4
0.3
0.2
0.1
0.0
1 2 3 4 5
Serial Position