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Modality effects in word identification*

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An experiment was designed to investigate the locus of persistence of information about presentation modality for verbal stimuli. Twenty-four Ss were presented with a continuous series of 672 letter sequences for word/nonword categorization. The sequences were divided equally between words and nonwords, and each item was presented twice in the series, either in the same or in a different modality. Repetition facilitation, the advantage resulting from a second presentation, was greatest in the intramodality conditions for both words (+ve responses) and nonwords (—ve responses). Facilitation in these conditions declined from 170 msec at Lag 0 (4 sec) to approximately 40 msec at Lag 63. Facilitation was reduced in the cross-modality condition for words and was absent from the cross-modality condition for nonwords. The modality-specific component of the repetition effect found in the word/nonword categorization paradigm may be attributed to persistence in the nonlexical, as distinct from lexical, component of the word categorization process.

A number of recent experiments (Hintzman, Block, & Inskeep, 1972; Kirsner, 1973; Craik & Kirsner, 1974) have shown that memory for the physical properties of verbal stimuli—features such as the modality of presentation, the case of visually presented letters, the sex of the speaker of auditorially presented words—lasts for a period too long to be accounted for in terms of echoic or iconic storage (Neisser, 1967). This experiment was concerned with examining how one of these physical features, namely, modality of presentation, is maintained in memory.

One possibility is that the effect is a by-product of activation of the lexicon, the permanent memory system which translates stimulus events into the verbal code. If there exist separate auditory and visual lexica, then during the period that activation of a particular lexical unit persists, information about the modality of the stimulus event would be available. Once the encoding was completed and the activation had ceased, this information would be lost. A second possibility is that there is a single lexicon which is involved in encoding all verbal stimuli, regardless of modality of presentation, and that the retention of modality information resides with a different memory component which is not involved in semantic analysis.

To differentiate between these two possibilities, a modification of a word identification paradigm introduced by Rubenstein, Lewis, and Rubenstein (1971) was employed. Ss were exposed to a long series of letter sequences, half of which were common English words. The task was to classify each sequence as to whether or not it was an English word. In this experiment, each item in the continuous series was presented a second time after one of four possible intervals. Reaction time was measured, and the dependent variable was the decrease in the amount of time required to decide whether the sequence was a word when the stimulus was presented for the second time. Pilot work had indicated that such a repetition effect—the faster RT to a stimulus when it is presented for a second time within a short period (Smith, 1968)—does in fact occur in such a word recognition task. All stimuli were presented both visually and auditorially, allowing a comparison of intramodality (IM) and cross-modality (CM) facilitation effects.

If the information which Ss retain about stimulus modality is due primarily to activation of modality-specific lexical units, then: (a) facilitation would be expected in the IM condition for words, (b) assuming that nonwords have no direct lexical representation, facilitation should be absent from the IM condition for nonwords, and (c) facilitation should be absent from the CM condition for words, since separate lexica would have been activated. If, on the other hand, modality information is retained in a nonlexical component of the memory system, facilitation would be expected in the IM conditions for nonwords as well as words, but not in the CM conditions.

In addition, there are several possible sources of facilitation in the CM condition for words. These are: (a) activation in a single modality-free lexicon, (b) cross-talk between modality-specific lexica, and (c) the involvement of a common phonological encoding component in the analysis of both auditorially and visually presented verbal stimuli. However, it follows from the assumption that nonwords are not represented

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Table 1
Mean Reaction Time for the Control and Lag Conditions as a Function of Material and Modality Combination

	Words					Nonwords				
	C	0	3	15	63	C	0	3	15	63
AA	982	826†	887†	915†	966	1066	921†	999†	1048	1059
VA	982	951	936*	970	1023	1066	1100	1052	1046	1071
VV	1028	857†	868†	983*	989*	1119	969†	1054†	1027†	1118
AV	1028	968†	999	953†	1009	1119	1087	1097	1102	1111

†$p < .01$ *$p < .05$

in the lexicon that a and b will not affect performance in the CM condition for nonwords. Similarly, due to the ambiguous relationship between the pronunciation of each auditory and visual nonword, by E and S, respectively, it seems unlikely that c will influence performance in the CM condition for nonwords. Thus, a CM component may be expected for words but not nonwords.

Thus, the design used in the present experiment can be used to differentiate between the physical and conceptual components involved in the storage of modality information. The physical and conceptual components are both available in the IM word condition, the physical and conceptual components are available individually in the IM-nonsense and CM-word conditions, respectively, and the CM-nonsense condition provides a control in which neither component is available. Thus, comparisons between these conditions can be used to determine the locus of the memory effect.

METHOD

Subjects

Twenty-four undergraduates from the University of Toronto S pool participated in the experiment. They were paid $1.50 on completion of the single experimental session.

Design

A 2 by 4 by 2 by 4 by 10 factorial design was used. The factors were: material (words, nonsense), modality combination (AA, VA, VV, AV), presentation (first, repetition), lag (0, 3, 15, 63), and trials (1 to 10). AA indicates auditory presentation on the first and repetition trials.

The 320 repetition trials for each combination of the experimental conditions (material by modality combination by lag) occurred in each of 10 concealed blocks of 64 trials. The other 32 trials in each block were first presentations for subsequent repetition trials, and the overall probability of first presentations was .5. The first 96 trials comprised a run-in of 32 practice trials, which included no critical first presentation trials, followed by 64 trials including the necessary critical first presentation trials and filler pairs of items within the range of lags used in the experiment.

The order of the 32 conditions (material by modality combination by lag) was different for each of the 10 replication blocks within each of two formats. Twelve Ss completed each format.

Material

The words were common two-syllable nouns of 5, 6, 7, or 8 letters. The nonsense items were constructed by reversing the syllables in a parallel list of words. These were then checked to eliminate any meaningful reversals. No additional effort was made to control digrammatic probability in the nonsense list of items.

Procedure

The presentation rate was 4 sec/item. Visual items were exposed for 0.5 sec and followed by a blank interval of 3.5 sec prior to the next auditory or visual item. Two formats were drawn up, each format constituting a random sample of the words and nonsense items from the pool.

The visual items were prepared in lowercase on an IBM Selectric typewriter. For presentation, the list was inserted in the typewriter, and this was advanced by a solenoid attached to the return button. A Shibadan TV camera was focused on the return carriage, and Ss viewed the stimuli on a Shibadan monitor. The typewriter was advanced twice for each visual word, once to bring the item onto the screen and once to introduce the blank phase. The screen remained blank during the presentation of auditory words.

The auditory items were recorded in a female voice at intervals appropriate to the mixed-modality sequence. The auditory items were presented via a loudspeaker located immediately above the TV screen from one track of the stereo tape recorder. The auditory and visual sequences were synchronized by feeding tones, located for the visual items, from the second auditory track through a speech relay to the solenoid of the typewriter. A Uher diapilot system was used to start the clock at the onset of each auditory and visual word.

The experimental task was to decide accurately and quickly whether each stimulus was an English word. Ss gave their answers orally, saying *yes* if it was English and *no* if it was not. They did not have to name the word. RT was measured from the onset of each word, and the clock was stopped by S's vocal responses amplified from a microphone signal.

RESULTS

The results, shown in Table 1, indicate that when actual words were presented, the time taken for word recognition was faster on the repetition trial than on the first presentation trial when the two words were presented in the same modality (IM condition). As the repetition interval was increased, this effect declined. If the two words were presented in different modalities (CM condition), facilitation likewise occurred, but to a much smaller extent. For the nonsense sequences, the time required to say "no" was similarly facilitated on repetition trials if the two items were in the same modality, but was not at all faster if they were in different modalities. The magnitude of the RT facilitation in the IM condition was approximately the same for words and nonwords.

The amount of facilitation at each lag condition was

calculated by subtracting $\overline{RT}$ for each repetition (second presentation) condition from $\overline{RT}$ for the appropriate first presentation control condition. For example, facilitation in the AA-word and VA-word conditions was calculated by comparing $\overline{RT}$ at each lag of the AA- and VA-word conditions with $\overline{RT}$ for all first presentation auditory words. Similarly, $\overline{RT}$ for all first presentation visual words provided the comparison for the VV- and AV-word conditions. This procedure was adopted because a direct test of item-specific facilitation was precluded in the CM conditions.

The statistical analysis of the data was completed in two stages. These involved, first, a test of the facilitation effect in each experimental condition and, secondly, comparisons between the magnitude of the facilitation effects in the various IM and CM conditions. First presentation data were pooled to provide a stable estimate of baseline performance in the auditory-word, visual-word, auditory-nonword, and visual-nonword conditions. The repetition effects were then tested, following Winer (1962, p. 89), by comparing $\overline{RT}$ for each lag with $\overline{RT}$ in the appropriate control condition. For example, the repetition effect for words in the AA condition was tested by comparing $\overline{RT}$ at each level of lag with $\overline{RT}$ for first presentation auditory words. RT for each S was based on approximately 80 and 10 observations for the control and lag conditions, respectively. The data and the results of the statistical analyses are shown in Table 1. Significant facilitation occurred at Lags 0 and 3 in the IM conditions for both words and nonwords. The facilitation effect remained significant at Lags 15 and 63 in the VV-word condition and at Lag 15 in the AA-word condition. Facilitation effects in the CM condition for words were small, less than 75 msec, and not systematically related to lag. No significant facilitation occurred in the CM conditions for nonwords.

Differences between facilitation effects in the repetition conditions were tested by entering the facilitation values in an overall analysis of variance (Ss by material by second presentation modality by same/different by lag), where same/different refers to the relationship between the first and second presentation modalities. The results of the analysis showed that the main effects of same/different [$F(1,23) = 101.6$, $p < .01$], lag [$F(3,69) = 23.9$, $p < .01$], and the interaction between same/different and lag [$F(3,69) = 16.7$, $p < .01$] were significant. There were no other significant effects at the .05 level.

The error data, presented in Table 2, show that the error rate was reduced in the repetition conditions and that there were fewer errors in the same conditions for words but not for nonwords. The overall error rate was 1.11%.

Table 2
Error Rates for Words and Nonwords as Functions of Presentation and Modality Combination

	First Presentation		Second Presentation			
	A	V	AA	VA	VV	AV
Words	0.94	1.30	0.20	0.72	0.32	1.14
Nonwords	1.35	2.24	0.93	0.63	1.67	0.52

DISCUSSION

In general terms, the results provide further evidence that information about the modality of presentation of verbal stimuli persists in memory for a period which must be considered in tens of seconds or even minutes rather than milliseconds. Complementary evidence has previously been found in attribute report (Hintzman, Block, & Inskeep, 1973; Kirsner, 1974), where Ss can reliably report modality of presentation after several minutes, and in recognition memory (Kirsner, 1974), where recognition performance is superior in IM relative to CM conditions for similar periods.

What light do the present results throw on the locus of this information in memory? First, if modality information is stored only as one of a list of features in a common modality-free lexicon, there is no obvious reason why the sign of this feature should affect performance on a lexical task where the feature value, indeed the feature itself, is irrelevant. That is, in order to classify a stimulus as a word, S must examine the semantic or lexical status of the letter sequence, and whether or not the item has previously occurred with the same or different sensory features value is irrelevant to this task. Thus, while the report and recognition memory findings concerning the persistence of modality information may be based on a signed feature, this explanation does not readily account for the difference between the repetition effects found for words in the IM and CM condition in the word identification paradigm.

Secondly, while the presence of facilitation in the CM condition for words is consistent with the notion that activation occurs in a common lexicon, the presence of greater facilitation in the IM condition suggests that modality-specific information is having an effect prior to the convergence of information from the auditory and visual channels. Moreover, the finding that this effect is insensitive to the lexical status of the letter sequence indicates that the relevant modality-specific information is having an effect prior to the convergence of information from the auditory and visual channels. Moreover, the finding that this effect is insensitive to the lexical status of the letter sequence indicates that the relevant modality-specific information is retained in a part of the memory system distinct from the lexicon.

The relatively small facilitation effects found in the CM condition for words can be explained in several ways. While the present study did not set out to distinguish between these alternatives, it does show that negligible persistence effects occur in the common component irrespective of whether this is determined at a lexical or phonological level.

Thus, the results suggest that information about the modality of verbal stimuli is maintained in a separate memory component which is not involved with conceptual analysis. Activation of this component shows rapid fading over time, but still persists at least 64 sec after presentation. The pattern of the results supports the tentative conclusion that this system exists prior to both: (a) the convergence of information from the auditory and visual channels, and (b) lexical analysis.

A final question of interest concerns the manner in which the modality information is encoded. Is it represented in a sensory nonverbal form, or does it reflect intentional, abstract encoding in the long-term verbal memory system? In the present experiment, performance is in no way predicated on the retention of modality information. Moreover, there is no obvious way in which an abstract encoding of modality of presentation could selectively facilitate performance in the IM condition of the word and nonword identification task. Thus, the present results support a representational component in the retention of information about the physical features of verbal stimuli.

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