1970

Encoding processes in recognition memory

Glen Alvin Raser

Iowa State University

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ENCODING PROCESSES IN RECOGNITION MEMORY

by

Glen Alvin Raser

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Signature was redacted for privacy.

In Charge of Major Work

Signature was redacted for privacy.

Head of Major Department

Signature was redacted for privacy.

Dean of Graduate College

Iowa State University
Ames, Iowa

1970
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INTRODUCTION AND LITERATURE REVIEW

Underwood (1969) has described a conceptualization of memory which emphasizes the role of attributes in the storage and retrieval of information. In fact, a memory for any specific event is conceived as simply a collection of attributes and has no psychological meaning without reference to those attributes. Events are stored or encoded in terms of attributes and these attributes serve to differentiate between memories and also as a retrieval mechanism for those memories. Underwood identifies a rather lengthy list of classes of attributes including temporal, spatial, frequency, modality, nonverbal associative, and verbal associative attributes.

Underwood identifies one specific nonverbal associative dimension as an acoustic dimension. Letters, digits, syllables, words, or series of words may be encoded, differentiated, and retrieved in terms of particular attribute values or combinations of values on an acoustic dimension. Also included among the verbal associative attribute dimensions is the semantic dimension. Again verbal material may be encoded, discriminated, and retrieved in terms of semantic properties.

These two dimensions, particularly as they are used in the encoding of material, are critically related by some current two-store memory theories. One of the distinctions made between short-term memory (STM) and long-term memory (LTM) is that encoding in STM is based on acoustic features while encod-
ing in LTM is based primarily on semantic features (Baddeley, 1966; Norman, 1969; Kintsch and Buschke, 1969). The basic distinction between STM and LTM generally agreed upon among most two-store theorists is the notion of STM as a limited capacity, temporary store where information is rapidly lost and forgotten unless rehearsed while LTM is regarded as a more permanent store requiring rehearsal and more extensive processing for storage (Waugh and Norman, 1965; Atkinson and Shiffrin, 1967). According to some theories information must pass through STM before going into LTM (Waugh and Norman, 1965) while direct encoding into LTM is allowed by others (Bjork, 1966; Kintsch and Buschke, 1969). The rapidity of forgetting from STM is illustrated by Atkinson and Shiffrin (1967) who suggest that under normal conditions information decays within a period of 15 - 30 seconds.

At an operational level the distinctions between STM and LTM are not clearly defined nor generally agreed upon. Two major kinds of situations are often regarded as involving STM, although the boundary conditions on these situations remain rather arbitrary. In one, STM responding is inferred from the use of very short retention intervals with either a limited amount of material or with longer lists where only the most recent items presented are regarded as representing STM. In the other, STM responding is inferred from attempts made to prevent rehearsal either by instructions not to re-
hearse or by use of a distracting task between presentation and recall or recognition. The rationale for the use of the first situation is that immediate responses are more likely to come from STM while at longer retention intervals information has been lost from STM and so responses are more likely to come from LTM. In the second situation preventing rehearsal is designed to prevent items from being processed into LTM and so responding is again more likely to be from STM. What isn't entirely clear is just how short a retention interval must be used or exactly what precautions must be taken in preventing rehearsal to insure STM responding.

The evidence both for acoustic encoding in tasks designed to involve STM responding and for semantic encoding in tasks designed to involve LTM responding is quite well established. Conrad (1964) required immediate written recall of visually presented strings of six consonants. The consonants were randomly selected from two sets of five consonants, with each set intuitively selected to be acoustically similar. Intrusion errors were scored in terms of which letters were substituted for which other letters. The pattern of errors was then compared to errors made for the same consonants when Ss were just listening to and writing down single letters spoken against a background of white noise. In both tasks confusions or substitutions were found to occur significantly more often within acoustically similar sets than between them, indicating
that at least some of the encoding was done on the basis of acoustic properties even when the material was presented visually. Wickelgren (1965) aurally presented eight item lists, half digits and half letters, for immediate ordered recall. He found that intrusions among letters, and between letters and numbers, followed acoustic similarity and that this tendency was more pronounced for vowels than consonants.

Baddeley (1966) used a slightly different method to demonstrate the existence of acoustic encoding. He presented lists of five words for immediate recall which were drawn from two separate item pools equated for frequency, one containing acoustically similar words and the other acoustically different words. Performance on lists made up of acoustically different words was significantly better than on lists made up of acoustically similar items. Murray (1967) used the same method and found better recall for lists of acoustically different letters than for acoustically similar letters.

A third method for showing acoustic effects on recall, the retroactive inhibition (RI) paradigm, was used by Dale and Gregory (1966). Ss were first shown a set of three words to be remembered (original learning or OL), then were presented with six words to read aloud (interpolated learning or IL). On experimental trials these six words were acoustically similar to (rhymed with) the OL words, while on the control trials they were acoustically dissimilar to the OL words. Recall
performance on the OL words was significantly depressed for experimental trials when compared to the control trials. IL intrusions also occurred more frequently with similar distracting material. Wickelgren (1966) applied the RI method to recognition memory for a single letter. Again interpolated lists containing acoustically similar letters lowered recognition performance.

Thus, evidence for encoding on the basis of acoustic properties in tasks designed to represent STM responding has been found using letters, digits, and words as stimuli, with both aural and visual presentation, and using both a recall and a recognition task.

Evidence for the existence of a semantic attribute dimension comes from a variety of LTM studies. Kintsch (1968) compared 40 item lists constructed from the most frequent associates given to four conceptual categories with lists made up of the most infrequent associates to those same categories under both recognition and recall. Recall was greatly facilitated for the highly semantically organized lists while recognition performance did not differ. Thus, while seemingly limited to the retrieval aspect for this task, the semantic variable was effective. Brown and McNeill (1966), in studying the "tip of the tongue" phenomenon, read dictionary definitions of words to Ss who were then to provide the appropriate target word. Ss not only often produced words which were similar
in meaning to the target words but were also able to accurately judge the relative similarity to the target word indicating both encoding and discrimination of words on the basis of semantic attributes.

Underwood (1965) used a continuous recognition task (where a series of items are presented with repetitions and S simply makes a yes or no response to each item indicating an old or new item respectively) to investigate the effects of semantic relationships on recognition memory. Sometimes instead of repeating items implicit associative responses (IAR) of those items were presented for recognition. IARs were generally taken from word association norms and included antonyms, converging associations, and superordinates of particular words presented earlier. False alarm rates for each of these three classes of words were significantly higher than for new words which were not semantically related to prior words in the series. These results suggest three specific attribute values along the semantic dimension which may be important in encoding. Using the same design Anisfeld and Knapp (1968) presented synonyms of prior words in a series for recognition and found a significant effect on false alarm rate. They interpreted their results as supporting the idea that words are encoded as semantic attributes or features. Grossman and Eagle (1970) used both synonyms and antonyms of prior words and also found increased false alarm rates for synonyms but
not for antonyms. All the above continuous recognition studies used quite long intervals between related presentations and so would qualify as LTM situations.

Studies of RI in serial learning (McGeoch and McDonald, 1931) and in paired-associate learning (McGeoch and McGeoch, 1937) have both shown that presenting intervening lists containing meaningfully similar items increases the RI effect.

The two complementary possibilities, that of semantic encoding in STM and acoustic encoding in LTM, have also been investigated but with conflicting results. Some studies have been concerned exclusively with possible semantic effects in STM. Loess (1967) presented triads of words using the Peterson and Peterson (1959) paradigm characterized by a single, rather short presentation of a small number of items followed by a distracting task such as counting backwards before recall or recognition. Triads were drawn from eight different conceptual categories (e.g. animals, vegetables, countries) and presented for 1.5 second with a 10.5 second retention interval filled with reading six digit numbers before recall. Two major conditions, differing in the sequence of categories from which triads were drawn, were compared. When categories were changed for every third triad, performance dropped rapidly within homogeneous sets of triads and increased markedly when the conceptual category was changed. Decreases in performance across trials in this situation is generally attributed to the build-
up of proactive inhibition (PI). Abrupt increases in performance level with changes in the stimulus materials (release from PI) indicate that a relevant encoding variable has been identified. Thus, a conceptual category did serve as a basis for encoding in this particular STM task. Wickens and Clark (1968) also found release of PI when words from opposite ends of the three meaning dimensions (evaluation, potency, and activity) of the semantic differential scales were used as categories with a 15 second retention interval.

However, Wickens, Clark, Hill, and Wittlinger (1968) using the same paradigm, could not find any evidence for release of PI when verbs and adjectives were used as different categories. The above three studies are consistent only if semantic effects in STM are regarded as specific to particular dimensions rather than general in nature.

Baddeley and Dale (1966) compared semantic effects in both STM and LTM tasks using the RI paradigm with paired-associate lists and found no evidence for semantic encoding in STM. Interference lists contained semantically similar stimulus terms for experimental groups. When several trials were given on the lists (LTM responding) semantic similarity significantly increased the RI effect. Performance for STM, when only one trial was given on lists containing from 2-6 pairs, did not differ as a function of semantic similarity of the interfering list.
Another study relevant to the comparison of semantic effects in both STM and LTM was reported by Tulving and Patterson (1968). An immediate free recall task was used with lists ranging from 12-24 words in length. In two of their conditions sets of four semantically related words were presented contiguously either at the end of the list or in the middle of the list. Thus, the opportunity for using the semantic relationship to aid recall existed for both STM and LTM responding. Recall for lists containing related items in the middle showed a much greater increase than recall for lists with related items at the end when compared to control lists containing only unrelated items. Serial position curves for the two experimental lists were quite similar for the recency portion but differed markedly for the middle serial positions. Thus, presenting semantically related items increased recall only slightly when responding was from STM but had a large effect when responding was from LTM.

Other studies have compared acoustic and semantic effects within a single task designed to represent STM responding. In addition to demonstrating acoustic encoding in STM, Baddeley (1966) and Dale and Gregory (1966) also used their STM tasks described earlier (see page 4) to investigate semantic effects. Baddeley (1966) used his immediate recall task with short lists of adjectives similar in meaning as compared to lists of semantically different adjectives. Recall of semantically
different lists was significantly greater than semantically similar lists but the effect was not nearly as large as for the acoustic manipulation. Dale and Gregory (1966) examined the effect of semantic similarity in their RI task. A significant of semantically similar interfering lists was found and interpreted as clear evidence for semantic encoding in their particular STM task. This result is in direct contradiction to the results of the Baddeley and Dale (1966) study. However, what Dale and Gregory fail to point out is that the acoustic effect was much larger than the semantic effect as was the case with the Baddeley (1966) study. Relatively small semantic effects as compared to acoustic effects with STM tasks might well be explained as due to a failure to completely eliminate LTM responding, particularly if direct encoding into LTM is allowed.

Wickens and Eckler (1966) also compared acoustic and semantic encoding in the Peterson and Peterson paradigm with a 20 second retention interval. After a few trials containing both word triads and letter triads a series of three letter triads was presented. Following this, experimental Ss were given a word triad which sounded like three letters (e.g. why, tea, kay) and control Ss were given the corresponding letter triad (YTK). Release from PI was found for experimental Ss as would be predicted if encoding were on the basis of semantic attributes. This result is interpreted to show a lack
of acoustic effects in STM. However, all that can be validly inferred from the results is that changes in conceptual category (letters vs. words) can result in release of PI even when the acoustic features of the stimuli remain the same. It is impossible to determine whether or not the constancy of acoustic features affected the extent of PI release.

The most compelling evidence for semantic effects in STM comes from those studies using the Peterson and Peterson paradigm. This paradigm is not the best method of insuring STM responding as questions can be raised concerning effects of the distracter task other than just preventing rehearsal, especially at relatively long retention intervals. It seems possible that counting backwards by threes for 10-15 seconds, for example, could also involve the use of STM and cause information in STM to be lost as well as prevent rehearsal. Then responding would be largely from LTM and would be expected to show semantic effects. Again allowing direct encoding into LTM makes the latter expectation even more plausible. Thus the evidence for semantic encoding in STM is not entirely conclusive.

There is evidence from several studies restricted to LTM situations concerning either acoustic effects only or comparing acoustic and semantic effects using a variety of paradigms. Dale and Baddeley (1969) essentially repeated the Baddeley and Dale (1966) RI study with repeated presentation but with
interference lists containing acoustically similar stimulus
terms and found no differential effect of acoustic similarity
on RI. Davis (1967) used the continuous recognition memory
task with IAR relationships and with homophone pairs to examine
acoustic relationships. The intervals between presentations
of related words were sufficiently long that performance
was quite likely based on LTM. Underwood's (1965) results
were replicated with IARs but having previously seen a homo­
phone of a word produced false recognitions at only a chance
level. Thus, acoustic similarity was not effective in this
LTM recognition task.

Eagle and Ortof (1967) presented lists of 26 words under
conditions of either focal or distracted attention (Ss carried
out a digit symbol coding task during presentation). A mul­
tiple choice recognition task followed which included alterna­
tives which were both semantically and acoustically similar
to the presented item. Acoustic errors were made significantly
more often, compared to control word alternatives, under the
distracted attention condition while semantic errors occurred
under neither attention condition. This result would imply
predominantly acoustic effects in LTM. However, there are
two aspects of this study which make interpretation somewhat
difficult. The distracted attention condition was similar to
the Peterson and Peterson paradigm in that a distracter task
was used except during presentation rather than after presenta­
tion.
The effect of coding digits during presentation may well have been to prevent processing of information into LTM. On the other hand, the retention interval, while not specified, apparently was long enough to allow some Ss to move from one room to another and so recognition could hardly be considered as immediate. The fact that semantic effects were not found under either condition is puzzling in light of other LTM data. Thus, these results are not clearly interpretable in terms of the STM-LTM distinction.

Buschke and Lenon (1969) presented 300 item lists and used a two alternative forced choice recognition task. Choice alternatives were either unrelated words, homophones, or synonyms. Both of the latter conditions decreased performance relative to the first by about the same amount. Thus, both acoustic and semantic effects were found in this LTM recognition task. Bruce and Crowley (1969) used both distributed and massed presentation of four either acoustically or semantically related words in lists containing 32 other unrelated words. After a 30 second delay, free recall performance was higher for semantically related words under both presentation conditions and for acoustically related words under massed presentation only. The results were interpreted as suggesting that acoustic encoding is not restricted to STM only. The fact that the acoustic relationship was effective only under one presentation condition suggests that it was less effective than the
This, the evidence concerning acoustic effects in LTM is also inconclusive. While this is due partly to problems in separating STM and LTM responding, it is more a problem of contradictory evidence. Some situations which clearly involve LTM show acoustic effects while others do not. The finding of acoustic effects in LTM situations, however, is less critical to the differential encoding distinction between STM and LTM than is the finding of semantic effects in STM situations. Acoustic encoding is not entirely restricted from LTM in the way that semantic is from STM. Encoding in LTM is regarded as much more elaborate and emphasizing semantic attributes in addition to retaining acoustic features while STM encoding is limited to acoustic attributes. Thus, some acoustic effects are to be expected but semantic encoding effects should predominate in LTM studies.

Tversky (1968) has proposed that the type of encoding used will depend upon specific aspects of the task being used rather than differing with the type of memory store being used. A resolution of the above contradictions would require that task characteristics which would result in the use of the same type of encoding could be demonstrated for tasks yielding similar results. However, if acoustic effects could be demonstrated in STM but not LTM and semantic effects in LTM but not STM with a single task, Tversky's proposal would
be much less useful.

There are two existing studies which have examined both acoustic and semantic effects in a memory task where both STM and LTM responding could be reasonably inferred. Bregman (1968) used a recall task but four different kinds of cues to test recall were interspersed among presentations of words for study. Thus, it was similar to the continuous recognition memory task except that either words were presented for study or cues were presented for recall rather than each item serving as both a study item and a test item. Retention interval was varied from essentially 0-288 seconds by varying the number of study words and/or cues presented between a word and the cue for recall of that word. Two of the cue types used are of interest to the present discussion, namely acoustic cues (e.g. "sounds like hose" when the target item was rose) and semantic cues (e.g. "is a chemical element" when the target item was lead). Both acoustic and semantic cues affected performance similarly as a function of retention interval. Cued recall decreased rapidly at first as retention interval increased and leveled off with longer intervals in both cases.

Kintsch and Buschke (1969) used two highly similar probe recall tasks to examine semantic effects and then acoustic effects as a function of serial position. In the first experiment lists containing eight synonym pairs were compared
with lists containing 16 unrelated words. Immediately after the presentation of a list a probe word from the list was presented and Ss were to give the word in the list which had immediately followed the probe item. Recall was significantly better for unrelated lists but only for early serial positions where LTM responding was most likely to occur. Performance was identical for synonym lists and unrelated lists for the last few serial positions where STM responding was most likely to occur. In the second experiment study lists composed of homophone pairs were compared to lists of unrelated items. Performance was again depressed for the homophone list but only for the last few serial positions representing STM responding. Recall did not differ significantly for the early serial positions. These results while inconsistent with Bregman's are entirely consistent with the STM-LTM distinction based on different types of encoding. Kintsch and Buschke suggested that those studies resulting in evidence for semantic encoding in STM failed to limit responding to STM only and were thus confounded with LTM responding.

In addition to the obviously different tasks used by Bregman and by Kintsch and Buschke, Bregman's results were obtained from a single group of Ss while Kintsch and Buschke used different groups of Ss in their two experiments. More importantly though, oral presentation was used in Kintsch and Buschke's first experiment while visual presentation was
used in the second. Thus, insofar as presentation mode is
critical in influencing the type of encoding used as suggested
by Tversky, Kintch and Buschke's results are open to possible
alternative interpretation.

Thus, the related notions of exclusively acoustic effects
in STM and exclusively semantic effects in LTM have not been
consistently supported. One purpose of the present study was
to again examine performance where both acoustic effects and
semantic effects could be measured with both STM and LTM re­
sponding within a single memory task so that possibly relevant
task related variables could be controlled.

A third notion has been offered to integrate the existing
data from studies concerned with acoustic and semantic effects
in memory. Shulman (1969) has suggested that a single store
model with differential encoding and/or forgetting rates for
different encoding dimensions is consistent with results
such as those reviewed above. In particular he suggests that
acoustic encoding is more prevalent in STM studies because
acoustic encoding is faster than semantic but that both kinds
of encoding can and do occur even at very short retention in­
tervals.

As test of his notion he used a probe recognition task
where Ss were asked directly about semantic and acoustic attri­
butes of words as well as the usual question of whether or not
the probe was a repeated item. Ss were given a list of ten
words, one of three possible cues (M, H, or I), and a probe word and asked to make a yes or no response. With an M cue a yes response was appropriate only if the probe word was a synonym of any of the items in the ten word list. With an H cue a yes response was appropriate only if the probe word was a homonym of any of the items in the ten word list. With an I cue a yes response was appropriate only if the probe word was an identical repetition of any of the items on the ten word list. Thus both semantic and acoustic encoding was encouraged as Ss didn't know until after the list was presented which dimension was relevant for that trial. The position of critical item in the lists (synonym, homonym, or to be repeated word) was varied over the ten serial positions within a list.

Shulman found closely parallel serial position curves for all three tasks, with each showing sizable recency effects. Performance in the homonym and identity tasks was virtually identical at all serial positions and nearly perfect on the last serial positions. Performance on the synonym task was lower over all serial positions. This last result was attributed to the fact that the degree of semantic similarity between synonyms is nearly always somewhat less than the degree of acoustic similarity between homonyms or the degree of overall similarity between a word and a repetition of that same word.
The finding of parallel serial position curves for all three tasks was taken as evidence that the information required for the three tasks was stored in functionally identical memory systems. The conclusion from these results was that both acoustic and semantic encoding occur to the same relative degree in what others have called STM when the task demands such encoding.

A second purpose of the present study was to examine a specific alternative explanation for the results obtained by Shulman. The possibility exists that the synonym judgment task required by Shulman could be done with only acoustic information stored, in which case, parallel serial position curves for the homonym and synonym task would be expected. Given a list of words stored acoustically and a probe word with a cue calling for a judgment of similarity on the basis of meaning, Ss could generate each stored word from the acoustic information available, then determine its semantic components and compare these with the meaning of probe word and arrive at a yes-no judgment of synonymity. The same criticism could be made of the Bregman (1968) results when semantic cues were provided to test recall. Again Ss could generate recently presented words from stored acoustic information, compared their semantic properties with the recall cue, and respond accurately without having stored semantic information. The second experiment was a partial replication of the Shulman
study along with a control for the possibility of synonym judgments based on only stored acoustic information and also a control for the other logical possibility, that of acoustic based only on stored semantic information.

The present study then included two experiments. In the first a single continuous recognition memory task was used to investigate the relative contributions of acoustic and semantic effects inferred from error data at a wide range of retention intervals. In the second experiment Shulman's probe recognition task was used with added control conditions to examine an alternative interpretation to Shulman's results which would argue against similar acoustic and semantic encoding in his STM task.
EXPERIMENT I

The continuous recognition memory method first described by Shepard and Teightsoonian (1961) has the advantage of allowing the manipulation of a relatively large number of different retention intervals within a fairly short experimental session. Also with this method it is possible to investigate specific attribute effects as was done by Underwood (1965) by presenting similar items along some attribute dimension for recognition along with repeated items. The rationale for inferences from false recognition data to encoding processes is that some information about a particular attribute dimension must be retained in order to produce above chance false alarms (saying an item was repeated when in fact it was not) for items similar along that dimension. In this experiment a range of retention intervals or lags was sampled which would include both STM and LTM responding given any one of the present dual memory viewpoints. Both synonyms and homophones of prior items were presented for recognition at each of the lag intervals along with true repetition of items.

Method

Design

The continuous recognition method involves presenting a series of items and requiring a response after each item is
presented to indicate whether or not that particular item was presented previously in the list. Retention interval can be manipulated by varying the number of items that occur between the first and second presentation (lag) of a particular item. In this experiment lags of 1, 2, 4, 6, 8, 16, 32, and 48 (0, 1, 3, 5, 7, 15, 31, and 47 intervening items respectively) were used to sample a wide range of retention intervals.

In addition to repeating items both homophones and synonyms of items presented previously were presented at the various lags in an attempt to determine the relative contribution of acoustic and semantic components at the various retention intervals with this particular kind of recognition task.

**Stimulus Materials**

The stimulus materials were in part selected from an initial pool of 375 homophone pairs taken from various homophone dictionaries and generated by the author and associates in the psychology department. From these pairs 128 were selected for which a close synonym for at least one member of the pair could be generated. This resulted in 128 triads of words; each including a base word, a homophone of the base word, and a synonym of base word (e.g. base word-hare, homophone-hair, synonym-rabbit). (See Appendix A.)

A single list of items presented for recognition con-
tained 352 words: including a primacy buffer of 64 words, four blocks of 64 words each containing two repeated words and homophone and a synonym of a prior word (the items of greatest interest) at each of the eight lags within each block, and a recency buffer of 32 words. The primacy buffer included a first and second presentation of 29 words selected at random from the remaining pool of homophone pairs with the restriction that only one word from a pair could be used. Each lag was represented at least once in the second presentation of the 29 words but responses to these words were not included in the data analysis. Also included in the primacy buffer were the first presentations of six words either to be repeated or a homophone or synonym of which was to be given later at the longer lags within the first block of items. The recency buffer included the first and second presentations of 13 words from the same source as the primacy buffer and represented each of the seven shortest lags at least once. Also included were repetitions at the three longest lags of six words from the same source which had been first presented in the fourth block of items. Responses to words in the recency buffer also were not included in the data analysis. The primacy and recency buffers were included to remove any primacy or recency effects that might have occurred.

The four blocks containing the critical items were identical in that each included two repeated items at each
of the eight lags, a homophone of a prior item at each of the eight lags, a synonym of a prior item at each of the eight lags, the first presentation of all but six of the 32 items just described (The term "first presentation" will be used hereafter to also include the presentation of a base word to be followed by either a homophone or a synonym. The term "second presentation" will include the presentation of a homophone or synonym of a prior word.), and six first presentation of items at the three longest lags which received the second presentation in the next block.

Two sets of four lists each were constructed with the preceding general structure. The two sets differed in that different random assignments of the 128 triads were made to the four representations of each of the eight lags within each of the four blocks. The four lists within a set differed in that after a triad was assigned to a particular lag by block combination, the base word-homophone combination was used for one list, the base word-synonym combination was used for another, the homophone-homophone combination for the third, and the synonym-synonym combination in the fourth list. Thus, second presentations were always homophones or synonyms of the base word. The end result was eight different lists of 352 words each of which randomly sampled two triads (each being used as a homophone pair, a synonym pair, and twice as a repeated item) for each of the four replications
of each lag within each block. This avoided complete confounding of a particular triad with a specific lag by block condition while keeping the number of different lists required at a manageable size.

Subjects

The 48 male and female subjects were either students from introductory psychology classes at Iowa State University who received extra credit for participation or students who answered an ad in the campus newspaper and received money for participation. Six Ss were assigned to each of the eight lists in the order in which they appeared at the laboratory. Ss were run in groups ranging from two to six in number.

Procedure

The lists were first printed by computer and then displayed directly from a memory drum on a monitor for presentation by means of closed circuit television. Items were presented at a rate of one word every three seconds. As each word appeared on the screen Ss recorded a response on a four point scale to indicate their certainty that the word was one which had been presented previously in the list. A response of "1" indicated a very low degree of certainty that the word was a repeated word, a response of "4" indicated a very high degree of certainty that the word was a repeated word, and responses of "2" and "3" indicated progressively higher intermediate degrees of certainty. (See Appendix B.)
Analysis and Expected Results

Rating responses from the four point certainty scale for the first and second presentations of homophones and synonyms were subjected to analysis of variance. Responses to repeated items were not included in the analysis; such items were presented only to give the task credibility. Responses to first presentations of homophones and synonyms were to estimate the normal false alarm rates and responses to the second presentations were to assess the relative contribution of acoustic and semantic encoding.

Thus, the data were analyzed using an $8 \times 6 \times 2 \times 2 \times 8 \times 4$ factorial design. The respective factors were Lists, Subjects within Lists, Presentation (first or second), Foil (homophone or synonym), Lag, and Blocks. The hypothesis of predominately acoustic encoding with short retention intervals and predominately semantic encoding at longer retention intervals would require a significant Presentation by Foil by Lag interaction for support.

Results

As indicated in the summary of the analysis of variance shown in Table 1, significant main effects were found for Presentation, Foil, and Lag. Second presentations resulted in significantly higher certainty rating
Table 1. Summary of analysis of variance of certainty ratings

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<th>Source of variation</th>
<th>Degrees of freedom</th>
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<td>Ss within lists (B)</td>
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<tr>
<td>Presentation (C)</td>
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<td>29.27**</td>
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<tr>
<td>AC</td>
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<td>1.366</td>
<td>1.97</td>
</tr>
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*Significant beyond the .05 level.

**Significant beyond the .01 level.
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than first presentations and homophone pairs resulted in significantly higher certainty ratings than synonym pairs. Variations in lag resulted in a bow-shaped function as shown in Figure 1 with the highest certainty ratings being given at lag 2 and the lowest at lag 48. The difference between these two lags was significant (p<.05) using the Newman-
Figure 1. Mean certainty ratings as a function of lag

Figure 2. Mean certainty ratings as a function of presentation and foil
Keuls test (Winer, 1962) while all other pairs of lag means did not differ significantly (p>.05).

There were two significant two-way interactions, Presentation by Foil and List by Lag. The Presentation by Foil interaction, shown in Figure 2, resulted from the fact that second presentations were given higher certainty ratings only for homophone pairs. The mean for second presentations of homophones was significantly greater than the means for the other three conditions (p<.01) while there were no differences among the latter means. Graphing the List by Lag interaction as shown in Figure 3 suggested that the lag effect was not consistently bow-shaped under all lists and that peaks occurred at lags somewhat longer than lag 2 for some of the lists.

Three other interactions, all involving the List factor, reached the .05 level of significance. These included one three-way interaction, List by Lag by Block, and two four-way interactions, List by Presentation by Foil by Lag and List by Foil by Lag by Block. However, because of the nature of the List factor those interactions involving Lists will not receive further consideration. The List factor was on which was included only as a control variable to avoid confounding particular triads with specific presentation by foil by lag by lag by block conditions and to avoid order effects possible when using only one list. Differences between levels of this factor lack meaning as they were, partially at least, randomly
Figure 3. Mean certainty ratings as a function of list and lag
determined. Thus, any attempt to interpret the above interactions would be quite difficult at best.

In addition there was one other significant four-way interaction, Presentation by Foil by Lag by Block. The presentation by foil conditions showed two general patterns at specific lag by block combinations. There were either no differences among the four conditions or the second presentation of homophones were given higher certainty ratings than at least one other condition. Within the second block there appeared to be more lags at which no differences were found. Whatever the reason for the interaction, there was no particular reason to expect it.

The Presentation by Foil by Lag interaction is presented in Figure 4. Comparisons were made among the four presentation by foil conditions within each lag and among lags within each of the presentation by foil conditions. As suggested by Winer (1962), these \textit{a priori} comparisons were made even though the three-way interaction term failed to reach significance since they were of primary interest in this experiment. The only significant differences among lags occurred with the second presentation of homophones where lag 2 resulted in higher certainty ratings than lag 1 ($p<.05$). Within lags 1, 32, and 48 the four presentation by foil conditions did not differ; elsewhere the second presentation of homophones resulted in significantly higher certainty ratings than the other three
Figure 4. Mean certainty rating as a function of presentation, foil, and lag
conditions while there were no differences among the latter three conditions.

Discussion

Given the constraints of a continuous recognition memory task, the above results provide very little evidence for either the encoding of acoustic and semantic attributes at differential rates or for the notion of a distinction between STM and LTM on the basis of acoustic and semantic encoding respectively. As shown in Figure 4, having seen a homophone of a word previously in the list increased the tendency to judge that word as a repeated word even though it was a new word. This was true for all lags except when the two members of the homophone pair were presented in immediate succession. It was particularly true when relatively few, but at least one unrelated word occurred between the presentations of the two homophones. Taken alone, this finding could be presented as evidence for predominately acoustic encoding at relatively short retention intervals. However, the nearly total lack of an effect on judging a word as a repeated word when a synonym of that word had been seen previously in the list lends no support to the notion of predominately semantic encoding at relatively long retention intervals. The lack of a synonym effect is particularly apparent at the longest retention intervals and, in fact, the lag effect with synonyms
closely parallels the lag effect with homophones except in the case where there were no intervening items where neither synonyms nor homophones were effective.

Several possible explanations exist as to why synonyms were not effective in producing false alarms at a level any higher than for new unrelated words. Previous investigators have found an effect of semantic similarity on false recognition using the continuous recognition memory paradigm. Anisfeld and Knapp (1968) and Grossman and Eagle (1970) found the effect using synonyms and Underwood (1965) found it with implicit associative responses (taken from word association norms) of prior words including the semantic relationships of antonyms, converging associations, and superordinates.

Two rather basic consistent procedural differences between this experiment and the three studies mentioned above are readily apparent. One is that in all three studies words were presented aurally at rates of from 7-10 seconds per word and each word was repeated when presented as compared to a single presentation of three second duration in the visual mode in the present study. Another is that words analogous to first presentations in this study were presented at least twice and as often as five times in some of the conditions in the other studies before the analogous second presentations were given. The rate difference may be tentatively discounted as being of crucial importance. Inspection of some
pilot data collected using the same lists and a six second per item presentation rate showed virtually the same pattern of responses as a function of lag for the second presentations of both homophones and synonyms as the faster rate. However, the modality difference may have been of importance in that with visual presentation orthographic attributes become more obvious and may have served as a basis for encoding and judging repetitions of items. If orthographic features were used to any great extent in performing the task the expectation would be for more false recognitions given to homophones of prior items than to synonyms of prior items since homophone pairs are much more similar in terms of orthographic features than are synonym pairs (e.g. bare-bear and bare-nude). Differences on the orthographic dimension were not controlled for because of the extreme difficulty involved in finding a large set of items where such control could be achieved.

Differences in the number of presentations of first presented items may also have been of importance. Underwood compared one and three presentations of words whose antonym IARs were presented later and found the effect with three presentations but not with one presentation. Underwood also found that the presentation of four or five words which had a common associate produced more false alarms when the common associate was presented than when only two or three words were given which had a common associate. However, within
the present experiment only one first presentation was adequate to produce false alarms on the second presentation for homophone pairs. It may be that with semantic relationships more than one presentation is required to produce false recognitions, while only one is enough for acoustic relationships, but as to why this should be so remains far from obvious.

Another possibility is that the particular set of synonyms used simply were not close enough along the semantic dimension to produce false alarms. That is, generally, there may not have been enough semantic features in common between pairs of synonyms to result in confusion between the two words. This possibility was further examined in the second experiment which used the same set of items in a different type of recognition task. There Ss were able to recognize probe words as synonyms of words embedded in 10 item lists at an above chance level. It still may be that more semantic overlap is required to produce false recognitions when judging whether or not an item is repeated than when simply recognizing synonyms. The particular synonyms used in this study were constrained in that one of the words in the pair also had to have a homophone and thus, may not have been as semantically similar as those used in other studies.

Whatever the most appropriate explanation for the lack of synonym effects may be, the fact that such effects were
not found at any of the lags used, limits possible explanations to the general kind offered above.

Two of the significant main effects, Presentation and Foil, and their interaction may be best interpreted as reflecting the effectiveness of homophones in causing false recognitions in the continuous recognition memory task. The lag effect should only be viewed as a general effect within the type of items used in the data analysis (completely new items and items whose synonyms and homophones had been presented previously) because of the failure of the lag variable to interact with any of the other interpretable variables. The trend for higher ratings with relatively short lags, however, appeared much more pronounced for the second presentation of homophones than for any other condition.

The finding of virtually no errors above a chance level with repeated homophones at lag 1, the very shortest retention interval where one might expect the greatest number of errors, merits further discussion. A reasonable explanation can be given in terms of a very short-term visual trace. Since each item remained on the screen for the full three seconds and was followed immediately by the next item, a sensory trace could well serve as a basis for comparison at lag 1. This sensory trace would be functionally similar to the contents of the sensory register discussed by Atkinson and Shiffrin (1967) except that it would not be as subject
to interference by presentation of other material. The contents of the sensory register has generally been investigated with very short presentation durations. It does not seem unreasonable to hypothesize that longer presentation durations might result in a sensory trace less subject to interference. The lack of homophone errors at lag 1 could also be explained by assuming a highly accurate and rapidly forgotten memory trace based on features other than or in addition to acoustic and semantic features (e.g. orthographic features). Such a memory trace could also serve as a basis for comparison at lag 1 and result in highly accurate performance.

The lag curve for identical repetitions generally found (e.g. Melton, Sameroff, and Schubot, 1967) differ in shape from the repeated homophone lag curve mostly at lag 1. The notion of a rapidly decaying sensory or memory trace fits well with this observed difference. In the case of identical repetitions an accurate trace for comparison at lag 1 would result in more judgments of identity and thus, very high performance while for repeated homophones it would result in fewer judgments of identity and low performance when using yes responses as the dependent variable. At the longer lags the curves would appear more similar if responses were being made largely on the basis of acoustic information rather than on the basis of a visual trace.
The remaining significant effect, the four-way interaction not involving Lists, cannot be regarded as very meaningful. The nature of the interaction was such that no orderly interpretation could be given. For example, there was no particular reason to expect homophones to be less effective at the longer lags in block 2 than in the other blocks nor for first presentations to result in higher certainty ratings than second presentations at lag 1 in block 4.

The general lack of block effects with the continuous recognition memory method is somewhat surprising in light of the usual findings with this method. While false alarm rates evidently had stabilized by the time the end of the primacy buffer had been reached (64 items), other studies have shown increases over much longer periods. Olson (1969) reported increases in false alarms over 300 trials of a 500 item continuous list. Kelton, Sameroff, and Schubot (1967), however, report the largest increases in false recognitions over the first 80 trials of their continuous list containing 480 items with very little increase thereafter. Consistent with their results was a slight increase in false alarms between blocks 1 and 2 and no increase thereafter in this study.

In spite of the negative outcome in terms of expected results, what has been demonstrated in this experiment is that the prior presentation of a homophone of a word increases
the tendency to call that word a repeated item, particularly at intermediate retention intervals. From this inferences to encoding processes on an acoustic or highly related dimension (such as orthographic) may be made.
EXPERIMENT II

The main purpose of the second experiment was to test an alternative to the interpretation of the results of the Shulman study described earlier which led him to the conclusion that acoustic and semantic encoding can be equally effective in an STM task if the task is designed to require such encoding. Also conditions were included which partially replicated his design but not exact procedure. At the same time a generalized replication of the first experiment reported here was also carried out.

Shulman's method was to present a list of ten words, a cue to indicate which of three tasks S was to perform, and a probe word requiring a yes-no recognition response. The three cues were the letters H, M, and I, respectively indicating that a yes response was appropriate if the probe word was a homonym of any of the ten words in the list, a synonym of any of the ten words in the list, and identical to any of the ten words in the list. One of the words within the list was either related to the probe word along the cued dimension or unrelated to the probe word on any of the three dimensions. Presenting the cue after the study list was designed to force attention on both acoustic and semantic features. Shulman found parallel serial position curves for the three tasks which he interpreted as indicating that the
types of information involved in his task (including semantic and acoustic) were stored in functionally identical memory systems. The argument is made here that the synonym judgment task need not necessarily have involved storage of semantic features. It seems possible that acoustic features only could have been stored and used to generate a "word" whose semantic features could be determined from long term memories based on experiences with that "word" prior to that particular experimental situation. To test this notion one can present a homophone of a synonym of the probe word within the list with a synonym cue. With acoustic storage only this condition should be identical with presenting simply a synonym of the probe word within the list as the acoustic information is identical for the synonym and its homophone.

With respect to the homonym task the other analogous logical possibility exists, storing only semantic features and generating acoustic features from long term memory based on prior experiences. The test for this notion involves presenting a synonym of a homophone of the probe word with a task requiring a homophone judgment. With only semantic storage this condition would be the same as simply presenting homophone of the probe word within the list. While the latter possibility seems rather unlikely in view of existing data, the appropriate conditions were included in the design.

The first experiment was also replicated in that synonyms
and homophones were presented within the list when the identity cue was used. While this is a slightly different task than the one used previously, false recognitions still represent the same underlying processes.

Method

Design

The task used involved a total of ten different conditions; three conditions with the synonym recognition cue, three conditions with the homophone recognition cue, and four conditions with the identity recognition cue. With the synonym cue one of the ten items in the list could be either a synonym of the probe word or a homophone of a synonym of the probe word or all ten words in the list were unrelated to the probe word. With the homophone cue one of the ten items in the list could be either a homophone of the probe word or a synonym of a homophone of the probe word, or all ten words in the list were unrelated to the probe word. With the identity cue one of the ten items in the list was either identical to the probe word, a synonym of the probe word, or a homophone of the probe word or all ten items in the list were unrelated to the probe word. The position of the critical item in the list was varied over the ten serial positions under each of the ten conditions. It should be recognized that this latter manipulation was somewhat arbitrary in the case of the three conditions having only unrelated items in the list.
Stimulus Materials

The initial pool of stimulus items included 110 triads selected randomly from the 128 used in Experiment I, two sets of 110 words each selected randomly from the remaining homophone pairs described in Experiment I with the constraint that only one homophone of a pair was used, and 880 words selected systematically (approximately every 35th word) from Part 1 of Thorndike and Lorge (1944). A constraint placed on all the above words was that none be greater than ten letters in length.

One of the sets of 110 homophone words was used to construct quadrads by assigning a single homophone from the set to each of the 110 triads. Care was taken to insure that the homophone assigned to a particular triad was unrelated on either the acoustic or semantic dimension to any of the existing words in the triad. Each quadrad then contained a base word, a homophone of the base word, a synonym of the base word, and unrelated to the base word.

Ten of the quadrads were then randomly selected and assigned to a particular condition by serial position combination for use in ten practice trials. Each condition and each serial position was sampled once in the set of practice trials. A single trial involved the presentation of ten words for study and a probe word for recognition along with a cue to indicate which of the three tasks was to be done. The condition assigned to a trial determined
which particular words were to be used as a probe word and
a study word from the quadrad assigned to that trial. Thus,
for the three conditions requiring a synonym judgment (S
cue) the synonym of the base word in the quadrad was always
used as the probe word and when a synonym was presented in
the list (condition S-S) the base word of the quadrad was
used as a study word, when a homophone of the synonym was
presented in the list (condition S-H) the homophone of the
base word was used as a study word, and when an unrelated
word was presented in the list (condition S-U) the unrelated
word from the quadrad was used as a study word. For the
three conditions requiring a homophone judgment (H cue)
the homophone of the base word in the quadrad was always
used as the probe word and when a homophone was presented in
the list (condition H-H) the base word of the quadrad was
used as the study word, when a synonym of the homophone was
presented in the list (condition H-S) the synonym of the
base word was used as a study word, and when an unrelated
word was presented in the list (condition H-U) the unrelated
word from the quadrad was used as a study word. For the
four conditions requiring an identity judgment (I cue) the
base word of the quadrad was always used as the probe word
and when an identical word was presented in the list (con-
dition I-I) the base word was used as a study word, when a
homophone was presented in the list (condition I-H) the base
word was used as a study word, when a homophone was presented in the list (condition I-S) the synonym of the base word was used as a study word, when an unrelated word was presented in the list (condition I-U) the unrelated word from the quadrad was used as a study word. Figure 5 illustrates the above ten conditions using a single quadrad. The remaining nine words in a list for a given trial included eight words selected randomly from the pool of 880 described above and one from the other set of 110 homophones. A restriction placed on the random selection was that no word used in the list as a filler item could be related either acoustically or semantically to either the critical item in the list or to the probe word. The homophone set was used in making up filler items to insure that at least one word which had a homophone was included in the ten item lists for all of the ten conditions. Thus, each of the ten practice trials included a critical study word with the appropriate probe word determined by its assigned condition from a randomly assigned quadrad and nine filler words from the two appropriate item pools. The same ten practice lists were given in the same order to all Ss.

An additional basic set of 100 lists was constructed for the remaining 100 trials by assigning the first column of each of ten 10 x 10 Latin Squares to trials numbered 11-110. The ten elements within a column represented each
### Quadrads

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**Figure 5.** Example of a quadrad and its use in selecting critical study words and probe words in the ten conditions
of the ten conditions and thus, determined the critical study words and probe words for each trial when the remaining 100 quadrads were randomly assigned to the 100 trials. The serial position of the critical study word within the ten item lists was determined by taking a single column of another 10 x 10 Latin Square and repeatedly assigning it to each block of ten trials. Each element within the column represented a different serial position so each serial position was tested once before any was tested twice and the order of testing serial positions remained the same between trial blocks of ten over the set of 100 trials. The result of the above assignments was that over the 100 trials each of the ten conditions was tested once at each of the ten serial positions. The filler words were assigned in the same manner as that described for the practice lists.

Nine additional sets of lists for trials 11-110 were then constructed by assigning columns 2-10 of the ten 10 x 10 Latin Squares used in the first set of lists to determine conditions tested for particular trials as was done with the first set of lists. The particular quadrad used the serial position tested and the filler items remained the same for any given trial across the ten sets of lists. Each quadrad was tested once under each condition, however, across the ten sets of lists.
Subjects

Fifty Ss from the same two sources as those in Experiment I were run in groups ranging from 2-5 in size. Five Ss were assigned to each of ten list sets in the order in which they appeared at the laboratory.

Procedure

The ten lists (actually ten sets of 110 ten item lists with a probe word and cue with each) were printed by computer for display on a TV monitor from the memory drum as was done in experiment I. Within a single trial the trial number and the ten study words were presented at a rate of one per second; the probe word was presented simultaneously with the cue to indicate the nature of the task for that trial for a period of 10 seconds. During this time Ss made a decision as to whether or not the probe word bore the relationship indicated by the cue to any of the items in the list and recorded a yes-no response. (See Appendix C.)

Analysis and Expected Results

The yes-no responses were analyzed using two correlated analyses of variance. In the first analysis the number of yes responses was used as the dependent variable while in the second the dependent variable was the number of correct responses. In the latter analysis a yes response was considered correct for conditions S-S, H-H, and I-I while a no
response was considered correct for the other seven conditions. The reason for doing the second analysis, even though it was correlated with the first, was to allow direct comparisons to be made for performance under those conditions where yes and no responses were appropriate.

Both analyses were done using a 10 x 5 x 10 x 10 factorial design. The factors were Lists, Subjects within Lists, Conditions, and Serial Position respectively. Of major interest are the results from the three synonym judgment conditions. Shulman's interpretation would require that conditions S-U and S-H show no differences while the alternative interpretation described earlier would require a difference between conditions S-U and S-H. The more extreme hypothesis of only acoustic encoding would also require no differences between conditions S-S and S-H with the analysis based on the number of yes responses. The main prediction was that condition S-H would differ from condition S-U in terms of number of yes responses. Within the homophone judgment conditions it was expected that conditions H-U and H-S would not differ and within the identity judgment task that both conditions I-H and I-S would differ from condition I-U. These latter differences were expected to vary with the serial position of the critical study word in the ten item list.
Results

The summary of the analysis of variance of the number of yes responses is shown in Table 2. Significant main effects were found for conditions and for Serial Position. As suggested by Figure 6 significantly more yes responses were given under condition S-S than either condition S-H or S-U (p<.01) and condition S-H also resulted in significantly more yes responses than condition S-U (p<.05). Within the homophone judgment task condition H-H produced significantly more yes responses than either condition H-S or condition H-U (p<.01) while the latter two conditions did not differ. Within the identity judgment task condition I-I resulted in significantly more yes responses than conditions I-H, I-S, and I-U (p<.01), condition I-H produced significantly more yes responses than conditions I-S and I-U (p<.01) while the latter two conditions did not differ. These comparisons and all those following were made using the Newman-Keuls test. Across tasks condition I-I produced more yes responses than conditions H-H (p<.05) and S-S (p<.01) and condition H-H resulted in more yes responses than condition S-S (p<.01). Conditions S-U and H-U did not differ significantly, also conditions H-U and I-U did not differ significantly but condition S-U did produce significantly more yes responses than condition I-U (p<.01). The only significant difference within serial positions was that more yes responses were given at
Table 2. Summary of analysis of variance of the number of yes responses

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Mean square</th>
<th>F values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lists (A)</td>
<td>9</td>
<td>1.288</td>
<td>1.31</td>
</tr>
<tr>
<td>Ss within lists (B)</td>
<td>40</td>
<td>.984</td>
<td></td>
</tr>
<tr>
<td>Conditions (C)</td>
<td>9</td>
<td>29.280</td>
<td>80.44**</td>
</tr>
<tr>
<td>AC</td>
<td>81</td>
<td>.364</td>
<td>1.58**</td>
</tr>
<tr>
<td>BC</td>
<td>360</td>
<td>.231</td>
<td></td>
</tr>
<tr>
<td>Serial Position (D)</td>
<td>9</td>
<td>.413</td>
<td>2.27*</td>
</tr>
<tr>
<td>AD</td>
<td>81</td>
<td>.182</td>
<td>1.12</td>
</tr>
<tr>
<td>BD</td>
<td>360</td>
<td>.163</td>
<td></td>
</tr>
<tr>
<td>CD</td>
<td>81</td>
<td>.298</td>
<td>1.41*</td>
</tr>
<tr>
<td>ACD</td>
<td>729</td>
<td>.211</td>
<td></td>
</tr>
<tr>
<td>BCD</td>
<td>3240</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant beyond the .05 level.

**Significant beyond the .01 level.
Figure 6. Per cent yes responses as a function of conditions

Figure 7. Per cent yes responses as a function of serial position
serial position 10 than at serial position 4 \((p<.05)\). The serial position curve is shown in Figure 7.

Both the List by Condition and the Condition by Serial Position interactions were significant at the .05 level. The first interaction will not be described in any great detail because of the difficulty in interpreting the List factor as was the case with the List factor in Experiment I. Differences between levels of this factor were again quite arbitrary. Particular conditions generally showed the same pattern of performance within the three types of tasks under each of the ten lists. The Condition by Serial Position interaction is shown in Figure 8. Comparisons were made between conditions within each serial position. For the synonym judgment task the superiority of condition S-S over condition S-U was limited to serial positions 2, 7, 8, 9, and 10 \((p<.01)\) and to serial positions 3 and 4 \((p<.05)\). The superiority of condition S-S over condition S-H was limited to serial positions 2, 8, and 10 \((p<.01)\) and to serial position 9 \((p<.05)\). The superiority of condition S-H over condition S-U was limited to serial position 10 \((p<.05)\).

Within the homophone judgment task the differences between the three conditions described above in the main effect were constant for all ten serial positions. Within the identity judgment task the superiority of the I-I condition over the other three conditions remained for all serial positions. The superiority of the I-H condition over the I-U condition was limited to serial positions 1, 8, and 9 \((p<.05)\) and to serial position
Figure 8. Percent yes responses as a function of condition and serial position.
6 (p<.01). The superiority of condition I-H over condition I-S was limited to serial position 9 (p<.05).

The three-way interaction term was not tested for significance because it was based on dichotomous data which do not meet the assumptions required for analysis of variance.

The summary of the analysis of variance of the number of correct responses is shown in Table 3. With this analysis the same two main effects and all three two-way interactions were found to be significant. For the homophone judgment task there were no significant differences between conditions in terms of correct performance. Within the synonym judgment task condition S-U resulted in better correct performance than either condition S-S (p<.01) or condition S-H (p<.05) while the latter two conditions did not differ. Within the identity judgment task the number of correct responses was less under condition I-H than under conditions I-U and I-S (p<.01) and condition I-I (p<.05) while the latter three conditions did not differ. Across the three tasks condition S-S produced less correct responses than either condition I-I (p<.01) or condition H-H (p<.05) while the latter two conditions did not differ. Also condition I-U produced more correct responses than condition S-U (p<.01) and condition H-U did not differ significantly from either of the other two unrelated conditions. Within the serial position main effect serial position 10 resulted in more
Table 3. Summary of analysis of variance of the number of correct responses

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Mean square</th>
<th>F values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lists (A)</td>
<td>9</td>
<td>.656</td>
<td>1.28</td>
</tr>
<tr>
<td>Ss within lists (B)</td>
<td>40</td>
<td>.513</td>
<td></td>
</tr>
<tr>
<td>Conditions (C)</td>
<td>9</td>
<td>5.126</td>
<td>11.81**</td>
</tr>
<tr>
<td>AC</td>
<td>81</td>
<td>.434</td>
<td>1.53**</td>
</tr>
<tr>
<td>BC</td>
<td>360</td>
<td>.284</td>
<td></td>
</tr>
<tr>
<td>Serial Position (D)</td>
<td>9</td>
<td>.476</td>
<td>2.22*</td>
</tr>
<tr>
<td>AD</td>
<td>81</td>
<td>.214</td>
<td>1.36*</td>
</tr>
<tr>
<td>BD</td>
<td>360</td>
<td>.157</td>
<td></td>
</tr>
<tr>
<td>CD</td>
<td>81</td>
<td>.291</td>
<td>1.41*</td>
</tr>
<tr>
<td>ACD</td>
<td>729</td>
<td>.207</td>
<td></td>
</tr>
<tr>
<td>BCD</td>
<td>3240</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant beyond the .05 level.

**Significant beyond the .01 level.
correct responses than serial positions 6, 5, and 1 (p<.05) while all other comparisons did not differ significantly.
The conditions and serial position main effects are presented graphically in Figures 9 and 10 respectively.

The Condition by Serial Position interaction is shown in Figure 11. Within the synonym judgment task condition S-U produced significantly more correct responses than condition S-S only at serial positions 6 (p<.01) and 7 (p<.05). Both conditions S-U and S-S produced significantly more correct responses than condition S-H at serial position 10 (p<.05). The lack of significant differences within the homophone judgment task was constant across all serial positions. For the identity judgment task condition I-U produced more correct responses than condition I-H only at serial positions 1, 6, and 9 (p<.05). Condition I-I resulted in higher correct performance than condition I-H at serial position 9 only (p<.01). Condition I-U also resulted in higher correct performance than condition I-I at serial position 6 only (p<.05).

Comparisons among the three conditions which matched Shulman's were also made within serial positions as shown in Figure 12. Condition I-I resulted in significantly more correct responses than condition S-S at serial positions 3, 6, and 7, (p<.01) and at serial position 9 (p<.05). Condition H-H resulted in more correct responses than condition S-S at serial position 6 (p<.01) and condition I-I resulted
Figure 9. Per cent correct responses as a function of conditions

Figure 10. Per cent correct responses as a function of serial position
Figure 11. Per cent correct responses as a function of conditions and serial position.
Figure 12. Per cent correct responses for conditions S-S, H-H, and I-I as a function of serial position.
in more correct responses than condition H-H at serial position 9 (p<.05).

Comparisons of serial positions within conditions showed that the serial position effects were limited to conditions I-I and S-S only. Within the I-I condition serial positions 9 and 10 resulted in significantly more correct responses than serial positions 4, 5, and 6 (p<.05 for all six comparisons). Within condition S-S serial position 10 resulted in more correct responses than serial positions 1, 3, 4, 5, 6, and 7 (p<.01) and serial position 2 (p<.05). Also performance at serial positions 8 and 9 was significantly greater than at serial position 6 (p<.05).

Again the three-way interaction was not tested for significance nor will the interactions involving the lists factor be reported as the same restrictions on those terms apply as were discussed in the first analysis presented.

Discussion

Differences in terms of the number of yes responses between conditions having study items related to the probe word (S-S, H-H, and I-I) and conditions having all unrelated study items (S-U, H-U, and I-U) may be interpreted as indicating sensitivity in recognizing synonyms, homophones, and identity. Ss did show such sensitivity at all serial positions for homophones and identity and for synonyms except
for the very first and middle serial positions. Homophone and identity recognition was generally better than synonym recognition probably because the degree of similarity of meaning between synonyms is generally somewhat less than the degree of acoustic similarity between homophones and the degree of overall similarity between identical repetitions of a word. This result was consistent with expectations. The I-I and H-H conditions differed significantly when yes responses were analyzed but not when correct responses were analyzed. The size of the difference was the same since the same data were used for those conditions where a yes response was appropriate in both analyses but the error terms were just different enough to give significance in one case but not in the other. This inconsistency between the two analyses simply serves to show the marginal nature of this difference.

The consistent difference between the unrelated conditions with the identity task and the synonym task (more yes responses and fewer correct responses for condition S-U) suggests that there was a response bias shift with synonym recognition. That is Ss were more willing to give a yes response or required less of an overlap in terms of meaning between the probe and the study list items to accept the probe as a synonym. This kind of bias shift is reasonable considering that the synonym task is more difficult
and that S probably develops expectations about the relative proportion of trials that contain synonyms of the probe from his experience with the homophone and identity trials. Because sensitivity is less for synonym recognition less yes responses are given when synonyms are presented and relatively more when synonyms are not presented to maintain a consistent proportion of yes responses across tasks.

The four identity conditions were essentially a replication of the first experiment. Again homophones did produce false recognitions while synonyms produced no more false recognitions than unrelated items. The homophone effect was most apparent for the later serial positions but also was rather pronounced for the very first serial position. The retention intervals for this experiment were about 10 seconds at the maximum and involved the presentation of more material so direct comparisons between the two experiments are difficult to make. The results do seem quite consistent as there was no synonym effect and the homophone effect was greatest at relatively short retention intervals in both.

The serial position main effect showed very little variation under either analysis. This result was not unexpected as serial position was not a meaningful variable for three of the ten conditions (the unrelated conditions under each task) and was not expected to be effective in one other condition (H-3).
Perhaps the most important implication of the above results is that within the constraints of this task synonym judgments were made at times on the basis of acoustic information only. This statement is based on the finding that probe words were judged as being synonymous with one of ten study words presented immediately prior to the probe word significantly more often when a homophone of a synonym of the probe word was presented among the study words than when semantically and acoustically unrelated study words were presented. This result was most consistent when the homophone was presented at the end of the study list. Thus, at very short retention intervals where acoustic encoding should be predominant given either a two store notion or different rates of encoding for different attributes, acoustic information was used as the basis for synonym judgments to a much greater extent than at longer retention intervals where semantic encoding is assumed to predominate. While this particular result does not prove two store theories nor prove the existence of different encoding rates, it does raise questions concerning the conclusions drawn in the Shulman study. Specifically the notion that performance under Shulman's synonym task reflects only semantic effects may be questioned and simultaneously his evidence for semantic encoding in STM appears less forceful. If the serial position curve in his synonym recognition task
reflects performance based on acoustic as well as semantic stored information then his conclusion concerning functionally identical memory systems for acoustic and semantic information may no longer be valid. While it is impossible to say exactly what shape the serial position curve would have for the synonym recognition task if only semantic information were being used, the evidence offered above would suggest a lowering of the recency portion. This in turn, would imply that semantic factors are of relatively less importance at very short retention intervals.

It should also be noted that the corresponding control condition in the homophone judgment task (presenting a synonym of a homophone of the probe word among the study items) produced no more judgments of acoustic identity than did presenting totally unrelated items in the study list. Thus, homophone judgments were relatively free of semantic effects at all retention intervals.

A rather obvious discrepancy appears between the present results and those reported by Shulman when considering over-all performance and performance as a function of serial position. There were fewer yes responses when judging homophones when a homophone had appeared in the list than when judging identity with the probe word being a repeated word. Shulman found no difference between these two conditions. Also there was virtually no serial
position curves for homonym and synonym judgments with pronounced recency portions. These later differences, however, appear to result from differences in performance levels for conditions between the two studies. Normalized serial position curves were drawn for both Shulman's data and the present data as shown in Figure 13 by dividing the number of yes responses at each serial position by the total number of yes responses for that condition. This procedure adjusts for difficulty differences between conditions. The normalized curves appear quite similar in shape; the present curves do appear to be rather noisy as might be expected since each point is based on less than half the number of observations as the Shulman curves.

Differences in performance levels between the two studies might have been due in part to the fact that Shulman used 50 practice trials as compared to 10 in this study. This might also account for the difference between identity judgment and homophone judgment tasks found here as practice would probably be more helpful on the homophone task as Js have likely had less prior experience at recognizing identity.
Figure 13. Normalized serial position curves for conditions S-S, H-H, and I-I compared to Shulman (1969)
GENERAL DISCUSSION

The two experiments reported here are consistent with respect to the larger questions raised earlier concerning acoustic and semantic encoding as related to retention interval. When recognizing identical repetitions of words, false alarm errors are made at a greater than chance rate to words whose homophones have been presented previously when the interval between the presentation of the pair of homophones is relatively short. The implication of homophone errors is that acoustic or related features are predominant enough in memory at these intervals to cause confusion between homophone pairs.

The evidence for the effectiveness of acoustic similarity in causing errors or reducing performance in STM situations has been well established elsewhere; what has been additionally shown here is that these effects are greatest at relatively short retention intervals in a recognition task which sampled a rather wide range of retention intervals. Whether the reduction in homophone errors at longer retention intervals occurred simply as a result of forgetting of acoustic information or because responses were made on the basis of other kinds of stored information such as semantic is a question that cannot be answered from the data presented here. The fact that
synonym errors were not made at the longer intervals would argue for the first alternative but since synonym errors did not occur at any retention intervals it may have been that the particular synonym pairs used were not similar enough to cause errors. Thus, responses still may have been given on the basis of semantic information at longer intervals without the corresponding synonym errors being made. The pattern of errors found for acoustic similarity is at best consistent with either a two store model of memory with a short-term acoustic store or a single store model of memory with a relatively rapid forgetting rate for acoustic information.

Any inferences from the homophone error data to existing memory models are severely limited by the lack of occurrence of synonym errors. Several possible reasons as to why such errors did not occur have already been discussed. Perhaps looking at patterns of synonym errors is not the best method of studying semantic encoding in a recognition situation. Since recognition is generally considered a quite sensitive measure of memory and since the semantic dimension includes more than just synonym relationships, it is not altogether unreasonable to suggest that a different task would be more appropriate for studying semantic encoding.

The synonym and homophone recognition tasks first used
by Shulman and adopted in this study do seem to tap acoustic and semantic effects more directly. Even then direct inferences to semantic and acoustic encoding may not be appropriate as demonstrated by the control conditions used in the second experiment. These kinds of recognition tasks do, however, appear potentially useful in separating the relative importance of acoustic and semantic attributes at various retention intervals, as they offer an opportunity to present study items bearing almost any imaginable relationship to the probe while asking directly about acoustic and semantic relationships.

The evidence relevant to hypothesized differential characteristics of acoustic and semantic encoding has been further complicated rather than clarified by these experiments. In particular the type of evidence offered by Bregman (1968) and by Shulman (1969) to demonstrate semantic encoding in STM situations has been opened to alternative interpretation by the demonstration that synonym recognition can occur, at least in part, with stored acoustic information only. Semantic and other encoding dimensions cannot be entirely ignored in STM tasks since not all of synonym recognition performance could be accounted for by the acoustic information, but these dimensions appear to be of somewhat less importance than the acoustic dimension.
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And finally I am most grateful to my wife, Chris, who spent many tedious hours in the typing of this manuscript and who also consistently offered aid and encouragement in many different ways.
APPENDIX A

Stimulus Materials

Experiment I

1. aisle-isle-atoll
2. allowed-aloud-permitted
3. alter-altar-change
4. ark-arc-boat
5. assent-ascent-agreement
6. ate-eight-consumed
7. bard-barred-poet
8. bare-bear-nude
9. beat-beet-win
10. bee-be-wasp
11. border-boarder-side
12. borough-borrow-city
13. boulder-bolder-rock
14. brewed-brood-fermented
15. bridle-bridal-halter
16. build-billed-construct
17. bury-berry-inter
18. buy-bye-purchase
19. caster-castor-wheel
20. ceiling-sealing-roof
21. cellar-seller-basement
22. cereal-serial-grain
23. cents-since-pennies
24. chased-chaste-pursued
25. chic-sheik-stylish
26. choose-chews-select
27. cite-sight-quote
28. clawa-clause-talons
29. close-clothes-shut
30. colonel-kernel-officer
31. cord-chord-string
32. cot-caught-bed
33. counsel-council-advice
34. current-currant-immediate
35. dawn-don-sunrise
36. daze-days-stun
37. dire-dyer-dreadful
38. dough-doe-bread
39. duct-ducked-vent
40. due-do-owed
41. error-air-mistake
42. faint-feint-feeble
43. fir-fur-pine
44. fissure-fisher-cleft
45. flair-flare-aptitude
46. flex-flecks-bend
47. flower-flour-rose
48. fowl-foul-bird
49. friar-fryer-monk
50. gamble-gambol-wager
51. guest-guessed-visitor
52. guilt-gilt-remorse
53. guys-guise-fellows
54. hale-hail-hearty
55. hare-hair-rabbit
56. haul-hall-carry
57. heal-heel-cure
58. herd-heard-flock
59. holy-wholly-sacred
60. hose-hoes- stocking
61. hue-hew-color
62. hymn-him-psalm
63. idol-idle-image
64. incite-insight-instigate
65. inn-in-hotel
66. jam-jamb-jelly
67. knotty-haughty-difficult
68. knows-nose-realizes
69. lane-lain-path
70. leased-least-rented
71. lessen-lesson-reduce
72. lyre-liar-harp
73. maize-maze-corn
74. male-mail-masculine
75. mare-mayor-horse
76. marshall-martial-sheriff
77. mast-massed-spar
78. metal-mettle-iron
79. mist-missed-fog
80. mite-might-louse
81. nay-neigh-no
82. oar-or-paddle
83. odd-awed-unusual
84. ought-aught-should
85. pact-packed-treaty
86. pail-pale-bucket
87. pare-pair-peel
88. paste-paced-glue
89. pause-paws-hesitate
90. plain-plane-ordinary
91. praise-prays-commend
92. presents-presence-gifts
93. profit-prophet-gain
94. rap-wrap-knock
95. raze-rays-destroy
96. reign-rain-rule
| 97. | right-write-correct |
| 98. | rot-wrought-decay |
| 99. | sale-sail-bargain |
| 100. | scene-seen-view |
| 101. | sea-see-ocean |
| 102. | seem-seam-appear |
| 103. | serf-surf-slave |
| 104. | sew-so-stitch |
| 105. | sire-sigher-father |
| 106. | slay-sleigh-kill |
| 107. | soul-sole-spirit |
| 108. | spade-spayed-shovel |
| 109. | stare-stair-gaze |
| 110. | stayed-staid-remained |
| 111. | strait-straight-channel |
| 112. | sucker-succor-lollipop |
| 113. | sum-some-total |
| 114. | sword-soared-saber |
| 115. | tale-tail-story |
| 116. | tax-tacks-tariff |
| 117. | tense-tents-nervous |
| 118. | thrown-throne-tossed |
| 119. | toad-towed-frog |
| 120. | tolled-told-chimed |
| 121. | urn-earn-jar |
122. vein-vane-artery
123. vise-vice-clamp
124. wail-whale-howl
125. wax-whacks-polish
126. wee-we-tiny
127. whirled-world-spun
128. wit-whit-humor
APPENDIX B

Instructions to Subjects
Experiment I

"This is an experiment in word recognition. You will see a rather long list of words presented one at a time on the TV monitor. As each word appears your task will be to simply indicate whether or not that particular word was presented previously in the list.

However, instead of making just a yes or response, you are to use a 4 point scale to indicate how certain you are that the word was presented previously. Multiple choice answer sheets are provided for recording your responses. As you will notice there are blanks labeled A-E behind each number. You are to use A-D only with an A response indicating a very high degree of certainty that a word was presented before in the list. Responses of B and C then indicate progressively higher intermediate degrees of certainty.

There will be some words in the list which are similar to other words in the list. Your task though is to look for identical repetitions of words.

Each word will be presented for a 3 second interval during which time you are to look at the word and make a response on the four point scale indicating your certainty judgement that it is a repeated word, so you will have to make decisions
quickly and work fast. As soon as you have completed one an-
swer sheet continue immediately to the next one. As each word
is presented you will hear a click from the memory drum at
the back of the room to help pace your activity.

So as each and every word is presented you are to make a
response on a four point scale to indicate how certain you
are that the word was presented previously in the list.

Are there any questions?"
APPENDIX C

Instructions to Subjects

Experiment II

"This experiment is concerned with recognizing certain properties of words. You will see a number of sets of word lists on the monitor each containing ten words immediately followed by an eleventh word which I will call the probe word and a letter cue. The cue will be a capital letter, either an S, H, or I, presented to the left of the probe word and will indicate which of three dimensions you are to use as a basis for the recognition task.

When an S cue appears a yes response is appropriate only if the probe word is a synonym of any of the ten words on the list. A no response is appropriate if the probe word was not a synonym of any of the words on the list. So if the probe word 'garbage' for example, and one of the words in the list were 'rubbish' you should give a yes response since garbage and rubbish are synonyms.

When an H cue appears a yes response is appropriate only if the probe word is a homophone of any of the ten words. For example, if the word 'chute' were the probe word and 'shoot' had appeared in the list, you would give a yes response since chute and shoot are homophones.

When an I cues appears a yes response is appropriate only
if the probe word is an identical repetition of one of the ten words in the list. A no response is appropriate if the probe word is not an identical repetition of any of the ten words.

The ten words will be presented at a rate of one second per word. The probe word with the cue will be presented for about 10 seconds. During this time you are to decide whether or not the probe word is related to any of the words on the ten item list in the manner specified by the cue and record a yes or no response. Use the blanks labeled A on your answer sheets for a no response and the blanks labeled B for a yes response.

Are there any questions?"