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Relational and Distinctive Information in Cued Recall and Priming in Item Recognition

by

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A thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF ARTS

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Abstract

Two experiments examined the possibility that cued recall is sensitive to differences in the processing of both relational and distinctive information, whereas priming in item recognition is sensitive to differences in the processing of only relational information. In both experiments two groups of subjects rated abstract and concrete word pairs prior to a memory test. One group rated the relatedness of each pair and a second group rated the imageability of each word within a pair. In Experiment 1 (*N* = 96) memory was tested using cued recall. Concreteness effects were larger following relatedness ratings than following imagery ratings. In Experiment 2 (*N* = 92) memory was tested using recognition and required speeded responses to single words. In the recognition test list, half of the B words from A-B pairs appeared in unprimed and primed conditions. Unprimed B words were preceded by a word from another pair. Each primed B word was preceded by its paired A word. Priming was the difference in response time between unprimed and primed B words. Rating task affected both recognition accuracy and priming. Although concreteness affected recognition accuracy and response time, concreteness effects were absent on priming. The findings from Experiment 1 indicate cued recall is sensitive to differences in the encoding of both relational and distinctive information, however, this interpretation must be considered in terms of a floor effect following imagery ratings. The findings from Experiment 2 indicate priming in item recognition is sensitive to the encoding of only relational information.

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Representation of an event in memory can be thought of as a set of features extracted and compiled from our knowledge about the event (Hunt & Marschark, 1987; Tversky, 1977). Some features of the event will be common and shared by similar events in memory, while other features will be unique to the particular event. For example, consider the words beer and wine as two separate events encoded into the memory system. Features such as "alcoholic", "intoxicant", "beverage", and so on are common and shared by both words. On the other hand, features such as "bottle cap", "malt extract", and "head" are unique to beer while features such as "cork", "grape extract", and "bouquet" are unique to wine. Sets of features that are common and shared by two or more events are referred to as relational information and processes that result in the extraction and compilation of relational information are referred to as relational processes. Features that are unique to particular events are referred to as distinctive information and processes that result in the extraction and compilation of distinctive information are referred to as distinctive processes.

Consistent with this theoretical distinction between relational and distinctive information, several studies have shown that memory for related events (e.g., beer-wine) is best when learning instructions focus attention on differences, and memory for unrelated events (e.g., beer-dog) is best when learning instructions focus attention on similarities (Guttentag, 1988; Hunt & Marschark, 1987; Ackerman, 1986; Hunt, Ausley, & Schultz, 1986; Hunt & Seta, 1984; Hunt & Einstein, 1981; Begg, 1978; Epstein, Phillips, & Johnson, 1975). These results suggest that related events induce the processing of relational information, whereas unrelated events induce the processing of distinctive information (Hunt & Einstein, 1981). These results also suggest that learning instructions will enhance memory performance only when they focus attention on the processing of information complementary to the information induced by the relationship between the events (Hunt & Marschark, 1987; Hunt & Seta, 1984; Hunt & Einstein, 1981). For example, memory for related events will be enhanced when learning instructions encourage the processing of distinctive features rather than the processing of redundant relational features. Conversely, memory for unrelated events will be enhanced by learning instructions that encourage the processing of relational features rather than the processing of redundant distinctive features. The results from these studies, therefore, indicate that the relative encoding of relational and distinctive information is influenced by the relatedness of the learning material as well as the nature of the learning instructions (Guttentag, 1988; Hunt &

Marschark, 1987; Hunt, Ausley, & Schultz, 1986; Hunt & Seta, 1984; Hunt & Einstein, 1981).

The effects of manipulating the relative encoding of relational and distinctive information have been examined on a variety of memory tasks including cued recall and simple item recognition (Marschark & Hunt, 1989; Ackerman, 1986; Hunt & Seta, 1984; Hunt & Einstein, 1981). In cued recall subjects are presented with pairs of words such as cheese-fur. The experimenter designates one word in the pair as the retrieval cue, for example cheese, and the other word as the target, for example fur. Later, the subjects attempt to remember the target event given the retrieval cue. In the case of cheese-fur, the subjects would attempt to recall fur given cheese- ?. In cued recall, several studies have shown that relational and distinctive information combine additively to produce optimum memory performance (Marschark & Hunt, 1989; Ackerman, 1986; Hunt & Seta, 1984). In simple item recognition, subjects are presented with a list of words. Memory for these words is tested by showing old and new words to the subjects one at a time. The subjects are asked to say "yes" to old words and "no" to new words. In studies that have examined simple item recognition, distinctive information appears to be at a premium although relational information can contribute to the recognition process in some circumstances (Hunt & Einstein, 1981;

Mandler, 1980; Humphreys, 1978). One implication of the differential effects of relational and distinctive information processing in cued recall and simple item recognition is that different memory tasks have different information requirements. In particular, cued recall appears to require the processing of relational and distinctive information, whereas simple item recognition appears to require primarily the processing of distinctive information.

One memory task on which the effects of manipulating the relative encoding of relational and distinctive information which has not yet been examined is priming in item recognition. Like cued recall, subjects in this task are presented a list of A-B word pairs (e.g., _cheese_-_fur_). Recognition for single items from the word pairs is then tested under speeded conditions. The test sequence of the single items are arranged so that the B member (i.e., _fur_) is preceded by the A member (i.e., _cheese_) of its study pair or by a word from another pair. When the B member of a pair is preceded by its A member then the B member is said to be _primed_. When the B member of a pair is preceded by a word from another pair then the B member is said to be _unprimed_. Typically, B members are responded to faster when preceded by the A member of its study pair than when the B member is preceded by a word from another pair (McKoon & Ratcliff, 1986). A measure of priming is the difference in reaction time between responding to unprimed and primed B members of A-B word pairs.

The relevance of examining the effects of manipulating the relative encoding of relational and distinctive information on priming in item recognition becomes clear on considering a recent finding by Rabinowitz (1986). He had young and old adults learn a list of weakly related and unrelated A-B word pairs in anticipation of a cued recall test. Interpolated between the study phase and recall test was a priming in item recognition task. Rabinowitz found overall age differences were large in cued recall, and nonexistent in priming. More importantly, however, age interacted with relatedness of the material only in cued recall; the age difference was attenuated for weakly related word pairs. The significance of this result is in recognizing that both cued recall and priming in item recognition have been interpreted as measures of the degree to which events are integrated in memory (Rabinowitz, 1986; Rabinowitz & Ackerman, 1982; Ratcliff & McKoon, 1978). However, in this case the interpretation of cued recall and priming in item recognition contradict each other. Cued recall performance indicated that older adults have difficulty in the integration of unrelated events while priming in item recognition indicated that there are no age differences in the integration of events in memory.

One approach to resolving this discrepancy in interpretation is to suggest that cued recall and priming in item recognition have different information requirements. In particular, cued recall requires the processing of both relational and distinctive information (Marschark & Hunt, 1989), whereas priming in item recognition may require the processing of only relational information. From this view, both cued recall and priming in item recognition can be sensitive to the degree to which information is integrated in memory, but because cued recall has an additional information requirement performance on the two tasks will differ in some circumstances. If this analysis is correct, then cued recall and priming in item recognition should be differentially sensitive to manipulations in the processing of relational and distinctive information. Specifically, cued recall performance should be sensitive to manipulations in both types of information, whereas priming in item recognition should be sensitive to manipulations in only relational information. A convincing line of evidence for this position, then, would be to show that a dissociation between cued recall and priming in item recognition exists when learning material has been equated in terms of its potential for relational information processing, but varies in its potential for distinctive information processing. Abstract and concrete materials are ideal for this type of experimental situation because it has been shown that abstract and concrete word pairs can receive equivalent levels of relational processing (Paivio, Clark, & Khan, 1988; Marschark, Richman, Yuille, & Hunt, 1987; Day & Bellezza, 1983), but concrete material supports greater amounts of distinctive information processing than abstract material (Marschark et al., 1987; Begg & Clark, 1975).

This paper examines the effects of manipulating the relative encoding of relational and distinctive information on cued recall and priming in item recognition. The purpose was to substantiate the claim that these two tasks have different information requirements. The first section reviews the distinction between relational and distinctive information. Emphasis will be placed on the different retrieval functions of relational and distinctive information as well as the evidence supporting this distinction. The second section considers concreteness effects in paired-associate learning from the point of view of relational and distinctive information processing. Section three briefly considers the relationship between concreteness and distinctiveness. The final section developes the argument for the information requirements underlying priming in item recognition.

<u>The Relational-Distinctive Information Dichotomy</u>

One important assumption concerning the theoretical distinction between relational and distinctive information is that the retrieval of a target event from memory can be viewed as "a process of progressive differentiation of information in memory" (Hunt & Marschark, 1987, p. 133). The process begins with a retrieval cue that specifies a set of related events from which a target can be drawn. The constraints on this set of events by the retrieval cue can be very general such as in "What did you do yesterday?" or more specific such as in "What did you do yesterday at lunch?" Once this set of events has been specified by the retrieval cue, more precise information may be necessary to distinguish between specific events contained within the set (Marschark & Hunt, 1989; Hunt & Marschark, 1987; Hunt & Seta, 1984; Hunt & Einstein, 1981). For example, the question, "What did you eat yesterday for lunch?" requires the retrieval of specific information about the potentional candidates that can be used in responding to the question. This can be seen by realizing that responding with "food" to the question is unsatisfactory. From this perspective, then, relational and distinctive information serve different functions in retrieval. Relational information serves to specify a set of related events from which a target event can be drawn, and distinctive information serves to distinguish between the events contained within the specified set of events (Marschark & Hunt, 1989; Hunt & Marschark, 1987; Hunt & Seta, 1984; Hunt & Einstein, 1981).

Application of the theoretical distinction between relational and distinctive information to various memory tasks requires that these two types of information be defined relative to the context of a particular learning task (Hunt & Marschark, 1987; Ackerman, 1986; Hunt & Einstein, 1981). With regard to this point it is important to note that it is impossible to establish beforehand the relational and distinctive features of an isolated event (Hunt & Marschark, 1987). Rather, the relational and distinctive information of a particular event must be described in terms of a relationship between the event, the learning context, and other event information in memory (Hunt & Marschark, 1987; Ackerman, 1986; Hunt & Einstein, 1981). To illustrate, consider again the word pairs beer-wine and beer-dog along with the feature "alcoholic". In the case of beer-wine the feature "alcoholic" operates relationally, whereas in the case of beer-dog this same feature operates distinctively. Therefore, it is important to keep in mind that the role of a particular feature will depend largely on the episodic context in which it is encountered.

Before considering the evidence in support of the theoretical distinction between relational and distinctive information, some characteristics of different learning instructions will be discussed. The issue is how do we know that one type of learning instruction will encourage the processing of relational features whereas another type of learning instruction will encourage the processing of distinctive features? First consider a categorization task where the goal is to produce a set of events that are organized around some unifying feature or set of features. Presumably, this task cannot be carried out if features that are common and shared by the events making up a potential category are not considered. Since a categorization task requires sensitivity to features shared by the events to be categorized, it can be thought of as a relational information processing task. Although one might argue that a categorization task requires some distinctions to be made between the events in order for them to be categorized, it is argued that the focus of attention in this task is on common features shared by a set of events, not on features that are unique to individual events.

Emphasizing common features in a set of events by a categorization task can be contrasted with a pleasantness rating task where relational features need not be considered. In a pleasantness rating task the goal is to determine the "pleasantness" of each word in a list of words relative to some neutral word such as mayor. Presumably, this task requires consideration of the particular meaning of a word rather than the features it shares with other words in the list (Hunt & Marschark, 1987). Insofar as consideration of a word meaning requires attention to sets of features that are unique to the particular word within the list context, the pleasantness rating task can be thought of as a distinctive information processing task. Although this argument is not entirely convincing, the pleasantness task does focus attention toward the features of individual words and away from any features that are common or shared with other words in the list context. Consequently, it may be best to characterize learning instructions in terms of emphasis on the processing of relational information. One type of learning instruction, such as a categorization task, encourages the processing of relational information while another type of learning instruction, such as pleasantness rating, does not encourage the processing of relational information. In considering the following discussion of the empirical support for the distinction between relational and distinctive information, it should be kept in mind that categorization tasks are thought to encourage relational information processing and pleasantness rating tasks are thought to encourage distinctive information processing.

Empirical support for the theoretical distinction between relational and distinctive information is provided by demonstrations that encoding and retrieval conditions can be arranged to differentially encourage the processing of both types of information, and that the two types of information interact in predictable ways (Humphreys & Bain, 1983; Hunt & Einstein, 1981). For example, Hunt and Einstein (1981) have shown that manipulating the relatedness of learning material and the nature of the learning task will influence the relative encoding of relational and distinctive information. The subjects in their study learned a list of related or unrelated words using either a category sorting or pleasantness rating task. Following the list learning session the subjects were asked to free recall the words from the list. Hunt and Einstein hypothesized that the related word list and sorting task would encourage the processing of relational information, while the unrelated word list and pleasantness rating task would encourage the processing of distinctive information. If the materials and learning tasks influence the encoding of relational and distinctive information, then it was expected that recall would be best in those circumstances where both types of information were encoded. Indeed, their results showed that the effect of orienting task depended on the type of word list learned (i.e., related or unrelated). Recall was best when subjects rated the pleasantness of words in a related list or when subjects sorted the words of an unrelated list into categories. These results suggest that the relationships among the material as well as the orienting task influence the encoding of relational and distinctive information. Moreover, when the influence of material and orienting task is not redundant then the encoding of an event is supplemented by complementary information and memory for the event is enhanced (Hunt & Marschark, 1987).

In a similar type of demonstration, Hunt and Seta (1984) have shown category sorting and pleasantness rating tasks differentially effect the free recall of large and small categories. They assumed that large categories would induce relational processing whereas small categories would induce distinctive processing. On the basis of this assumption they predicted a learning task by category size interaction. The results confirmed this prediction. Recall of large categories was best following the pleasantness rating task, that is, distinctive processing, whereas recall of small categories was best following the sorting task.

Recently, Hunt, Ausley, and Schultz (1986) have extended the findings of Hunt and Seta (1984) to textual material. In Experiment 1 the subjects read a random list of sentences related to three different themes: circus, football, and airport. The number of sentences representing a particular theme within a list was varied. As the subjects read the sentences they were asked to either sort the sentences according to theme or rate the pleasantness of each sentence. Again, like Hunt and Seta (1984), the assumption was made that a large number of sentences within a list relating to the same theme would induce relational processing whereas a small number of sentences within a list relating to the same theme would induce distinctive processing. Analysis of the free recall data yielded an interaction between orienting task and the number of sentences representing a particular theme. Together the findings of this study and the previous two studies are important not only because they show that both relational and distinctive information operate together to produce optimum memory performance (Hunt & Einstein, 1981; Hunt & Seta, 1984; Hunt, Ausley, & Schultz, 1986), but also because the distinction between relational and distinctive information generalizes to the analysis of linguistic units larger than single words (Hunt, Ausley, & Schultz, 1986; Hunt & Marschark, 1987).

Additional converging evidence for making a theoretical distinction between relational and distinctive information is based on the finding that relational and distinctive processing tasks have different effects on a wide range of dependent measures (Hunt, Ausley, & Schultz, 1986). Conditions encouraging relational processing produce higher clustering and category recall scores (Hunt & Einstein, 1981; Hunt & Seta, 1984; Ackerman, 1986, Experiment 1). Conditions encouraging distinctive processing, on the other hand, produce higher item recognition and items per category[1] recall scores (Hunt & Einstein, 1981; Hunt & Seta, 1984). Not only do these findings give additional support to the viability of making a distinction between the two types of information, but they also make plausible the assumption that the two types of information serve different retrieval functions: relational information specifies a set of events from which a target event is to be drawn, and distinctive information allows for the discrimination of events within the specified set.

Concreteness Effects in Paired-Associate Learning

Consistent with the interpretation that relational and distinctive information serve different retrieval functions, Hunt and Marschark (1987) have outlined how relational and distinctive information support paired-associate cued recall. In this paradigm the subjects are presented with a list of A-B word pairs (e.g., cheese-fur) to remember. The subjects are then instructed to recall the B word when they are presented with the A word as a retrieval cue (e.g., cheese - ?). Since the items within word pairs are typically unrelated, it becomes important to establish a pair-specific relational link between the individual words of each pair during study. Once this pair-specific relational link has been established it can be reactivated by the cue word at test. Reactivation of a pair-specific relational link then provides access to distinctive information representing individual words within a pair (Hunt & Marschark, 1987; Marschark, et al., 1987). One implication of this analysis is that words that are inherently more distinctive than other words in the encoding context should be recalled best. A second implication of this analysis is that any effects of distinctiveness on cued recall should be curtailed if the processing of pair-specific relational information is interfered with at either encoding or retrieval. A third implication of this analysis is that pairwise relational information can serve a discriminative function between other word pairs in the list as well as an integrative, relational function for individual words within word pairs (Marschark & Hunt, 1989). To emphasize this latter point consider the word pairs Italy-Switzerland and Guatemala-Honduras. Notice the same information about continents that can be used to establish a relationship between the countries in each word pair can also be used to discriminate the pair of European countries from the pair of American countries. In this sense, the same information can serve both a relational as well as a distinctive function.

Consistent with this analysis of paired-associate cued recall, Marschark and Hunt (1989, Experiments 3 & 4) have examined the concreteness effect in paired-associate learning. The concreteness effect refers to the superior cued recall of concrete word pairs (e.g., ball-pencil) relative to abstract word pairs (e.g., democracy-liberty). Concrete words are those words that are capable of arousing a sensory experience such as an image, sound, or tactile experience with great ease. For example, it is very easy to imagine a picture of a ball or even the sound of a ball bouncing off the floor. Abstract words on the other hand are those words that arouse sensory experiences with great difficulty. For example, it is very difficult to imagine a picture of democracy or even a sound related to democracy. The greater availability of perceptual information of concrete as compared to abstract words make concrete words more distinctive (Marschark & Hunt, 1989; Hunt & Marschark, 1987).

On the basis of this greater availability of perceptual information for concrete words, Marschark and Hunt (1989) reasoned that concreteness effects result from the greater discriminability or distinctiveness of concrete words relative to abstract words. This greater distinctiveness of concrete words operates at both a pairwise and individual item level of analysis (Marschark & Hunt, 1989). In particular, concrete words provide a basis for increasing the distinctiveness of both the relationship between words in a pair as well as the distinctiveness of individual words within a pair (Marschark, et al., 1987; Hunt & Marschark, 1987; Marschark & Hunt, 1989). As a result, concrete words and pairs are more distinctly represented in the learning context than are abstract words and pairs. Therefore, when pairwise relational information has been encoded and is reactivated by a retrieval cue at test, then concrete words should be recalled better than abstract words because of the greater distinctiveness of concrete words.

To examine this proposal Marschark and Hunt (1989) hindered access to pairwise relational information at encoding (Experiment 3) or at retrieval (Experiment 4) for concrete and abstract word pairs. In the first experiment access to pairwise relational information during encoding was either encouraged or denied by assigning a particular learning instruction to two different groups of subjects. In one group of subjects the processing of pairwise relational information was encouraged by having the subjects rate the ease with which the two items in a word pair could be combined into a meaningful relationship. In a second group of subjects relational information processing was denied by having the subjects rate separately the imagery values of each item within a pair. The data from the experiment showed that the concreteness effect occurred only in the relational processing group where pairwise relational information had been encoded and then reactivated at retrieval. Moreover, cued recall for both concrete and abstract word pairs was better following relational processing than following separation imagery. Thus, when pairwise relational information is not encoded, as was the case for the imagery group, cued recall performance suffers and concreteness effects disappear because pairwise relational information was unavailable at retrieval, consequently preventing access to distinctive information.

In a second experiment, access to pairwise relational information was encouraged or denied by manipulating the type of cue given at retrieval. Two groups of subjects generated a word that they thought would later help them remember both words in a word pair. This encoding task focused the subjects' attention on the intersection of the relationship between the word pair and the generated cue, and away from the union between items within a word pair (Marschark & Hunt, 1989). Therefore, pairwise relational information should be available at retrieval with only the subject generated cue. Accordingly, one group of subjects, the mediator cue group, was given the word that they had generated as a retrieval cue whereas the other group, the stimulus cue group, was given the first member of a word pair as a retrieval cue. Concreteness effects were present and cued recall was best for the mediator cue group, thus showing that the recovery of pairwise relational information at retrieval is prerequisite to distinctive information asserting an influence in cued recall.

On the basis of the forgoing data, four useful properties can be listed concerning the relational-distinctive information dichotomy in paired-associate learning: (a) relational information specifies a set of related events from which a target event can be selected, whereas distinctive information allows for the discrimination of a target event within the specified set of events; (b) both relational and distinctive information are necessary for optimum memory performance in cued recall; (c) manipulating either type of information processing at either encoding or retrieval has predictable effects on memory performance; and (d) distinctiveness effects in cued recall depend on the recovery of pairwise relational information at retrieval (Marschark & Hunt, 1989).

Concreteness and Distinctiveness

Marschark et al. (1987) suggested that abstract and concrete material can receive equivalent levels of integrative, relational processing, but concrete material can potentially receive more distinctive processing than abstract material. According to Marschark et al. (1987) this difference in distinctive information processing between abstract and concrete materials accounts for the concreteness effect in paired-associate learning, particularly when relational information is available to the processing of concrete material at both encoding and retrieval. This interpretation of the concreteness effect originates from studies similar to those discussed earlier showing that manipulating the availability of relational information at either encoding or retrieval can attenuate the difference between abstract and concrete words in cued recall (Marschark & Hunt, 1989). Several additional studies examining semantic similarity (Begg & Clark, 1975) and composite imagery ratings for abstract and concrete words (Paivio et al. 1988; Day & Bellezza, 1983) are also compatible with this distinctive information processing interpretation of the concreteness effect.

First, Begg and Clark (1975) had subjects rate the semantic similarity of abstract and concrete words appearing in two different context conditions. Each context condition biased a different meaning of the word being rated. Abstract words were given higher semantic similarity ratings than concrete words showing that different meanings of abstract words were judged to be more similar than concrete words. This finding is of particular interest because it can be interpreted from the relational-distinctive information dichotomy suggesting that the meanings of concrete words are more distinctive (i.e., not as similar) as those of abstract words.

Second, Day and Bellezza (1983, Experiment 2) asked a group of subjects to judge the relatedness of related abstract word pairs and unrelated concrete word pairs on a seven-point scale. Not surprisingly, the abstract word pairs received higher ratings (relatedness from 5.5 to 6.5) than the concrete word pairs (relatedness from 1.19 to 1.93). After judging relatedness, these two sets of word pairs where then shown to a second group of subjects who were engaged in an interactive imagery task. In addition to this task the subjects were asked to rate the vividness of the interactive image. The subjects were then given a cued recall test. The novel finding of this experiment was that related abstract word pairs received higher vividness ratings than unrelated, concrete word pairs. But, the unrelated, concrete word pairs nevertheless showed a cued recall advantage over related abstract pairs. More recently, these same effects have been replicated by Paivio, et al. (1988). The implication of this data is that abstract and concrete word pairs can receive equivalent amounts of integrative, relational processing, but concrete word pairs differ from abstract word pairs in the availability of distinctive information.

Priming in Item Recognition

As mentioned earlier, one memory task on which the effects of manipulating the relative encoding of relational and distinctive information which has not yet been examined is priming in item recognition. As a consequence, little is known about the relational and distinctive information requirements for this task. In spite of this it was suggested that priming in item recognition may require only the processing of relational information, but no reasons were given as to why this should be the case. One line of reasoning is as follows. First, the priming effect is assumed to reflect the degree to which a cue and target word have been integrated in memory (Rabinowitz, 1986; McKoon & Ratcliff, 1980). The greater the integration between the cue and target word the greater will be the priming of the cue to the target at test. One of the functions of relational information is to integrate or link a cue and target word around a set of common and shared features. The distinctiveness of the cue and target by contrast does not contribute to this process of integration, since distinctive information is what allows for discrimination between the cue and target word. Hence, factors influencing the processing of relational information should be relatively more important to the demonstration of priming than factors influencing the distinctiveness of the cue and target. This should be the case because only relational features provide a basis for integrating a cue and a target word.

The priming data from Rabinowitz (1986) is consistent with this interpretation. Recall that Rabinowitz (1986) had a group of young and old adults learn related and unrelated word pairs. The priming data from the experiment showed that there were no age differences in the amount of priming for related and unrelated word pairs. More importantly however, there was a main effect of relatedness indicating that related word pairs showed greater priming effects than did unrelated pairs. This was consistent with the suggestion that priming in item recognition is sensitive to the amount of integration that occurs between the words in a study pair. This finding is also consistent with the present view that related word pairs induce the processing of relational information while unrelated word pairs induce the processing of distinctive information. Thus, the larger priming effect for related word pairs can be taken as evidence that priming in item recognition may require only the processing of relational information.

Overview of Experiments

Two experiments examined the sensitivity of cued recall and priming in item recognition to manipulations in the processing of relational and distinctive information. In both experiments subjects learned a list of words consisting of abstract and concrete word pairs. The abstract and concrete word pairs in the study list were equated in terms of mean relatedness rating. In this manner, the amount of integrative, relational processing for both the abstract and concrete words was equivalent while only the concrete word pairs potentially supported greater levels of distinctive information processing. Thus, given that the processing of both relational and distinctive information affect cued recall performance and if, as hypothesized, the processing of only relational information affects priming, then manipulations in the concreteness of the material should affect cued recall but not priming.

In both experiments, subjects performed one of two types of learning tasks that encouraged or denied the processing of pairwise relational information. In this regard, one group of subjects, the relational group, rated the ease of integrating the members of a word pair into a meaningful relationship; a second group of subjects, the separation imagery group, rated separately the imagery value of each member of a word pair. The purpose of the learning task manipulation was twofold. First, the learning tasks brought a margin of control over the nature of the subjects' processing activity (Craik & Lockhart, 1972). Second, a more stringent test of the proposal that cued recall and priming in item recognition are differentially sensitive to relational and distinctive information was possible. Specifically, when the encoding of pairwise relational information was discouraged, as in the separation imagery group, then concreteness effects should be attenuated in cued recall (Marschark & Hunt, 1989). Similarly, the size of the priming effect in item recognition should be smaller following separation imagery instructions for both abstract and concrete word pairs as compared to that found following relational processing instructions. Experiment 1 examined the effects of these manipulations in cued recall while Experiment 2 examined these same manipulations in priming in item recognition. Thus the purpose of this study was to investigate the sensitivity of cued recall and priming in item recognition to manipulations in the processing of relational and distinctive information.

Experiment 1

In Experiment 1 two groups of subjects studied a list of abstract and concrete word pairs. Within each list the set of abstract and concrete word pairs were matched for pair relatedness. One group of subjects, the imagery instruction group, judged separately the ease with which each word in the word pair would evoke a sensory experience. By focusing the subject's attention separately on each word in a word pair the processing of shared features between the words was discouraged. The second group of subjects, the relational instruction group, judged the ease with which the members of each word pair could be combined into a meaningful unit. Hence, the relational instruction group was encouraged to process features that were shared by the words in each pair. Following the initial judgment task and a distractor task, both groups of subjects were given an unexpected cued recall test for the right hand member of each word pair. The expectation for Experiment 1 was that a concreteness effect should result for targets studied under the relational instruction but not the imagery instruction. Specifically, concrete targets were expected to be recalled better than abstract targets only when the subjects were given the relational learning instruction. This result was expected on the assumption that the cued recall advantage for concrete targets depends on both shared and distinctive features being present in the memory representation of the word pairs. This result would replicate the findings of Marschark and Hunt (1989) and provide further evidence that the cued recall measure is sensitive to variation in the processing of both shared and distinctive features of the target.

Method

Subjects. Participants were 120 adults recruited from the introductory psychology subject pool at the University of Manitoba. All subjects were native speakers of English and received partial course credit for their participation. Of these 120 participants, 24 served in a preliminary norming study and 96 served in the cued recall portion of the experiment.

Design. The design was a 2 (Instruction: Imagery or Relational) X 2 (Target Concreteness: Abstract or Concrete) factorial, resulting in four experimental conditions. Instruction was a between subjects factor and Target Concreteness was a within subjects factor.

Material.

Norms. A preliminary norming study was carried out to obtain relatedness ratings on a pool of abstract and concrete word pairs. These relatedness ratings were then used to select a smaller set of abstract and concrete pairs. The word pairs appearing in each of these two smaller sets were matched as closely as possible on relatedness rating. This produced a set of abstract pairs and a set of concrete pairs that were equated for relatedness. These two smaller sets of abstract and concrete pairs served as critical experimental pairs in the cued recall portion of Experiment 1.

To construct the pool of abstract and concrete pairs used in the preliminary norming study, 80 abstract and 80 concrete nouns were selected from the Paivio, Yuille, and Madigan (1968) norms. Abstract nouns had a concreteness rating less than or equal to 4.00; concrete nouns had a concreteness rating greater than or equal to 6.00. These abstract and concrete nouns were combined into 40 abstract and 40 concrete pairs. Each pair was judged by the experimenter to require a moderate amount of effort to combine into a meaningful relationship. The left-hand member of each word pair was designated the (A) cue word and the right-hand member was designated the (B) target word.

An additional 48 nouns were selected from the Paivio et al. (1968) norms and combined into 24 filler pairs. Twelve of these filler pairs were mixed word pairs consisting of six abstract-concrete and six concrete-abstract word pairs. Words with moderate concreteness ratings made up the remaining 12 word pairs. Moderate concreteness is defined as a concreteness rating greater than 4.00 but less than 6.00. One-half of the 24 filler pairs were combined so that they were either highly related (e.g., hammer-tree) or completely unrelated (e.g., cheese-tree). These filler pairs were included to ensure that the subjects considered carefully each word pair and sample the entire range of values on the rating scales.

For the relatedness rating task in the preliminary norming study, and all subsequent rating tasks in Experiment 1 and Experiment 2, the word pairs were presented in booklets with the appropriate rating scale. The ordering of the word pairs in each booklet was determined randomly for each subject with the restriction that an equal proportion of abstract, concrete, and filler word pairs appeared on each page in the booklet.

To obtain preliminary relatedness ratings, a group of 24 naive subjects judged the effort required to combine each word pair into a meaningful relationship (see Appendix A for the complete instructions). Ratings were recorded on a seven-point relatedness scale. A rating of "1" on the scale indicated that a word pair was very difficult to combine into a meaningful relationship (i.e., the word pair had low relatedness). Examples of abstract and concrete word pairs difficult to combine into a meaningful relationship are essence-rule and cheese-fur, respectively. A rating of "7" on the scale indicated that a word pair was very easy to combine into a meaningful relationship (i.e., the word pair had high relatedness). Examples of abstract and concrete word pairs easy to combine into a meaningful relationship are joy-victory and hammer-nail, respectively. From these ratings, a mean relatedness rating for each word pair was calculated. On the basis of the mean relatedness rating for each word pair, the larger set of abstract and concrete pairs was reduced to a smaller set of 20 abstract and 20 concrete pairs. This was accomplished by matching abstract and concrete word pairs as closely as possible in mean relatedness and then eliminating the most discrepant matched pairs from each set. The result of this process was a set of abstract and concrete pairs that were equivalent in relatedness, but differed in concreteness. The words that were eliminated from the matched set of abstract and concrete pairs served as new distractors in the recognition priming task. The critical experimental pairs, as well as the filler pairs, are shown in Appendix B along with their respective relatedness ratings.

Experimental material. Experimental subjects received study booklets consisting of 76 word pairs: the matched set of 20 abstract and 20 concrete pairs from the relatedness rating task, the 24 filler pairs, and an additional 12 buffer pairs. One-half of the buffer pairs appeared at the beginning and one-half at the end of each booklet. Each buffer contained two abstract and two concrete pairs, one abstract-concrete pair, and one concrete-abstract pair.

Procedure. The subjects were tested in groups under incidental learning instructions. One group of subjects, the relational group, performed the same rating task that was used to obtain the relatedness ratings for the abstract and concrete word pairs. A second group of subjects, the separation imagery group , rated separately the ease with which each word in a word pair aroused a mental picture, sound, or sensory experience (see Appendix A). On this scale "1" indicated that a word arouses a sensory experience with great difficulty or not at all (i.e., low imagery), and "7" on the scale indicated that a word arouses a sensory experience very easily (i.e., high imagery). Groups of subjects were assigned randomly to each instruction condition. In addition, rating booklets for each condition were distributed randomly to the subjects and 48 subjects participated in each of the two conditions.

Prior to the cued recall test the subjects were given a two minute distractor task consisting of a maze (see Appendix C). The distractor task was included to remove short term savings of the word pairs in the study list. Following the distractor task, the subject were given five minutes to complete the cued recall task. The subjects wrote their responses on recall sheets next to the left member or A cue word (e.g., cheese - ?).

Results and Discussion

For the analyses in Experiment 1 and Experiment 2 all reported effects were judged significant at a p-value $\leq .05$, unless reported otherwise. Interactions in both experiments were analyzed further through analyses of simple effects. Analysis of variance tables and summary tables for analyses of simple effects in Experiment 1 and Experiment 2 are found in Appendix D.

Cued recall performance as a function of Instruction and Target Concreteness is shown in Table 1. The cued recall data was examined with a 2 x 2 mixed analysis of variance (Table D.1.1). Both main effects and the interaction were significant. Subjects recalled more targets when given the relational learning instruction ($M = 0.380$) than when given the imagery instruction ($M = 0.055$), $F(1, 94) = 241.55$, $MSe = 8.42$, as well as more concrete targets ($M = 0.330$) than abstract targets ($M = 0.115$), $F(1, 94) = 221.84$, $MSe = 4.52$. The Instruction X Target Concreteness interaction, $F(1, 94) = 101.54$, $MSe = 4.52$, resulted from a larger concreteness effect occurring with the relational learning instruction than with the imagery learning instruction.

Analyses of simple effects for the interaction suggest the effect of the relational learning instruction was to increase cued recall performance for both abstract and concrete word pairs, but that this increase was much greater for concrete than abstract pairs. In addition, concrete targets were remembered significantly better than abstract targets at each level of instruction, but this better memory for concrete targets was larger when the subjects were given

Table 1.

Mean proportion of correctly recalled B Targets in Experiment 1.

	Target Concreteness	
Instruction	Abstract	Concrete
Imagery	0.02	0.09
Relational	0.19	0.57

the relational learning instruction. Together these results suggest that, when the processing of shared features is encouraged at encoding and the information is inherently rich in distinctive features, superior cued recall will result.

The pattern of results in Experiment 1 support the conclusion that the cued recall measure is sensitive to changes in the processing of both relational and distinctive information. The primary evidence for this conclusion stems from (a) the attenuation of the concreteness effect with the imagery instruction relative to that found with the relational instruction, and (b) the superior recall of concrete targets learned with the relational instruction. These results support Marschark and Hunt's (1989) suggestion that concreteness effects in cued recall are present to the extent that target information can be learned along with information relating the cue and target together. Furthermore, this relational information must be recoverable at retrieval before the greater distinctiveness of concrete pairs will assert an influence on performance. In cued recall the presence of the A cue word enhances the likelihood that relational information will be recovered when the cue and target have been relationally encoded. Hence, disruption of processing relational information at either encoding or retrieval will attenuate or eliminate the concreteness effect (Marschark & Hunt, 1989).

Although the results support the forgoing interpretation, there is the possibility that the interaction in Experiment 1 may be the consequence of cued recall performance being near zero for abstract targets learned with the separation imagery instruction. If the interaction is the consequence of a floor effect, then there is some doubt as to whether or not the presence of shared information in the retrieval cue is necessary to demonstrate a concreteness effect. However, despite the possibility of a floor effect, the pattern of results in this experiment replicate the findings of Marschark and Hunt (1989, Experiment 3). As was the case in this experiment, Marschark and Hunt (1989) found concreteness effects were robust following relational processing instructions, while concreteness effects were eliminated following separation imagery instructions. Unlike the present experiment, Marschark and Hunt (1989) reported cued recall performance following the seperation imagery instuction at approximately 10% and 15% correct for abstract and concrete pairs, respectively. Even though cued recall performance following the separation instruction in their experiment was greater than that reported here, there was still no concreteness effect. The absence of a concreteness effect given greater cued recall performance following separation imagery instructions in the Marschark and Hunt (1989) experiment, as well as the similar pattern of results found in this experiment and the Marschark and

Hunt (1989) experiment, suggest that the interaction reported here is characteristic of performance following relational and separation imagery instructions.

Experiment 2

Experiment 2 was identical to Experiment 1 except that subjects' memory for the abstract and concrete study words was examined with a recognition test instead of a cued recall test. On this recognition test the subjects made "yes-no" discriminations between old study words and new distractor words that were presented one at a time. In particular, when a subject identified a word as an old study word they were to respond "yes" to that word. If, on the other hand, they did not identify the presented word as an old study word they were to respond "no" to that word. The time taken to make a judgement about each word was recorded as well as whether or not the judgement was correct. The recognition test list was constructed so that half of the old abstract and concrete B target words (i.e., the right-hand member of each study pair) were preceded by their study words. These B target words were primed targets. The other half of the old abstract and concrete words were preceded by an old word from another study pair. These B target words were unprimed items.

Under these testing conditions, primed B targets should be responded to faster than unprimed B target words, and the relational instruction should produce faster response times to B targets than the separation imagery instruction. In addition, the relational instruction should produce faster response times for primed targets than targets in all of the other conditions. Demonstration of this effect is important to the argument that priming in item recognition is sensitive to differences in the processing of relational information. No other effects were expected in Experiment 2, and, most notably, there should be no interactions involving target concreteness. Thus, the basic purpose of Experiment 2 was to examine the sensitivity of priming in item recognition to differences in the processing of shared and distinctive features for abstract and concrete word pairs.

Method

Subjects. Subjects were 92 adults from the pool used in the previous experiment. None had served in Experiment 1.

Design. The design was a 2 (Instruction: Imagery or Relational) X 2 (Target Concreteness: Abstract or Concrete) X 2 (Target Type: Unprimed or Primed) factorial, resulting in eight experimental conditions. Instruction was the only between subjects factor.

Material. Study booklets were the same as those used in Experiment 1. For the recognition phase, 24 unique recognition test lists were constructed from one recognition test order. Each recognition test list consisted of 160 words: 40 A cue and 40 B target words from the abstract and concrete word pairs, and 80 new distractor words not presented in the study list. These distractor words were the words that were eliminated from the matched set of abstract and concrete pairs in Experiment 1 (see Appendix B).

To ensure that each B target word of the abstract and concrete word pairs appeared equally often in each of the primed and unprimed conditions, the abstract and concrete word pairs were divided randomly into 2 sets of 10 abstract and 10 concrete word pairs. For 12 of the 24 recognition test lists one set of abstract and concrete word pairs served in the primed condition and the other set served in the unprimed condition. In the remaining 12 lists the word pairs that served in the primed condition in the first 12 lists were assigned to the unprimed condition, and the word pairs serving in the unprimed condition were assigned to the primed condition. This set of 24 unique recognition test lists was used twice with each of the two learning tasks.

The recognition test order designated recognition test list positions for seven types of items (see Appendix E): distractors, A words from abstract pairs, A words from concrete pairs, B words from abstract and concrete pairs in both the primed and unprimed conditions. The construction of the recognition test order for these seven types of items was done randomly with four restrictions (cf. Rabinowitz, 1986). First, an equal number of each item type appeared in each quarter of the recognition test order. Second, no more than 4 old words (i.e., cue or target words) or 4 new words (distractors) occurred in consecutive order. Third, 20 words intervened between the A cue words and B target words of designated unprimed pairs. Fourth, an unprimed B word was always preceded by another old word, an A or B item from another pair. Although each item type appeared in the same designated positions throughout all lists, each recognition test list was unique in the sense that the words representing each item type were assigned randomly to these designated positions.

Procedure. Subjects were tested individually. As in Experiment 1 the subjects rated words according to either the relatedness instruction or the imagery instruction, and were then engaged in a two minute distractor task. Upon completion of the rating and distractor tasks, the subjects were seated in front of a microcomputer and instructed on the recognition task (see Appendix F). The first part of the recognition task involved a short practice session to acquaint the subjects with responding on the keyboard. This was described to the subjects as a manual dexterity task. On each trial of this task the word "Yes" or "No" appeared on the computer screen and the subject pressed the appropriate button. The subjects were encouraged to respond as quickly and accurately as possible. Between each trial a 500 ms intertrial interval elapsed. The practice session consisted of 24 such trials and was repeated again at the end of the recognition priming task. Labeling of the "Yes" and "No" buttons was determined randomly for each subject.

Following the "yes/no" practice session, the subjects began the speeded recognition task. The words appeared one at a time on the computer screen and the subjects pressed the "Yes" response button if the word was either the left- or right-hand member of any of the word pairs they rated before in the experiment. The subjects pressed the "No" response button if a word was one that they had not seen before in the experiment. As in the practice session, the subjects were encouraged to respond as quickly and accurately as possible. Following each response the screen cleared and a 500 ms intertrial interval elapsed before the onset of the next word. A brief rest period (30 sec) was given to the subjects after the presentation of every 40 words (cf. Rabinowitz, 1986). The recognition test order was constructed such that a B target word was never the next word following a rest period. Presentation of experimental stimuli and recording of the subjects' responses was controlled by a Macintosh computer (see Appendix G).

Results and Discussion

Priming. Prior to calculating mean reaction time scores for each subject, each subject's reaction time data was entered into an outlier selection procedure. This was done to remove extreme reaction time scores that may have resulted from a distraction or temporary lapse in attention (Whitney, 1986). The procedure involved calculating the standard deviation of reaction time on the 80 old study words and eliminating any reaction times that were more than three standard deviations from the mean reaction time. The percent throw outs (%TO) for each type of B target word is shown in Table 2. The overall percentage of throw outs was small (M = 1.7%).

Once outliers had been removed from each subject's data set, mean reaction time for correctly recognized B targets was examined only when the preceding A word was correctly recognized. This assumes that priming can be demonstrated only when a B target word is preceded by the correct recognition of the prime (cf. Rabinowitz, 1986).

The data from the two sets of abstract and concrete pairs were combined for all subsequent analyses. In none of these analyses did the set variable interact with any other variable.

Mean reaction time in milliseconds for correctly recognized B targets as a function of Instruction, Target Concreteness, and Target Type is given in Table 2. A 2 X 2 X 2 mixed analysis of variance was applied to this data (Table D.2.1). The main effects of Target Concreteness, $F(1, 90) = 44.22$, $MSe = 40962.77$, and Target Type $F(1, 90) = 54.22$, $MSe = 25449.50$, were significant. In addition, the Instruction X Target Type interaction was also significant, $F(1, 90) = 11.33$, $MSe = 25449.50$. No other effects were significant.

The main effect of Target Concreteness indicates that concrete targets ($M = 795$) were recognized faster than abstract targets ($M = 935$). The main effect of Target Type shows that primed targets ($M = 804$) were responded to faster than unprimed targets ($M = 926$). The Instruction X Target Type interaction is shown in Figure 1. Inspection of Figure 1 suggests that the Instruction X Target Type interaction is the result of primed targets being responded to more quickly than unprimed targets when the relational instruction is used to learn the material. Analysis of simple effects for this interaction showed that primed targets were responded to more quickly than unprimed targets in both the imagery and relational instruction conditions. Further, unprimed

Table 2.

Mean Correct Response Times (in Milliseconds) to B Targets, Proportion Errors, and Percent Thrown Out in Experiment 2.

		Item type				
Target Concreteness	Instruction	Unprimed	%TO	Primed	%TO	Difference
Abstract	Imagery	979 (0.32)	1.0	931 (0.35)	2.0	48
	Relational	1005 (0.39)	2.5	826 (0.38)	1.4	179
Concrete	Imagery	841 (0.26)	1.5	756 (0.18)	2.1	85
	Relational	880 (0.35)	2.0	702 (0.22)	0.8	178

Note: Error rates appear in parentheses; %TO = percent thrown out.

targets did not differ across the levels of instruction. For primed targets , however, this same difference did approach significance, $p < .0541$ (Table D.2.3). Thus, the source of the Instruction X Target Type interaction is a larger priming effect for targets learned with the relational instruction than with the imagery instruction.

The recognition priming data shows that the priming measure is largely sensitive to changes in the processing of relational information, but relatively insensitive to changes in the the distinctiveness of the material. This conclusion is supported by the Instruction X Target Type interaction and the failure of the Target Concreteness manipulation to interact with the Target Type variable. The amount of priming was influenced by the particular processing strategy assigned to the subject, and not by the inherent distinctiveness of the material. When the target was encoded relationally with its study cue, as in the relational instruction group, priming effects were larger than when the target was encoded separately from its cue, as in the imagery instruction group. This was the case for both abstract and concrete materials. As mentioned in the introduction, demonstration of this effect is essential to the argument that priming is sensitive to changes in the degree of integration of the study material.

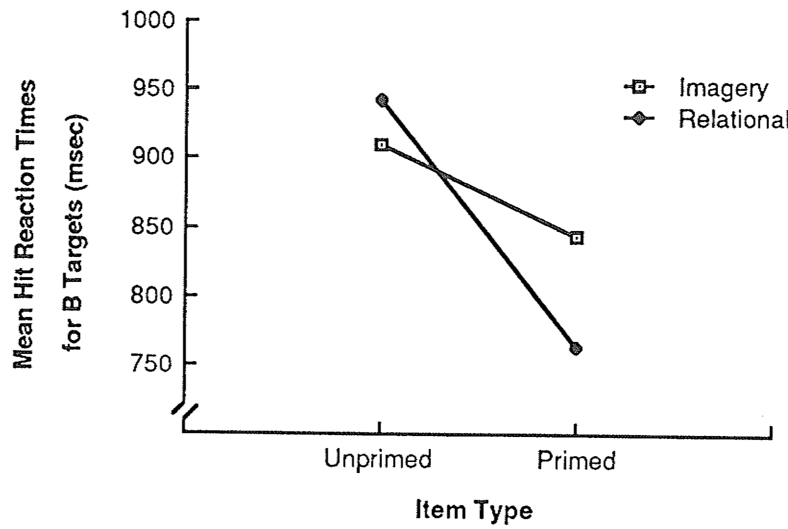

Figure 1. Mean reaction time to B targets as a function of Instruction and Target Type.

The main effect of Target Concreteness suggests that differences in the processing of distinctive information is manifested in an overall difference in reaction time but not in the priming measure itself. Thus the priming in item recognition paradigm does appear to be sensitive to changes in both relational and distinctive information, but these differences are captured in separate parts of the data analysis. The priming measure, the difference between the unprimed and the primed conditions, captures the influence of relational information processing, whereas the overall difference between the abstract and concrete materials captures a difference in distinctive information processing.

In summary, the priming effect is assumed to reflect the degree to which a cue and target word have been integrated in memory (Rabinowitz, 1986; McKoon & Ratcliff, 1980). The greater the integration between the cue and target word the greater will be the priming of the the cue to the target. One of the functions of relational information is to integrate or link a cue and target word around a set of common and shared features. The distinctiveness of the cue and target, by contrast, does not contribute to this process of integration, since distinctive information is what allows for the discrimination between the cue and target word. Hence, factors influencing the processing of relational information should be relatively more important to the demonstration of priming than factors influencing the distinctiveness of the cue and target. The priming data of this experiment are clearly consistent with this interpretation.

Subsiduary Data Analyses.

Error Data. The subject was considered to have made an error whenever an incorrect "no" response was made to either the prime, target, or both the prime and target. Thus there is a 75% chance of a subject being credited with an error if the subject was responding in a random fashion. The proportion of these errors for each condition are shown in Table 2. Analysis of variance on the error data used the same design as that used for the priming data (Table D.3.1). Both the main effect of Target Concreteness and Target Type were significant, $F(1, 90) = 58.89$, $MSe = 1.79$, and $F(1, 90) = 8.52$, $MSe = 2.20$, respectively. The main effect of Target Concreteness showed that fewer errors were made on concrete targets ($M = 0.25$) than abstract targets ($M = 0.36$). The main effect of Target Type showed fewer errors were made on primed ($M = 0.28$) than on unprimed items ($M = 0.33$). As well as these main effects there was also a significant Target Concreteness X Target Type interaction , $F(1,90) = 14.67$, $MSe = 1.97$. These effects reflect the smaller error rates for primed concrete targets.

One point concerning the analysis of error data is that it can be used to argue against a speed/accuracy tradeoff in explaining the priming results reported above. If a speed/accuracy tradeoff was responsible for the priming data, then faster response times would be associated with greater error rates. Inspection of the error rates in Table 2 show that this is not the case. Faster response times tend to be accompanied by lower error rates.

Recognition. As was the case for the priming analysis, the data from the two sets of abstract and concrete pairs were combined. Although the set variable did interact with the instruction and concreteness variables, inclusion of the set variable did not significantly alter any of the reported effects.

Table 3 shows hit rate proportions for A cue words. This data was analyzed using a 2 (Instruction) X 2 (Concreteness) mixed analysis of variance (Table D.4.1). The main effect of concreteness was significant, $F(1, 90) = 54.11$, $MSe = 3.59$, indicating concrete cue words ($M = 0.84$) were recognized better than abstract cue words ($M = 0.74$). No other effects were significant.

Hit rate proportions for B target words are presented in Table 4. These data were analyzed using a 2 (Instruction) X 2 (Target Concreteness) X 2 (Target Type) mixed analysis of

Table 3.

Mean Proportion of Correctly Recognized A Targets for Each Instruction and Target Concreteness in Experiment 2.

	Concreteness	
Instruction	Abstract	Concrete
Imagery	0.76	0.86
Relational	0.72	0.83

variance (Table D.5.1). The main effects of Target Concreteness and Target Type were significant, $F(1, 90) = 14.18$, MSe = 1.69, and $F(1, 90) = 26.98$, MSe = 1.40, respectively. Concrete targets (M = 0.86) were recognized better than abstract targets (M = 0.81), and primed targets (M = 0.86) were recognized better than unprimed targets (M = 0.80). The analysis also showed a significant Instruction X Target Type interaction, $F(1, 90) = 7.45$, MSe = 1.40, as well as a marginally non-significant Target Concreteness X Target Type interaction, $F(1, 90) = 3.83$, $p < .0535$, MSe = 1.25. No other effects were significant.

Figure 2 shows the Instruction X Item Type interaction. Inspection of Figure 2 suggests that the interaction is a consequence of the poorer recognition of unprimed targets learned with the relational learning instruction in comparison to the other three conditions. Analysis of simple effects indicate that when the cue and target have been encoded relationally then recognition of a B target is best when the target is preceded by its A study cue (i.e., when the target is primed). In addition, when the A cue word and B target word have been processed individually with the imagery instruction then it made little difference to the recognition of the B target when the target was primed by its A study cue.

Table 4.

Mean Proportion of Correctly Recognized B Targets for Each Instruction, Target Concreteness, and Target Type in Experiment 2.

	Concreteness			
	Abstract		Concrete	
Instruction	Unprimed	Primed	Unprimed	Primed
Imagery	0.81	0.82	0.85	0.90
Relational	0.77	0.84	0.77	0.90

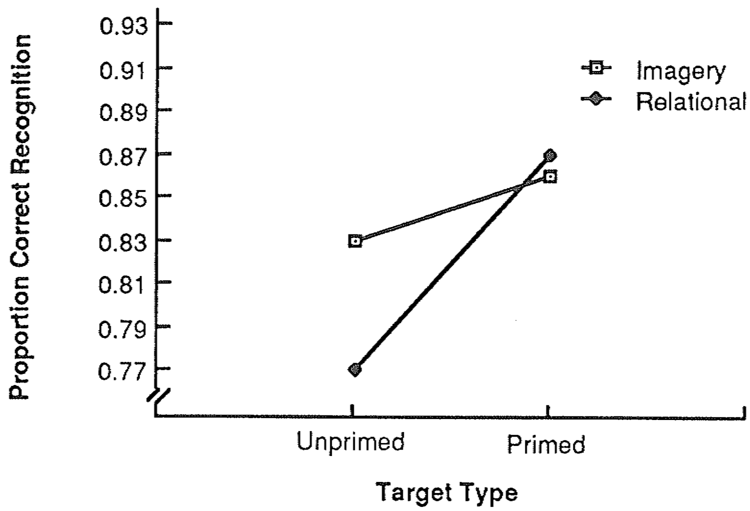

Figure 2. Mean proportion of correctly recognized B targets as a function of Instruction and Target Type.

Figure 3 shows the Target Concreteness X Target Type interaction. Figure 3 suggests that a concreteness effect in recognition is present when B targets are primed with their A study cue. Analysis of simple effects confirmed this interpretation. Recognition was better for primed concrete targets than primed abstract targets, but there was no difference in recognition between unprimed concrete and abstract targets. In addition, the effect of priming the B target was to improve recognition for both abstract and concrete pairs, but this improvement was much greater for concrete than abstract pairs.

To assess the possibility of any response bias operating during the recognition of old target words, an analysis of false alarm rates was carried out. This was done to be sure that higher recognition rates were the result of better discrimination between old study words and new distractor words, and not the result of either the Instruction or Target Concreteness variables to produce a bias toward a "yes" response[2]. A false alarm occurred whenever a subject incorrectly identified a new distractor word as an old study word (i.e., the subject said "yes" to a distractor). The proportion of false alarms are presented in Table 5 and were analyzed as a function of Instruction and Concreteness.

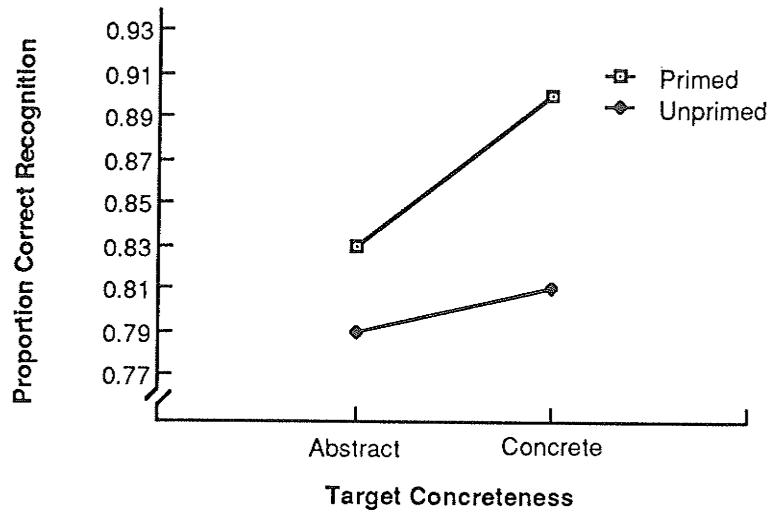

Figure 3. Mean proportion of correctly recognized B targets as a function of Instruction and Target Concreteness

The 2 X 2 mixed analysis of variance yielded a significant main effect of Concreteness, $F(1, 90) = 134.44$, $MSe = 8.42$ (Table D.6.1). This effect indicates that subjects were more likely to respond "yes" to abstract distractors ($M = 0.26$) than to concrete distractors ($M = 0.14$). No other effects were significant.

The false alarm analysis shows that the recognition analysis underestimates the difference in recognition performance between the concrete and abstract targets. The underestimation of this difference has two implications for interpreting the recognition data. First, the higher recognition rates for concrete material as compared to abstract material reflect better discrimination between old and new concrete words, and therefore, is not the result of a greater tendency to respond "yes" to concrete words. Second, because the difference in recognition performance between concrete and abstract material is underestimated, the recognition of abstract targets is exaggerated in relation to concrete targets. As a consequence, the Target Concreteness X Target Type interaction shown in Figure 3 is more apparent than real. For this reason, and the marginal non-significance of the interaction to begin with, this interaction is not considered further.

The concreteness effect found in the recognition data is consistent with previous findings of Hunt and Einstein

Table 5.

Mean Proportion of False Alarms for Each Instruction and Distractor Concreteness in Experiment 2.

	Concreteness	
Instruction	Abstract	Concrete
Imagery	0.27	0.16
Relational	0.25	0.12

(1981) showing that recognition performance is a function of variables influencing the distinctiveness of individual words. Presumably, successful recognition of single words relies primarily on information that serves to discriminate old study words from new distractor words, that is, it depends on discriminative information (Hunt & Einstein, 1981). Since the primary retrieval function of distinctive information is to help discriminate between candidate targets, then factors such as the concreteness of the material should have a large impact on recognition judgements. Indeed this was the case for recognition of both A cue words and B target words. Conversely, factors contributing to the processing of relational information should be relatively less important (Hunt & Einstein, 1981).

With regard to this last point the Instruction X Target Type interaction suggests that relational information can play a role in recognition under some circumstances. In particular, when the cue and target have been relationally encoded then a dependence between the cue and target is created. This dependence between the cue and target involves pair-specific, relational information. As was argued in the case of cued recall, access to discriminative target information will depend on the recovery of pair-specific, relational information before recognition can proceed. Once this pair-specific, relational information has been recovered, however, the recognition process can then proceed on the basis of the distinctiveness of target information.

In the priming in recognition paradigm recovery of this pair-specific, relational information can occur in one of two ways depending on whether or not the target word has been unprimed or primed. First, when the target is unprimed the subject must initiate the recovery of this information. The degree to which the subject is successful at recovering pair-specific, relational information will determine recognition performance. Second, when the target is primed then the spread of activation from the prime to the target can be thought of as providing relational access to the target. Hence, the recovery of of pair-specific, relational information is not a problem in the primed condition and recognition can proceed without an additional recovery stage. In the situation where the cues and targets have been encoded separately, as in the imagery instruction condition, the cue and target are not dependent. Therefore, the recovery of pair-specific information is unnecessary for access to distinctive target information. The pattern of error and response time data for unprimed targets in Table 2 suggest this interpretation. There are fewer errors and response times are on average 33 milliseconds faster for unprimed targets in the imagery instruction conditions than in the relational instruction conditions. Fewer errors and longer response times are what would be expected if the recognition process requires an additional recovery stage in the unprimed condition when the target and cue have been processed relationally. However, this explanation of the Instruction X Target Type interaction is post hoc, and assumes that the pattern of error and response time data for unprimed targets indicates real differences between the imagery and relational instruction conditions.

General Discussion

The experiments in this paper were designed to investigate the sensitivity of cued recall and priming in item recognition to manipulations in the processing of relational and distinctive information. Disregarding a possible floor effect in Experiment 1, the findings of these experiments suggest that cued recall is sensitive to differences in the processing of both relational and distinctive information, whereas priming in item recognition is primarily sensitive to differences in the processing of relational information. While it is concluded that the priming measure in item recognition is insensitive to differences in the distinctiveness of the material, it is suggested that the effect of distinctiveness is nevertheless manifested in the priming in item recognition paradigm, albeit not in the priming measure itself.

In Experiment 1 the effect of manipulating the distinctiveness of the learning material and access to relational information during encoding was examined on a cued recall test. Concreteness effects were large and recall was best for concrete pairs learned with a relational learning instruction. In contrast, concreteness effects were attenuated when the abstract and concrete word pairs were learned with the separation imagery instruction. These results replicate the findings of a previous investigation by Marschark and Hunt (1989), showing that concreteness effects depend on the encoding and retrieval of relational information. When processing of relational information is disrupted at either the encoding or retrieval stage, concreteness effects are attenuated. In Experiment 1 disruption of relational encoding was accomplished by having subjects learn abstract and concrete material with a separation imagery instruction. In considering the results from Experiment 1 the possibility of a floor effect must be kept in mind.

Marschark and Hunt (1989) explain concreteness effects such as those in Experiment 1 by the greater distinctiveness of concrete as compared to abstract pairs. Their explanation assumes relational and distinctive information serve different functions in retrieval. Relational information specifies a set of events from which a target can be drawn, that is, relational information serves a generative function (Marschark & Hunt, 1989; Marschark et al, 1987; Hunt & Marschark, 1987; Hunt & Seta, 1984; Hunt & Einstein, 1981). Once a set of events has been specified then distinctive information asserts an influence by allowing for the precise discrimination between the events contained within the set (Marschark & Hunt, 1989; Marschark et al, 1987; Hunt & Marschark, 1987; Hunt & Seta, 1984; Hunt & Einstein, 1981). In a paired associate learning task, word pairs are related by their appearance in the same learning context. Within this learning context, pair-specific, relational information links the members of each pair and distinguishes each pair from the other pairs in the list. In addition to pair-specific, relational information, distinctive information is required to identify each word within the learning context as well as each word within a pair. Concreteness enhances the distinctiveness of pairwise relations within the learning context as well as the distinctiveness of individual words within pairs (Marschark & Hunt, 1989). When relational information is activated by a cue in recall, then concrete words are recalled better than abstract words because they are easier to discriminate within the learning context than are abstract words. This better ability to discriminate concrete words results from the greater distinctiveness of both the pairwise relationship and individual words within pairs (Marschark et al., 1987; Marschark & Hunt, 1989).

Dual coding theory provides an alternative explanation to that proposed by Marschark and Hunt (1989). According to dual coding theory, concreteness effects in cued recall are explained by the joint functioning of a verbal and a nonverbal cognitive system (Paivio et al. 1988). Particular emphasis is placed on the ability of the the nonverbal system to generate images to word pairs and later to retrieve those images given a cue during recall. This functioning of the nonverbal system is captured by the conceptual peg hypothesis. Essentially, the conceptual peg hypothesis says that in paired-associate learning the cue word of a study pair acts like a peg onto which the target word is hooked and later retrieved from memory (Paivio, 1986). In the process of learning a word pair, arousal of the nonverbal system will aid in the hooking of the target to the cue. That is, imagery mediates learning of the word pair. For example, the word pair cheese-fur might be integrated with an image of a cartoon cheese character wearing a fur coat. Concrete words are thought to have a greater number of connections to the nonverbal system than are abstract words, and, therefore, are more likely to aid retrieval of the mediating images that were present during the learning of the word pair. Given that the mediating images are more likely to be retrieved with a concrete cue word, so should the retrieval of the target be more likely. In this sense a concrete cue is a more solid conceptual peg than is an abstract cue (Paivio, 1986).

In Experiment 2 the effect of manipulating material distinctiveness and relational encoding was again examined, but this time within the context of a "priming in item recognition" paradigm. Although larger priming effects were found for words learned with relational instructions than imagery instructions, the size of the priming effect did not vary as a function of target distinctiveness. That is, the size of the priming effect was the same for abstract and concrete materials. Despite the equivalent priming effects for concrete and abstract material, concrete materials had an overall advantage in response time. Together these results suggested that differences in the processing of relational and distinctive information are manifested in the priming in item recognition paradigm. However, these differences are manifested in two different ways. First, the overall advantage in response time to concrete material relative to abstract material indicates a difference in the processing of distinctive information. Second, a larger priming effect for material learned with the relational instruction, relative to material learned with the separation imagery instruction, indicates a difference in relational information processing.

The recognition data in Experiment 2 showed a concreteness effect and an interaction between Instruction and Target Type. The concreteness effect reflected better recognition for concrete study words than abstract study words. The interaction between Instruction and Target Type showed that recognition of targets learned in relation to a study cue was best when the targets were primed. However, recognition of these primed targets did not differ from targets processed individually with the imagery instruction. Although these results are consistent with previous findings suggesting that recognition is primarily a function of variables influencing the distinctiveness of individual words (Hunt & Einstein, 1981), the interaction between Instruction and Target Type suggests further that recovery of pair-specific, relational information will be important to recognition in some circumstances, particularly when the target has been encoded relationally.

The pattern of data in cued recall, priming, and recognition from Experiment 1 and Experiment 2 show that the processing of relational and distinctive information affect each of these measures differently. Presumably this is because the information requirements for successful performance on each of these three tasks is different. In cued recall both relational and distinctive information are important for optimum memory performance (Marschark & Hunt, 1989; Ackerman, 1986; Hunt & Seta, 1984). Priming in item recognition, on the other hand, relies mainly on relational information. Finally, in a simple recognition task distinctive information is most important although there are situations where relational information will also be important (Hunt & Einstein, 1981; Mandler, 1980; Humphreys, 1978).

Previous research by Rabinowitz (1986) on cued recall and priming in item recognition has also shown different patterns of results on these dependent measures when age and the relatedness of word pairs are considered as variables. Rabinowitz explains these differences in terms of the attentional demands of each task at retrieval. From this perspective cued recall requires effort because it involes memory search, evaluation of the search, and response production. Recognition involves both an effortful retrieval process and an automatic familiarity component (Mandler, 1980). Priming in item recognition involves mainly an automatic component (McKoon & Ratcliff, 1980; Ratcliff & McKoon, 1978). Thus cued recall, recognition, and priming in item recognition reflect decreasing reliance on effortful processes and increasing reliance on automatic processes (Rabinowitz, 1986).

The analysis of the information requirements for cued recall, recognition, and priming in item recognition compliments Rabinowitz's (1986) argument by suggesting why the retrieval demands for different memory tasks vary. Presumably, the retrieval requirements are different because each memory task has different information requirements. For example, cued recall requires the processing of both relational and distinctive information whereas priming in item recognition requires primarily relational processing. One advantage in taking this information approach is that it accommodates the influence of encoding factors as well as the retrieval mechanisms responsible for performance on these memory tasks. From this perspective both retrieval and encoding conditions need to be taken into account in order to provide a full account of performance.

Direction of Future Research

Before concluding, the present research suggests several directions for future research. First, the recognition data presented here suggests that the conditions under which the recovery of pair-specific, relational information will be important needs further investigation. In this regard Mandler (1980) has argued that organizational variables have an affect on recognition performance. He cites evidence showing that, when an unrelated word list is sorted into subjective categories, there is a direct correlation between the number of categories into which the words are sorted and recognition performance. Mandler (1980) also adds that the size of this correlation is a function of the time interval between sorting and the recognition test. When recognition is tested immediately following category sorting then organization has little impact on performance. However, as the time interval between sorting and test increases so does the effect of organization on recognition. This result suggests that the information requirements for a task changes as a function of time. Thus, in recognition it would appear that relational information becomes more important as the time interval between study and test increases. However, the time interval effect may occur only when the words in a study list are processed relationally as with a category sorting task. If words are processed as discrete units then the time interval effect may not result as access to discriminative information for this latter situation does not depend on the recovery of relational information. The access to discriminative information does not depend on the recovery of relational information in this situation simply because relational information has not been encoded. An interesting test of this position would be to examine recognition performance following several time delays when the material has been encoded relationally versus when it has been encoded as individual units.

Similarly, Humphreys (1978) has argued that the recovery of relational information is important for recognition when word pairs are learned with paired-associate instructions. His argument is based partly on the observation that recognition for words tested in intact study pairs (A-B) is better than recognition for words tested in rearranged study pairs (A-Br). This difference between recognition for words tested in intact study pairs and words tested in rearranged pairs is called the context effect. The context effect is explained by assuming that there are two retrieval routes available for the recovery of relational information for words tested in intact pairs as compared to one retrieval route for the words tested in rearranged pairs (Humphreys, 1978). Extending the implications of this type of result, Humphreys and Bain (1983) argue that a retrieval cue and information analysis is necessary for a full understanding of recognition memory. Such a cue and information analysis of recognition memory is compatible with Tulving's idea of encoding specificity (Tulving, 1983; Tulving & Thomson, 1973). Essentially, the encoding specificity position states that a retrieval cue will be effective to the extent that the information available in the cue matches information encoded during the learning of the original event. An effective retrieval cue acts like a key to unlock the memory for an event. Similarily, R. R. Hunt (personal communication, May, 1988) has undertaken a project examining the role of relational and distinctive information in retrieval cues. Studies of this nature should better our understanding of the conditions under which the recovery of relational information will be important for recognition.

A second line of research involves assessing the attentional requirements for processing relational and distinctive information. In this regard the distinction between automatic and effortful processing proposed by Hasher and Zacks (1979) is useful. Assuming a limited capacity model of attention (Kahneman, 1973), automatic processes place few demands on attentional capacity and do not interfere with ongoing processing activity. Effortful processes, however, require considerable attentional capacity and are under the strategic control of the learner. One of the many criterion that Hasher and Zacks (1979) list for determining automaticity is the effect of manipulating instruction on performance. In particular, automatic processes do not benefit from instruction on how to perform them; conversely, effortful processes do benefit from instruction. The interactions involving the instruction variable in Experiment 1 and Experiment 2 show that performance does benefit from the processing strategy the subject adopts. This type of result implies that at least some processing of information may be strategic and under the control of the subject. However, the data presented here make it difficult to determine exactly what information and how much processing of that information is under strategic control. Nevertheless, Hunt and Mitchell (1982) have made the suggestion that attention to relational information is a conscious process requiring processing capacity, whereas the processing of orthographically distinctive features occurs automatically.

Finally, one reason for conducting this study was to establish the validity of the method developed here in order to examine memory performance in a population of elderly subjects. In particular, the present method should be able to isolate any systematic age differences in the processing of relational and distinctive information. Guttentag (1988) has begun to address this issue using free recall as a dependent measure. The procedure in this study was similar to that of Hunt and Seta (1984). Young and older adults sorted or rated the pleasantness of categorizeable word lists. Each word list was made up of large and small categories. A third group of young subjects rated the same material under conditions of divided attention. This young divided-attention group was included in order to model older subjects' performance where processing capacity is thought to be diminished (Craik, & Byrd, 1982; Rabinowitz, Craik, & Ackerman, 1982). Again, the sorting task and large categories were assumed to encourage relational processing while the pleasantness rating task and small categories were assumed to encourage distinctive processing. Consistent with previous findings, all groups of subjects showed that recall of large categories was best following pleasantness rating, whereas recall of small categories was best following category sorting. However, in considering differences between the three groups, older subjects and young divided-attention subjects did not differ from each other, but showed an overall performance deficit relative to the young full-attention group. Guttentag (1988) argues this pattern of results favours the view that older adults have a general deficit in the processing of semantic information as a consequence of diminished processing capacity, rather than a specific deficit in the processing of either relational or distinctive information.

Guttentag (1988) proposes two mechanisms by which diminished processing capacity can affect memory performance in the elderly. Both mechanisms are thought to strain the limits of available processing capacity. The first mechanism is concerned with the enrichment or elaboration of information pertaining to individual events. The second alternative mechanism is concerned with the integration of contextual detail with individual events (Craik & Byrd, 1982; McIntyre & Craik, 1987). From within the framework of processing relational and distinctive information these mechanisms suggest two very different possibilities for explaining age related changes in memory. The first mechanism points toward some form of processing deficit in distinctive information. This follows from the argument that elaboration functions to increase the distinctiveness of a event (Jacoby & Craik, 1979; Hunt & Einstein, 1981). The second mechanism is more difficult to accommodate within the framework of relational and distinctive information processing, but nevertheless suggests that poor integration of specific event information within the general encoding context may have an impact on relational access to that event at retrieval.

In view of these arguments it is difficult to reconcile age related memory changes in terms of specific deficits in the processing of either relational and distinctive information. However, there are at least two reasons for pursuing the possibility of systematic age differences in the processing of relational and distinctive information. First, it would seem premature to reject the the possibility of systematic age differences in the processing of relational and distinctive information on the basis of a single study. Second, not all of the available evidence fits the view of a general deficit in the processing of semantic information on the part of older adults. For example, Guttentag (1988) found that even though older subjects did not recall as much information as younger full-attention subjects, older subjects had higher category clustering scores than did their younger counter-parts. To the extent that category clustering scores reflect the amount of relational processing, the higher clustering scores for the older adults may indicate that relational processing may have occurred at the expense of processing distinctive information. The implication is not that older adults cannot and do not process distinctive information, but rather that this type of processing may have suffered as a consequence of processing relational information. Although the clustering data does support this line of reasoning more research is needed to clarify this issue.

In conclusion, the differences in performance between cued recall and priming in item recognition help support the theoretical distinction between relational and distinctive information as well as their intended retrieval functions. Relational information can be thought of as sets of features that are common and shared by two or more events. As such, relational information serves to integrate and link events in memory as well as a generative function in retrieval (Hunt & Marschark, 1987; Hunt & Seta, 1984; Hunt & Einstein, 1981). Distinctive information, in contrast, can be thought of as being sets of features that are unique to particular events, and serving primarily a discriminative or diagnostic function in retrieval (Marschark & Hunt, 1989; Hunt & Marschark, 1987; Hunt & Seta, 1984; Hunt & Einstein, 1981, Tversky, 1977). This distinction functions well for understanding and organizing information from a wide variety of memory problems.

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Footnotes

[1] The items per category measure is the mean number of items from a category recalled. This measure differs from clustering in that words from the same category do not have to appear consecutively, that is, in clusters (Hunt & Einstein, 1981; Hyde & Jenkins, 1969).

[2] To illustrate the importance of considering the false alarm rates for interpreting the recognition data consider the following thought experiment. A subject is shown a list of words to study. Following the study phase the subject is then presented with a list of old study words and new distractor words one at time. The subject is instructed to respond "yes" to an old word and "no" to a new word. In addition the subject is rewarded 5¢ for each correct recognition or hit of an old study word, but is not penalized for incorrectly identifying a new distractor word as old, that is, making a false alarm. Under these circumstances the subject would likely respond "yes" to both old study words and new distractors in order to maximize payoff. Obviously in this situation a high hit rate does not reflect recognition for the old study words, but rather some other aspect of performance. Therefore, if false alarm rates are not considered then the experimenter may erroneously conclude that the high hit rate reflects excellent recognition of old study words.

Appendix A

Instructions for Rating Tasks and Cued Recall

A.1 Rating Tasks

A.1.1 Relatedness

A.1.2 Imagery

A.2 Cued Recall

A.1 Rating Tasks

The relatedness instructions described in this section were used to obtain relatedness ratings for the word pairs as well as to guide the subjects' processing activity in the relational orienting condition. The relatedness task instructions have been adapted from the imagery instructions found in Paivio, Yuille, and Madigan (1968, pp. 4-5). The imagery task instructions are essentially those found in the same source with the exception of the description of the second rating scale for each word pair.

A.1.1 Relatedness

This experiment is part of a scaling study to gather information about the properties of words. In particular, nouns differ in their capacity to be formed into a meaningful relationship with other nouns. The meanings of some nouns can be related very quickly and easily, whereas the meanings of other nouns can be related only with difficulty (i.e., following a long delay) or not at all. Your task is to rate a list of word pairs on the ease or difficulty with which the meaning of one word can be combined into a relationship with the meaning of a second word. When the meaning of the two words can be related quickly and easily the word pair should be given a <u>high relatedness</u> rating. On the other hand, when the meanings of the two words cannot be related at all then the word pair should be given a <u>low relatedness</u> rating. Consider the word pairs <u>iron</u> - <u>clothes</u> and <u>cheese</u> - <u>fur</u>. For the iron - clothes word pair a relationship between the meanings of the two words can be established quickly and easily, and would be rated as high relatedness. For the cheese - fur word pair, on the other hand, a relationship between the meanings of the two words is very difficult to establish and would be rated as low relatedness.

Your ratings will be made on a seven point scale where <u>one</u> is the low relatedness end of the scale and <u>seven</u> is the high relatedness end of the scale. Please make your rating by circling a number from 1 to 7 that best indicates your judgement about the ease or difficulty of relating the meanings of the two words in each word pair. Word meanings that can be related easily and quickly should be given a rating of 7, whereas word meanings that cannot be related at all should be given a rating of 1. Use the portion of the scale between these two extremes to rate appropriately the ease or difficulty of combining the two words into a meaningful relationship. <u>Feel free to use the entire range of numbers</u>, from 1 to 7; at the same time, don't be concerned about how often you use a particular number <u>as long as it reflects your true judgement about the word pair</u>. Work fairly quickly but please consider each word pair carefully.

Below are some examples. Indicate the ease of establishing a relationship between the meanings of the two words by circling the appropriate number.

bread - crust

low relatedness							high relatedness
	1	2	3	4	5	6	7

---

hammer - creator

low relatedness							high relatedness
	1	2	3	4	5	6	7

---

disaster - festivity

low relatedness							high relatedness
	1	2	3	4	5	6	7

If necessary, refer back to these instructions when rating the words on the following pages. If you have any questions please ask them now. Otherwise, turn the page and begin.

A.1.2 Imagery

This experiment is part of a scaling study to gather information about the properties of words. In particular, nouns differ in their capacity to arouse mental images of things or events. Some words arouse a sensory experience, such as a mental picture or sound, very quickly and easily, whereas others may do so only with difficulty (i.e., after a long delay) or not at all. Your task is to rate a list of words as to the ease or difficulty with which they arouse mental images. Any word which, in your estimation, arouses a mental image (i.e., a mental picture, or sound, or some other sensory experience) very quickly and easily should be given a high imagery rating; any word that arouses a mental image with difficulty or not at all should be given a low imagery rating. Think of the words "apple" and "fact". Apple would probably arouse an image relatively easily and would be rated as high imagery; fact would probably do so with difficulty and would be rated as low imagery. It is important that you note only the ease of getting a mental image of an object or an event to the word.

Your ratings will be made on a seven-point scale, where one is the low imagery end of the scale and seven is the high imagery end of the scale. Please make your rating by putting a circle around the number from 1 to 7 that best indicates your judgement of the ease or difficulty with which the word arouses imagery. The words that arouse images most readily for you should be given a rating of 7; words that arouse images with the greatest difficulty or not at all should rated 1; words that are intermediate in ease or difficulty of imagery, of course, should be rated appropriately between the two extremes. Feel free to use the entire range of numbers, from 1 to 7; at the same time, don't be concerned about how often you use a particular number as long as it reflects your true judgement about the word. Although the words appear in pairs, please rate each word individually. Use the scale on the left to rate the left-hand member of each word pair; use the scale on the right to rate the right-hand member of each word pair. Work fairly quickly but please consider each word carefully.

Below are some examples. Indicate the ease of getting an image by circling the appropriate number.

bread - crust

low imagery						high imagery	low imagery						high imagery
1	2	3	4	5	6	7	1	2	3	4	5	6	7

hammer - creator

low imagery						high imagery	low imagery						high imagery
1	2	3	4	5	6	7	1	2	3	4	5	6	7

disaster - festivity

low imagery						high imagery	low imagery						high imagery
1	2	3	4	5	6	7	1	2	3	4	5	6	7

If necessary, refer back to these instructions when rating the words on the following pages. If you have any questions please ask them now. Otherwise, turn the page and begin.

A.2 Cued Recall

In this next part of the experiment I will test your ability to recall the word pairs you rated in the first part of the experiment. To help you with this recall, one of the words in each of the word pairs will be given as a cue. Your task is to recall the other word that was presented along with the cue word. Write your response in the space provided next to the cue word. You may take as much time as you need to complete this task.

Appendix B

Experimental Material

B.1 Critical Experimental Pairs

B.2 Filler Pairs

B.3 Buffer Pairs

B.4 Distractors for Experiment 2

B.1 Critical Experimental Pairs

	Pair Concreteness		
Abstract	Rating	Concrete	Rating
reflection - drama	2.92	cotton - forest	2.92
exhaustion - blandness	2.92	alcohol - steam	2.92
custom - disposition	2.96	bronze - infant	2.96
fortune - illusion	3.00	gold - cobblestone	3.00
trouble - miracle	3.00	fire - sea	3.00
institute - position	3.21	troops - cattle	3.21
nonsense - opinion	3.46	wigwam - moss	3.46
evidence - impression	3.46	tripod - chair	3.46
theory - origin	4.71	mantel - rock	4.71
reminder - engagement	5.21	flag - queen	5.21
genius - effort	4.67	nail - arrow	4.67
formation - method	4.75	microscope - tweezers	4.79
mischief - predicament	4.75	peach - wine	4.79
management - welfare	4.46	accordion - caterpillar	4.50
impulse - pressure	4.04	window - bottle	4.08
heredity - tendency	5.25	thorn - scorpion	5.29
essence - recognition	3.13	tobacco - volcano	3.08
amount - elaboration	3.13	mountain - pole	3.08
mind - health	5.21	musician - saloon	5.08
strength - flexibility	5.50	robber - car	5.54
Mean	3.99		3.99
SD	0.95		0.96

B.2 Filler Pairs

Pair Relatedness					
Related			Unrelated		
abstract - concrete					
destruction	-	army	idiom	-	piston
hour	-	timepiece	chance	-	skillet
competence	-	juggler	episode	-	jelly
concrete - abstract					
monk	-	devotion	mast	-	kindness
blister	-	infection	macaroni	-	attitude
college	-	semester	lad	-	freedom
medium concrete					
algebra	-	mathematics	leader	-	shriek
pollution	-	industry	profile	-	odor
lubricant	-	friction	gilt	-	item
malaria	-	disease	fatigue	-	decree
examination	-	answer	background	-	charter
air	-	oxygen	errand	-	link

B.3 Buffer Pairs

abstract - abstract		
fun	-	pleasure
necessity	-	fact
appearance	-	madness
victory	-	sensation

concrete - concrete		
student	-	frog
appliance	-	coffee
slipper	-	ankle
doctor	-	flesh

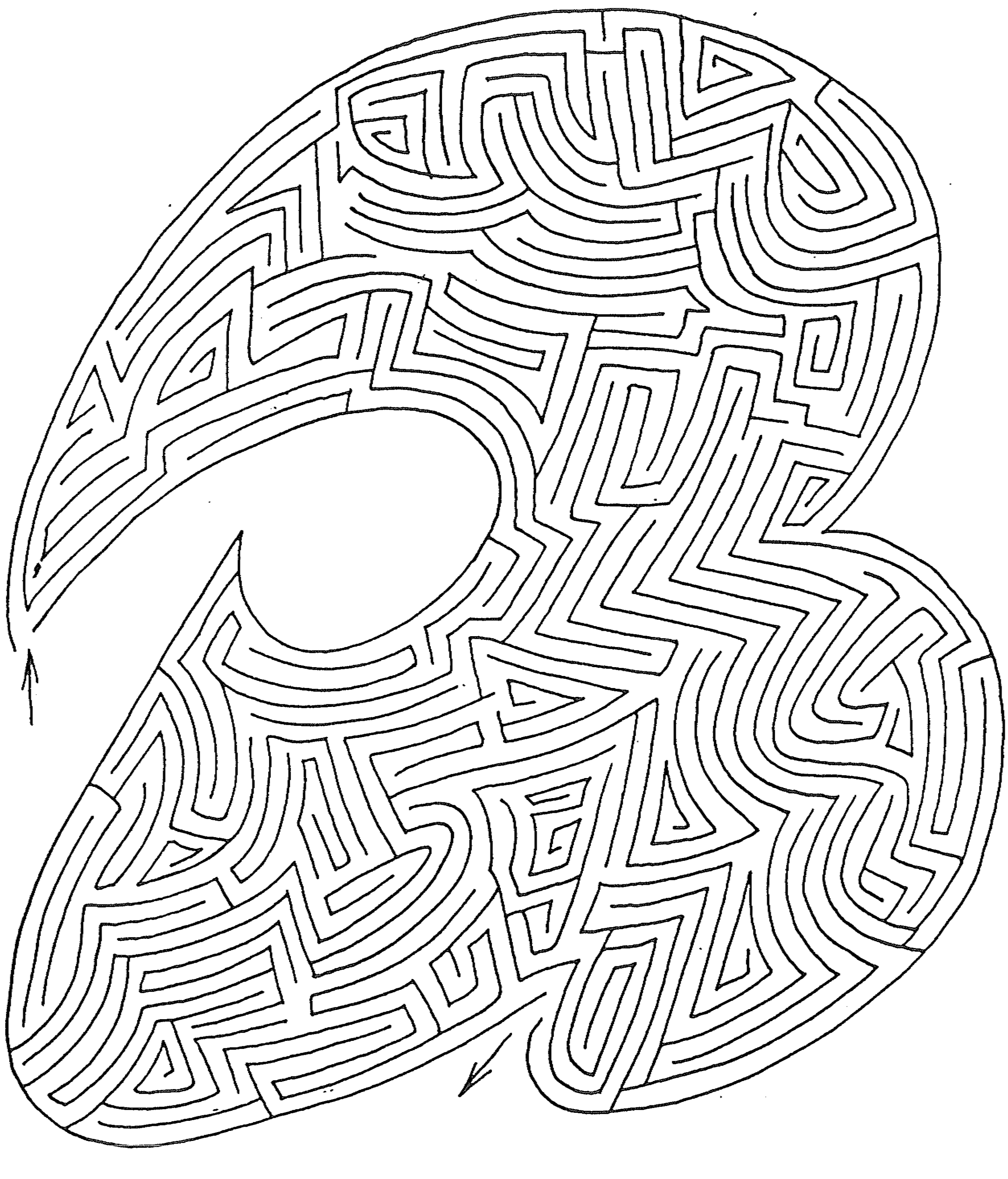
mixed pairs		
fisherman	-	sobriety
dress	-	style
law	-	foam
pride	-	city

B.4 Distractors for Experiment 2

Pair Concreteness			
Abstract		Concrete	
unreality	context	coin	barnacle
virtue	occasion	ink	chin
centennial	emergency	magazine	flash
prosperity	justice	letterhead	apple
opportunity	event	poet	settler
safety	unit	whale	nutmeg
research	discovery	glacier	plank
pep	satire	pencil	elephant
warmth	blessing	railroad	bowl
misconception	quality	diamond	engine
knowledge	fault	elbow	brain
history	quest	hurricane	grass
expression	increment	beaver	circle
silence	gravity	factory	bird
cost	development	rubble	vegetable
interest	power	pupil	noose
cleanness	dream	wheat	umbrella
chance	economy	sugar	hairpin
velocity	vacuum	nectar	lice
shock	discretion	pipe	tool

Appendix C

Distractor Task



Appendix D

Statistical Analyses

This appendix contains the analysis of variance tables, interaction tables, and summary tables for simple effects analyses. The degrees of freedom that are reported for pooled error terms in simple effects analyses were calculated according to the Satterthwaite approximations provided by Winer (1971).

Table D.1.1.

2 X 2 Mixed Anova for Total Correct Cued Recall in Experiment 1

Source	df	SS	MS	F	Pr > F
Between					
Instruction	1	2034.5052	2034.5052	241.55	0.0001
Error	94	791.7396	8.4228		
Within					
Concreteness	1	1003.7552	1003.7552	221.84	0.0001
Instrution*Concreteness	1	459.4219	459.4219	101.54	0.0001
Error(Concreteness)	94	425.3229	4.5247		

Table D.1.2.

Treatment Totals for Examining the Instruction X Target Concreteness Interaction in Experiment 1.

	Target Concreteness		
Instruction	Abstract	Concrete	Totals
Imagery	18	89	107
Relational	182	550	732
Totals	200	639	839

Table D 1.3.

Summary Table of Tests on Simple Effects in Experiment 1.

Treatment Comparison	df	MS	F	Pr > F
Between Instructions within Abstract Targets	1	280.17	43.30	0.0001
Between Instructions within Concrete Targets	1	2213.76	342.16	0.0001
Between levels of Target Concreteness under the imagery instruction	1	52.51	11.59	0.0010
Between levels of Target Concreteness under the relational instruction	1	1410.67	311.41	0.0001
Error Terms for treatment comparisons				
Error for testing Instruction effects within Target Concreteness	172	6.47		
Error for tesing Target Concreteness effects within Instruction	94	4.53		

Table D.2.1.

2 X 2 X 2 Mixed Anova for Priming (milliseconds) in Experiment 2.

Source	df	SS	MS	F	Pr > F
Between					
Instruction	1	51443.4810	51443.4810	0.40	0.5292
Error	90	11601391.484	128904.3498		
Within					
Concreteness	1	1811469.4592	1811469.459	44.22	0.0001
Instruction*Concreteness	1	24212.5680	24212.5680	0.59	0.4440
Error(Concreteness)	90	3686649.7228	40962.7747		
Type	1	1379962.5680	1379962.5680	54.22	0.0001
Instruction*Type	1	288232.0680	288232.0680	11.33	0.0011
Error(Type)	90	2290455.1141	25449.5013		
Concreteness*Type	1	7335.4592	7335.4592	0.30	0.5829
Instruction*Concreteness*Type	1	7353.3288	7353.3288	0.30	0.5824
Error(Concreteness*Type)	90	2173220.9620	24146.8996		

Table D.2.2.

Treatment Totals for Examining the Instruction X Target Type Interaction in Experiment 2.

	Target Type		
Instruction	Uprimed	Primed	Totals
Imagery	83731	86705	170436
Relational	77613	70288	147901
Totals	161344	156993	318337

Table D.2.3.

Priming Summary Table for Simple Effects Analysis
of the Instruction X Target Type Interaction in Experiment 2.

Treatment Comparison	df	MS	F	Pr > F
Between Instructions within Unprimed Targets	1	48068.89	0.62	0.4325
Between Instructions within Primed Targets	1	291606.66	3.78	0.0541
Between Target types under the imagery instruction	1	203423.50	7.99	0.0058
Between Target types under the relational instruction	1	1464771.14	57.56	0.0001
Error Terms for treatment comparisons				
Error for testing Instruction within Target Type effects	124	77176.93		
Error for tesing Target Type within Instruction effects	90	25449.50		

Table D.3.1

2 X 2 X 2 Mixed Anova for Error Data in Experiment 2.

Source	df	SS	MS	F	Pr > F
Between					
Instruction	1	33.4810	33.4810	3.68	0.0581
Error	90	817.8315	9.087		
Within					
Concreteness	1	105.4592	105.4592	58.90	0.0001
Instruction*Concreteness	1	0.1332	0.1332	0.07	0.7857
Error(Concreteness)	90	161.1576	1.7906		
Type	1	18.7201	18.7201	8.52	0.0044
Instruction*Type	1	3.3288	3.3288	1.52	0.2215
Error(Type)	90	197.7011	2.1967		
Concreteness*Type	1	28.8288	28.8288	14.67	0.0002
Instruction*Concreteness*Type	1	0.0245	0.0245	0.01	0.9114
Error(Concreteness*Type)	90	176.8967	1.9655		

Table D.4.1

2 X 2 Mixed Anova for Total Correct Recognition of A Targets in Experiment 2.

Source	df	SS	MS	F	Pr > F
Between					
Instruction	1	28.9620	28.9620	2.78	0.0992
Error	90	939.1413	10.4349		
Within					
Concreteness	1	194.1359	194.1359	54.11	0.0001
Instruction*Concreteness	1	0.4402	0.4402	0.12	0.7270
Error(Concreteness)	90	322.9239	3.5880		

Table D.5.1.

2 X 2 X 2 Mixed Anova for Total Correct Recognition of B Targets in Experiment 2.

Source	df	SS	MS	F	Pr > F
Between					
Instruction	1	6.7935	6.7935	1.77	0.1870
Error	90	345.8696	3.8430		
Within					
Concreteness	1	24.0109	24.0109	14.18	0.0003
Instrution*Concreteness	1	3.1413	3.1413	1.86	0.1765
Error(Concreteness)	90	152.3478	1.6928		
Type	1	37.8370	37.8370	26.98	0.0001
Instrution*Type	1	10.4457	10.4457	7.45	0.0076
Error(Type)	90	126.2174	1.4024		
Concreteness*Type	1	4.7935	4.7935	3.83	0.0535
Instrution*Concreteness*Type	1	0.0109	0.0109	0.01	0.9260
Error(Concreteness*Type)	90	112.6957	1.2522		

Table D.5.2.

Recognition Treatment Totals for Examining the Instruction X Target Type Interaction in Experiment 2.

	Target Type		
Instruction	Uprimed	Primed	Totals
Imagery	764	792	1556
Relational	708	798	1506
Totals	1472	1590	3062

Table D.5.3.

Recognition Summary Table for Simple Effects Analysis
of the Instruction X Target Type Interaction in Experiment 2.

Treatment Comparison	df	MS	F	Pr > F
Between Instructions within Unprimed Targets	1	17.04	6.50	0.0118
Between Instructions within Primed Targets	1	0.20	0.08	0.7917
Between levels of Target Type under the imagery instruction	1	4.26	3.04	0.0847
Between levels of Target Type under the relational instruction	1	44.02	31.44	0.0001
Error Terms for treatment comparisons				
Error for testing Instruction effects within Target Type	148	2.62		
Error for tesing Target Type effects within Instruction	90	1.40		

Table D.5.4

Recognition Treatment Totals for Examining the
Target Concreteness X Target Type Interaction in Experiment 2.

	Target Type		
Concreteness	Uprimed	Primed	Totals
Abstract	723	761	1484
Concrete	749	829	1578
Totals	1472	1590	3062

Table D.5.5.

Recognition Summary Table for Simple Effects Analysis
of the Target Concreteness X Target Type Interaction in Experiment 2.

Treatment Comparison	df	MS	F	Pr > F
Between Concreteness within Unprimed Targets	1	3.67	2.50	0.1156
Between Concreteness within Primed Targets	1	25.13	17.10	0.0001
Between levels of Target Type for Concrete Words	1	7.85	5.90	0.0160
Between levels of Target Type for Abstract Words	1	34.78	26.15	0.0001
Error Terms for treatment comparisons				
Error for testing Concreteness effects within Target Type	176	1.47		
Error for tesing Target Type effects within Concreteness	179	1.33		

Table D.6.1.

2 X 2 Mixed Anova for False Alarms in Experiment 2

Source	df	SS	MS	F	Pr > F
Between					
Instruction	1	74.3967	74.3967	2.20	0.1417
Error	90	3046.1848	33.8465		
Within					
Concreteness	1	1105.4402	1105.4402	134.44	0.0001
Instrution*Concreteness	1	10.0489	10.0489	1.22	0.2719
Error(Concreteness)	90	740.0109	8.2223		

Appendix E

Recognition Test Order

E.1 Codes for Recognition Test Order

E.2 Recognition Test Order

E.1 Codes for Recognition Test Order

Item Type	Description	Code
Distractors	abstract distractor concrete distactor	a distract c distract
Abstract A Words	unprimed condition primed condition	aa aa'
Concrete A Words	unprimed condition primed condition	ca ca'
Abstract B Words	unprimed condition primed condition	ab ab'
Concrete B Words	unprimed condition primed condition	cb cb'

E.2 Recognition Test Order

Set 1	Set 2	Set 3	Set 4
c a	a distract	c distract	a a
a b	a distract	c distract	c a'
a distract	c a	a distract	c b'
c distract	c distract	a a	a distract
a distract	c a'	a b	c distract
c a'	c b'	c b	a distract
c b'	a a	a b	c a
c distract	a a	a distract	c b
c distract	a distract	c a'	c distract
a distract	a a'	c b'	a a
a distract	a b'	a a	a b
a a	a distract	c distract	c a
c b	c a'	a distract	c distract
a b.	c b'	a distract	c distract
a distract	a b	a a'	a distract
a distract	c distract	a b'	a a'
c distract	a distract	a a	a b'
a a'	c distract	c distract	c distract
a b'	c distract	c distract	c a
c distract	c a'	c distract	c distract
a distract	c b'	c a'	a distract
c distract	a distract	c b'	c distract
a a'	c distract	c a	a distract
a b'	c a	c distract	a a'
a distract	a b	a distract	a b'
c distract	a b	a distract	c distract
c distract	c distract	c a'	a a'
c distract	a distract	c b'	a b'
a a	a distract	c b	c b
c b	c distract	c distract	c b
c b	a a'	a a'	a distract
a distract	a b'	a b'	a distract
c a'	c b	c distract	a distract
c b'	c b	c distract	c a'
c distract	c distract	a distract	c b'
a distract	c distract	a distract	a b
c a	a distract	c a	c distract
a a'	a a	a b	c distract
a b'	c distract	a distract	a distract
c a	a distract	a distract	a distract

Appendix F

F.1 Priming in Item Recognition

Now I will give you a recognition test for the words you rated in the first part of the experiment. You will be shown a series of four short test lists that are made up of words from the first part of the experiment and words that you have not seen before in the experiment. The words from each test list will appear one at a time on the computer screen. If you think that the word is one that you have seen before in the rating task, then press the "yes" button; if on the other hand you think that you did not see the word before in the rating task, then press the "no" button. Please pres the appropriate response button as quickly and accurately as possible. You will not be told whether or not you have made a correct choice. Once you have made a choice get ready for the next word because it will appear on the computer screen almost immediately after you have pressed a button.

Following each test list you will be given a short rest. The computer will sound a tone and the word "REST" will appear on the screen. When you hear the tone a second time and the "READY" appears on the computer screen, press any key on the key board and get ready for the next test list. Before the first word from the next test list is presented, a dot will appear briefly on the screen. Peer directly at the dot. A few moments later the first word from the list will be shown. Repeat the judgement task with this new list of words.

Before presenting the four test lists, I am going to test your manual dexterity. On the computer screen the word "Yes" or "No" will appear. Your task is to press the button labeled the same as the word appearing on the screen. If the word "Yes" is shown then press the button labeled "Yes"; likewise, if the word "No" is shown then press the button labeled "No". Please press the appropriate response button as quickly and accurately as possible. You will not be told whether or not you have made a correct choice.

When you have finished the dexterity task, the computer will present a message "Ready--Word List". Press any key to dismiss this message and peer directly at the dot on the screen. The four test lists will then be presented to you. After responding to the forth list, the computer will present another message "Ready Dexterity". Press any key to dismiss this message and repeat the manual dexterity task.

Some final notes. Rest index fingers lightly on top of the read and green keys at all times. When you press a key do so quickly and sharply.

Appendix G

Computer Software

G. 1 6800 Assembly Code for Drexell's Millisecond Timer

G. 2 Pascal Interface to Millisecond Timer

G. 3 Global Variables

G. 4 Main Program

G. 1 6800 Assembly Code for Drexell's Millisecond Timer

```
0000        ;======
0000        ;====== File: MilliTimerAsm.Txt
0000        ;====== Language: MDS Assembler v1.2
0000        ;====== Author: Robert Westall, Software Development Group,
0000        ;====== Drexel University
0000        ;====== Westall, R., Perkey, M. N., & Chute, D. L. (1986).
0000        ;====== Accurate millisecond timing on
0000        ;====== Apple's Macintosh using Drexel's MilliTimer. Behavior
0000        ;====== Research Methods, Instruments, & Computers, 18 (3), 307-311.
0000        ;======
0000
0000                              INCLUDE              MacTraps.D
0000                              INCLUDE              SysEquX.D
0000
0000                              XDEF                 MilliCount
0000                              XDEF                 MilliControl
0000
0000                             MilliCount
0000   225F                               MOVE.L       (SP)+,A1
0002   41F8 0192                          LEA          Lvl1DT,A0
0006   2068 0018                          MOVEA.L      24(A0),A0
000A   2EA8 FFF8                          MOVE.L       -8(A0),(SP)
000E   4ED1                               JMP          (A1)
0010
0010                             MilliControl
0010   2F0A                               MOVE.L       A2,-(SP)
0012   2478 01D4                          MOVEA.L      VIA,A2
0016   157C 0040 1C00                     MOVE.B       #%01000000,VIER(A2)
001C   102A 0800                          MOVE.B       VT1C(A2),D0
0020   2078 02A6                          MOVEA.L      SysZone,A0
0024   2278 02AA                          MOVEA.L      ApplZone,A1
0028
0028   45C0 xxxx        (PX)      @0:     LEA          MilliInterrupt,A2
002C   B3C8                               CMPA.L       A0,A1
0030   xx               (R)               BLE.S        @1
0030   B548                               CMPM.W       (A0)+,(A2)+
0032   66 F4            (P)               BNE.S        @0
0034   70 06                              MOVEQ        #6,D0
0036   B588                       @2:     CMPM.L       (A0)+,(A2)+
0038   56C8 FFFC        (P)               DBNE         D0,@2
003E   xx               (R)               BEQ.S        @3
003E   5988                               SUBQ.L       #4,A0
0040   60 E6            (P)               BRA.S        @0
0042   91FC 0000 0026             @3:     SUBA.L       #38,A0
0048   42A8 0008                          CLR.L        8(A0)
004C   A41F                               _DisposPtr   ,SYS
004E
```

```
004E    0C6F 0000 0008          @1:  CMPI.W    #0,8(SP)
0056    xx               (R)         BEQ.S     @4
0056    70 26                        MOVEQ     #38,D0
0058    A51E                         _NewPtr   ,SYS,CLEAR
005A    4A40                         TST.W     D0
005E    xx               (R)         BNE.S     @4
005E    5088                         ADDQ.L    #8,A0
0060    2478 01D4                    MOVEA.L   VIA,A2
0064    002A 0040 1600               ORI.B     #%01000000,VACR(A2)
006A    022A 007F 1600               ANDI.B    #%01111111,VACR(A2)
0070    43F8 0192                    LEA       Lvl1DT,A1
0074    2348 0018                    MOVE.L    A0,24(A1)
0078    157C 000B 0800               MOVE.B    #$0B,VT1C(A2)
007E    157C 0003 0A00               MOVE.B    #$03,VT1CH(A2)
0084
0084    70 0E                        MOVEQ     #14,D0
0086    43C0 xxxx        (PX)        LEA       MilliInterrupt,A1
008A    30D9                    @5:  MOVE.W    (A1)+,(A0)+
008C    51C8 FFFC        (P)         DBRA      D0,@5
0090    157C 00C0 1C00               MOVE.B    #%11000000,VIER(A2)
0096    245F                    @4:  MOVE.L    (SP)+,A2
0098    225F                         MOVE.L    (SP)+,A1
009A    548F                         ADDQ.L    #2,SP
009C    4ED1                         JMP       (A1)
009E
009E                     MilliInterrupt
009E    1029 0800                    MOVE.B    VT1C(A1),D0
00A2    41FA FFF2        (P)         LEA       *-12,A0
00A6    5298                         ADDQ.L    #1,(A0)+
00A8    5290                         ADDQ.L    #1,(A0)
00AA    0C90 0000 0708               CMPI.L    #1800,(A0)
00B2    xx               (R)         BMI.S     @6
00B2    4290                         CLR.L     (A0)
00B4    53A8 FFFC                    SUBQ.L    #1,-4(A0)
00B8    4E75                         @6:       RTS
```

G. 2 Pascal Interface to Millisecond Timer

```
UNIT MilliTime;
INTERFACE

        PROCEDURE MilliControl (CtrlFlag : Boolean);
        FUNCTION MilliCount : LongInt;


IMPLEMENTATION

        PROCEDURE MilliControl;
        external;

        FUNCTION MilliCount;
        external;

END.
```

G. 3 Global Variables

```
{ This unit defines some global constants, types and variables used      }
{ throughout this application .                                          }

unit IRDMGlobals;

interface

 const

  ListLen = 208;

{Resource Ids and Dialog button numbers}

  RsrcId = 129;
  MyWindId = 23314;
  YesButtIdL = 401;
  NoButtIdR = 402;
  YesButtIdR = 403;
  NoButtIdL = 404;
  stopIconId = 0;
  cautionIconId = 2;
  ExpOvrId = 132;
  RestWindId = 20855;

  ok = 3;
  test = 1;
  yes = 11;
  no = 7;
  relate = 9;
  imagery = 10;
  quit = 14;
  subNum = 13;
  lstNum = 16;

{'rectangle  constants}

  rectyTop = 134;
  rectyLeft = 57;
  rectyBottom = 160;
  rectyRight = 122;

  rectnTop = 134;
  rectnLeft = 237;
  rectnBottom = 160;
  rectnRight = 302;

  cornerWidth = 13;          { ( rect?Bottom - rect?Top ) / 2 'oval dimensions for no button}
```

```
  maskTop = 87;
  maskLeft = 80;
  maskBottom = 105;
  maskRight = 280;

{'return rectangle constants}

  YesSpotx = 77;                       {'yes point x cord}
  YesSpoty = 151;                      {'yes point y cord}
  YesSpotx1 = 258;
  NoSpotx = 261;                       {'no point x cord}
  NoSpoty = 151;                       {'no point y cord}
  NoSpotx1 = 80;


  AppleChar = $14;              {'ascii value for the applemark}
  charwidth = 8;
  windoWidth = 365;

{•autoKeyMask = 32 'mask for the auto-key event•}
  zKey = 1073741824;
  slashKey = 1048576;
  spaceBar = 512;
  optionKey = 4;
  enterKey = 16;
  commandKey = 32768;
  isi = 28;

{constants for handling the rest period and ready windows}

  restPeriod = 24;
  readyPeriod = 5;
  spotPeriod = 1;
  BulletChar = 165;
  ReadyxPnt = 42;
  ReadyPnt = 60;
  RestxPnt = 47;
  restDexterity = 24;           {'number of trials to the end of Dexterity trials}
  restPriming = 10;             {'trails before 30" rest}
  rest = 2;
  StudyList = 1;
  wordypnt = 100;
  bulletxpnt = 178;
  SetNoYes = 0;
  SetYesNo = 1;
  title = '';
  NoChar = 'n';
  YesChar = 'y';
```

```
type
  myString = string[15];
 var

{'----------------------------Data    Storage------------------------------}


  Judgements : packed array[1..ListLen] of char;        {'yes no judgement storage}
  stimuli : packed array[1..ListLen] of myString;
  tStart : packed array[1..ListLen] of LongInt;  {'starting time of word display}
  tStop : packed array[1..ListLen] of LongInt;   {'subjects stop response time}
  chk : packed array[1..ListLen] of LongInt;
  ButtonState : packed array[1..4] of integer;  {Dialog button states}

{'MilliTimer}

  MyTime, NewTime, StopTime, timelsi, dely : LongInt;

{'Window and Dialog}

  theRsc : DialogPtr;
  MyWindowPtr, RestWindowPtr : WindowPtr;
  YesControlPtr, NoControlPtr : ControlHandle;
  iconHandle : Handle;
  theEvent : EventRecord;
  theMask, theKey, wordnum, YesNo, s, i, itemNumber : integer;
  rectY, rectN, rectMask, inRect : Rect;
  currentPort : GrafPtr;
  oldOrigin : Point;
  Quitting, Done : boolean;
  theDoNoChar, theDoYesChar : char;

  keys : KeyMap;

  subjectNum, listNum, cond, word, ReadyPrompt : str255; {may not need these}

  D1File, D2File, WordFile : text; {file references}

implementation

end.
```

G. 4 Main Program

```
PROGRAM MyResource;

    USES
        IRDMGlobals, MilliTime;

    PROCEDURE TimeOut (dely : LongInt);
    forward;
    PROCEDURE SetNextWord;
    forward;
    PROCEDURE Setrial;
    forward;
    PROCEDURE MaskWord;
    forward;
    PROCEDURE GetKey;
    forward;
    PROCEDURE DoNo;
    forward;
    PROCEDURE DoYes;
    forward;

    PROCEDURE Init;
    BEGIN
        theMask := EveryEvent - KeyUpMask - MUpMask - AutoKeyMask;
        SetEventMask(theMask);
        FlushEvents(EveryEvent, 0);
        Quitting := false;
        setRect(rectY, rectyLeft, rectyTop, rectyRight, rectyBottom);
        setRect(rectN, rectnLeft, rectnTop, rectnRight, rectnBottom);
        setRect(rectMask, maskLeft, maskTop, maskRight, maskBottom);
        MyTime := 0;
        NewTime := 0;
        StopTime := 0;
        timelsi := 0;
        wordnum := 0;
        i := 0;
        ReadyPrompt := 'Ready';
        SetCursor(Arrow);
    END; {Init}

    PROCEDURE DoTest;
        VAR
            title, theStr : str255;
            theLen, itemType, itmNumber : integer;
            theControl : ControlHandle;
            itemHandle : Handle;
            dispRect : Rect;
```

```
BEGIN
          s := 0;
          showtext;
          GetDItem(theRsc, lstNum, itemType, itemHandle, dispRect);
          GetIText(itemHandle, listNum);
          title := concat('stimFile.', listNum);
          reset(WordFile, title);
          WHILE NOT eof(WordFile) DO
                  BEGIN
                          s := s + 1;
                          readln(WordFile, theStr);
                  END;
          close(WordFile);
          writeln(s, theStr);
          REPEAT
          UNTIL button;
          HideAll;
     END;{DoTest}

     PROCEDURE DoRadioButton (theDialog : DialogPtr;
                               theActive, theInactive : integer);

          VAR
                  itemType, itmNumber : integer;
                  theControl : ControlHandle;
                  itemHandle : Handle;
                  dispRect : Rect;

     BEGIN
          itmNumber := theActive;
          GetDItem(theDialog, itmNumber, itemType, itemHandle, dispRect);
          theControl := ControlHandle(itemHandle);
          SetCtlValue(theControl, 1);

          itmNumber := theInactive;
          GetDItem(theDialog, itmNumber, itemType, itemHandle, dispRect);
          theControl := ControlHandle(itemHandle);
          SetCtlValue(theControl, 0);
     END;

     PROCEDURE DoDialog;
     BEGIN

          Done := False;
          theRsc := GetNewDialog(RsrcId, NIL, WindowPtr(-1));
          ShowWindow(theRsc);

          REPEAT
                  Done := false;
                  modalDialog(NIL, itemNumber);
```

```
            CASE itemNumber OF
                    test :
                            BEGIN
                                    DoTest;
                            END;
                    ok :
                            BEGIN
                                    Done := true;
                            END;
                    yes :
                            BEGIN
                                    DoRadioButton(theRsc, yes, no);
                            END;
                    no :
                            BEGIN
                                    DoRadioButton(theRsc, no, yes);
                            END;
                    relate :
                            BEGIN
                                    DoRadioButton(theRsc, relate, imagery);
                            END;
                    imagery :
                            BEGIN
                                    DoRadioButton(theRsc, imagery, relate);
                            END;
                    quit :
                            BEGIN
                                    DisposDialog(theRsc);
                                    ExitToShell;
                            END;
                    OTHERWISE
            END; {case}
        UNTIL Done;
END; {DoDialog}

PROCEDURE ReadStimuli;
        VAR
                title, theStr : str255;
                theLen, itemType, itmNumber : integer;
                theControl : ControlHandle;
                itemHandle : Handle;
                dispRect : Rect;

BEGIN

        s := 0;
        title := 'DexterityT1';
        reset(D1File, title);
        WHILE NOT eof(D1File) DO
                BEGIN
                        s := s + 1;
```

```
                    readln(D1File, theStr);
                    stimuli[s] := theStr;
                END;
            close(D1File);

            GetDItem(theRsc, lstNum, itemType, itemHandle, dispRect);
            GetIText(itemHandle, listNum);
            title := concat('stimFile.', listNum);
            reset(WordFile, title);
            WHILE NOT eof(WordFile) DO
                BEGIN
                    s := s + 1;
                    readln(WordFile, theStr);
                    stimuli[s] := theStr;
                END;
            close(WordFile);

            title := 'DexterityT2';
            reset(D2File, title);
            WHILE NOT eof(D2File) DO
                BEGIN
                    s := s + 1;
                    readln(D2File, theStr);
                    stimuli[s] := theStr;
                END;
            close(D2File);

    END; {ReadStimuli}

    PROCEDURE SetUpWindow;
        VAR
            itemType, itmNumber : integer;
            theControl : ControlHandle;
            itemHandle : Handle;
            dispRect : Rect;
            theChar : char;

    BEGIN
        MyWindowPtr := GetNewWindow(MyWindId, NIL, WindowPtr(-1));
        ShowWindow(MyWindowPtr);
        SetPort(MyWindowPtr);
        TextFont(SystemFont);
{   SetOrigin(0, 0);}

{Get the value of the yes button}
        GetDItem(theRsc, yes, itemType, itemHandle, dispRect);
        theControl := ControlHandle(itemHandle);
        YesNo := GetCtlValue(theControl);

        CASE YesNo OF
            SetNoYes :
```

```
                    BEGIN
                        YesControlPtr := GetNewControl(YesButtIdR,
                        MyWindowPtr);
                        HiliteControl(YesControlPtr, 255);
                        NoControlPtr := GetNewControl(NoButtIdL,
                        MyWindowPtr);
                        HiliteControl(NoControlPtr, 255);
                        theDoNoChar := YesChar;
                        theDoYesChar := NoChar;
                    END;
                SetYesNo :
                    BEGIN
                        YesControlPtr := GetNewControl(YesButtIdL,
                        MyWindowPtr);
                        HiliteControl(YesControlPtr, 255);
                        NoControlPtr := GetNewControl(NoButtIdR,
                        MyWindowPtr);
                        HiliteControl(NoControlPtr, 255);
                        theDoNoChar := NoChar;
                        theDoYesChar := YesChar;
                    END;
        END; {case}
    END; {SetUpWindow}

    PROCEDURE GetKeyPress;
    BEGIN
        GetKeys(keys);
        WHILE (keys[0] = 0) AND (keys[1] = 0) DO
            BEGIN
                GetKeys(keys)
            END;
        NewTime := MilliCount;
        StopTime := TickCount;
    END; {GetKeyPress}

    PROCEDURE DoReady (ReadyPrompt : str255);
        CONST
            smallWindowWidth = 112;
        VAR
            savePort : GrafPtr;
            duration, ReadyxPnt : integer;
    BEGIN
        duration := 2;
        sysbeep(duration);
        RestWindowPtr := GetNewWindow(RestWindId, NIL, WindowPtr(-1));
        GetPort(savePort);
        SetPort(RestWindowPtr);
{   SetOrigin(0, 0);}
        SetRect(inRect, 10, 10, 42, 42);
        iconHandle := GetIcon(cautionIconId);
        OffSetRect(inRect, 35, 0);
```

```
                PlotIcon(inRect, iconHandle);
                TextFont(SystemFont);
                ReadyxPnt := trunc(((smallWindowWidth - length(ReadyPrompt) * 6) / 2));
                MoveTo(ReadyxPnt, ReadyPnt);
{   ReadyPrompt := 'Ready';}
                DrawString(ReadyPrompt);

                REPEAT
                        GetKeyPress;
                UNTIL (keys[1] <> 0);

                DisposeWindow(RestWindowPtr);
                SetPort(savePort);
{   SetOrigin(0, 0);}
        END; {DoReady}

        PROCEDURE DoFixation;
                VAR
                        theChar : char;
        BEGIN
                theChar := chr(BulletChar);
                dely := 60;
                moveto(bulletxpnt, wordypnt);
                drawchar(theChar);
                TimeOut(dely);
        END; {DoFixation}

        PROCEDURE DoRest;
                CONST
                        RestPrompt = 'Rest';
                        restperiod = 1800;
                VAR
                        savePort : GrafPtr;
        BEGIN
                RestWindowPtr := GetNewWindow(RestWindId, NIL, WindowPtr(-1));
                GetPort(savePort);
                SetPort(RestWindowPtr);
{   SetOrigin(0, 0);}
                SetRect(inRect, 10, 10, 42, 42);
                iconHandle := GetIcon(stopIconId);
                OffSetRect(inRect, 35, 0);
                PlotIcon(inRect, iconHandle);
                TextFont(SystemFont);
                MoveTo(RestxPnt, ReadyPnt);
                DrawString(RestPrompt);
                dely := restperiod;
                TimeOut(dely);
                DisposeWindow(RestWindowPtr);
                SetPort(savePort);
{   SetOrigin(0, 0);}
        END; {DoRest}
```

```
PROCEDURE TimeOut; {(dely : LongInt)}
        VAR
                stopTick : LongInt;
BEGIN
        stopTick := TickCount + dely;
        WHILE TickCount < stopTick DO
END; {TimeOut}

PROCEDURE DoDexterity;
        VAR
                DexTrial : Integer;
BEGIN
        i := i + 1;
        DoReady(ReadyPrompt);
        DoFixation;
        DexTrial := 0;
        FOR DexTrial := 1 TO 24 DO
                SetNextWord;
        IF i < 2 THEN
                BEGIN
                        DoRest;
                        ReadyPrompt := 'Ready--Word List';
                        DoReady(ReadyPrompt);
                END;
END; {DoDexterity}

PROCEDURE DoPriming;
        CONST
                numPrimeSets = 4;
                numPrimeTrials = 40;
        VAR
                PrimeSet, PrimeTrial : Integer;
BEGIN
        DoFixation;
        PrimeSet := 0;
        FOR PrimeSet := 1 TO numPrimeSets DO
                BEGIN
                        PrimeTrial := 0;
                        FOR PrimeTrial := 1 TO numPrimeTrials DO
                                SetNextWord;
                        DoRest;
                        IF PrimeSet = numPrimeSets THEN
                                ReadyPrompt := 'Ready Dexterity'
                        ELSE
                                BEGIN
                                        DoReady('Ready');
                                        DoFixation;
                                END;
                END;
END; {DoPriming}
```

```
PROCEDURE SetNextWord;
	CONST
		No = 1;
		Yes = 2;
	VAR
		wordxpnt, len : integer;
BEGIN

	wordnum := wordnum + 1;

	word := stimuli[wordnum];
	len := length(word);
	Setrial;

	word := copy(word, 1, len);
	len := length(word);
	wordxpnt := round(((windowidth - (len * charwidth)) / 2));

	MilliControl(true);                                   {'0 the clock}
	moveto(wordxpnt, wordypnt);

	IF wordnum > 1 THEN
		timelsi := StopTime + isi
	ELSE
		timelsi := StopTime;
	WHILE timelsi > StopTime DO
		BEGIN
			StopTime := TickCount;
		END;
	synch;
	DrawString(word);
	MyTime := MilliCount;
	REPEAT
		GetKeyPress;
	UNTIL (keys[1] = commandKey) OR (keys[1] = optionKey);
	MaskWord;
	GetKey;
	CASE theKey OF
		No :
			DoNo;
		Yes :
			DoYes;
	END; {case}
END; {SetNextWord}

PROCEDURE Setrial;
BEGIN
	TextMode(0);

	FrameRoundRect(rectY, cornerWidth, cornerWidth);
	FrameRoundRect(rectN, cornerWidth, cornerWidth);
```

```
            CASE YesNo OF
                SetNoYes :
                    BEGIN
                        MoveTo(NoSpotx1, YesSpoty);
                        DrawString('No');
                        MoveTo(YesSpotx1, NoSpoty);
                        DrawString('Yes');
                    END;
                SetYesNo :
                    BEGIN
                        MoveTo(YesSpotx, YesSpoty);
                        DrawString('Yes');
                        MoveTo(NoSpotx, NoSpoty);
                        DrawString('No');
                    END;
            END;
        END; {Setrial}

{'----------------------------GetKey--------------------------------------}

        PROCEDURE GetKey;
        BEGIN

{•    if keys[1] = enterKey then•}
{•    whichkey = 1;             {64k rom machines•]}

            IF (keys[1] = optionKey) THEN
                theKey := 1;            {'128 k rom machines}

            IF keys[1] = commandKey THEN
                theKey := 2;
        END; {GetKey}

{'----------------------------DoNo--------------------------------------}

        PROCEDURE DoNo;
        BEGIN

            InvertRoundRect(rectN, cornerWidth, cornerWidth);

            Judgements[wordnum] := theDoNoChar;
            tStart[wordnum] := MyTime;{'starting time of word display}
            tStop[wordnum] := NewTime; {'subjects stop response time}
            chk[wordnum] := NewTime - MyTime;
            dely := 5;
            TimeOut(dely);
            InvertRoundRect(rectN, cornerWidth, cornerWidth);

        END; {DoNo}
```

```
{'----------------------------DoYes-------------------------------------}

    PROCEDURE DoYes;
    BEGIN

        InvertRoundRect(rectY, cornerWidth, cornerWidth);

        Judgements[wordnum] := theDoYesChar;
        tStart[wordnum] := MyTime;{'starting time of word display}
        tStop[wordnum] := NewTime; {'subjects stop response time}
        chk[wordnum] := NewTime - MyTime;
        dely := 5;
        TimeOut(dely);
        InvertRoundRect(rectY, cornerWidth, cornerWidth);

    END; {DoYes}

{'----------------------------MaskWord----------------------------------}

    PROCEDURE MaskWord;
        VAR
            currentPort : GrafPtr;
    BEGIN
        FrameRect(rectmask);
        PaintRect(rectmask);
        dely := 5;
        TimeOut(dely);
        GetPort(currentPort);
        EraseRect(currentPort^.portrect);
        DrawControls(MyWindowPtr);
    END; {MaskWord}

{'----------------------------DoSave----------------------------------}

    PROCEDURE DoSave;
        TYPE
            subjData = RECORD
                    theStimulus : str255;
                    theResponse : char;
                    theReactionTime : longint;
                    chkOnTime : longint
                END;
            subjDataFile = FILE OF subjData;
        VAR
            x, itemType, itmNumber : integer;
            theControl : ControlHandle;
            itemHandle : Handle;
            dispRect : Rect;
            theStr, title : str255;
            pascalDataFile : subjDataFile;
            DataFile : text;
```

```
            Data : subjData;
    BEGIN
        GetDItem(theRsc, subNum, itemType, itemHandle, dispRect);
        GetIText(itemHandle, subjectNum);
        GetDItem(theRsc, lstNum, itemType, itemHandle, dispRect);
        GetIText(itemHandle, listNum);
        GetDItem(theRsc, relate, itemType, itemHandle, dispRect);
        theControl := ControlHandle(itemHandle);
        YesNo := GetCtlValue(theControl);
        IF YesNo = 1 THEN
            cond := '.rel'
        ELSE
            cond := '.img';
        title := concat('IRDM_Ss', subjectNum, 'L', listNum, cond);
        theStr := concat('Pascal.dat_Ss', subjectNum, 'L', listNum, cond);
        open(DataFile, title);
        open(pascalDataFile, theStr);
        x := 0;
        FOR x := 1 TO wordnum DO
            BEGIN
                WITH Data DO
                    BEGIN
                        theStimulus := stimuli[x];
                        theResponse := Judgements[x];
                        theReactionTime := tStop[x] - tStart[x];
                        chkOnTime := chk[x];
                        writeln(DataFile, theStimulus, theResponse,
                        theReactionTime, chkOnTime);
                    END;
                write(pascalDataFile, Data);
            END;
        close(DataFile);
        close(pascalDataFile);
    END; {DoSave}

{'----------------------------CleanUp---------------------------------}

    PROCEDURE CleanUp;
    BEGIN
        DisposeWindow(MyWindowPtr);
        DisposDialog(theRsc);
    END; {CleanUp}

{'----------------------------ExpOver---------------------------------}

    PROCEDURE ExpOver;
        VAR
            ignore : integer;
    BEGIN
        ignore := Alert(ExpOvrId, NIL);
    END; {ExpOver}
```

```
{'----------------------------Main----------------------------------}

        VAR
                duration, loop : integer;
                theChar : char;

BEGIN {Main}
        WHILE NOT Quitting DO
                BEGIN
                        Init;
                        DoDialog;
                        HideCursor;
                        ReadStimuli;
                        SetUpWindow;
                        DoDexterity;
                        DoPriming;
                        DoDexterity;
                        ShowCursor;
                        duration := 2;
                        sysbeep(duration);
                        ExpOver;
                        DoSave;
                        CleanUp;
                END;
END. {Main}
```