Journal of Experimental Psychology
1969, Vol. 79, No. 1, 39–42

EFFECTS OF IAR OCCURRENCE DURING LEARNING ON RESPONSE TIME DURING SUBSEQUENT RECOGNITION

JAMES HALL, ROBERT SEKULER, AND WILLIAM CUSHMAN
Northwestern University

Each of 20 *S*s was presented with two lists of words. In List 2 were (*a*) words strongly associated with certain words appearing in List 1 (E words), (*b*) words not associated with any List 1 words (control or C words), and (*c*) words repeated from List 1 (R words). For each List 2 word *S* indicated whether or not it had occurred in List 1. Speed for correct responses to C words was significantly greater than for correct responses to E words. Speed for correct responses to R words was significantly greater than for incorrect responses to E words. These results are interpreted by a model of recognition memory performance within a signal detection framework. Choice times are proposed as a useful index of the occurrence of implicit associative responses.

Underwood (1965) has proposed that when a verbal unit is perceived, the representational response (RR) made is likely to elicit an *implicit* associative response (IAR). In an experiment relevant to this hypothesis, Underwood (1965) presented a long list of words to college students who were instructed to identify any word that had appeared earlier in the list. Late in the list were several words that had not appeared earlier but were strong natural language associates of earlier appearing words and thus were expected to have occurred earlier as IARs with relatively high frequency. For example, "light" which appeared late in the list was expected to have occurred earlier as an IAR when "lamp" was presented. Based on this reasoning, it was expected that these associates (e.g., light) frequently would be falsely recognized as having occurred earlier. This prediction was confirmed: For three of the five classes of words used, false recognition of associates was reliably more frequent than for control words. Since then, several investigators have reported similar results, both with adults (Davis, 1967) and with children (Hall & Ware, 1968).

The present experiment was concerned with the occurrence of IARs that do *not* result in false recognitions. More specifically, can one conclude that words not falsely recognized did not occur previously as IARs? Or, as might be suspected, are *S*s often able to discriminate between a word that actually had been presented and one that had occurred only as an IAR? In other words, does false-recognition rate provide an underestimate of IAR frequency? To examine these questions, the response latencies for associates not falsely recognized were compared with those for control words (i.e., nonassociates not falsely recognized).

METHOD

Subjects.—The *S*s were 20 college students (7 males and 13 females) enrolled in an introductory psychology course at Northwestern University.

Design and procedure.—The word lists and the function of each word are shown in Table 1. The procedure for each *S* consisted of a single visual presentation of each of the 26 words in List 1 at a 5-sec. rate. The *S*s were instructed to pay attention to the words and to try to remember them, but that the order of the words was unimportant. Immediately following presentation of List 1, instructions for List 2 (the recognition list) were given. The *S*s were told that a second set of words would be presented, that some of the words on List 2 had appeared on List 1 and some had not, and that their task was to decide whether each word was "old" or "new" and to press a spring-loaded toggle switch accordingly. The interval between a response and presentation of the next word was 12 sec. All words were presented automatically on slides using a Kodak Carousel projector. List 2 contained four types of words:

Experimental (E) words were strong natural language associates of the critical stimulus (CS) words in List 1, but had not themselves appeared in List 1. The 12 E words are those expected to occur frequently during List 1 presentation as IARs to the CS words. This expectation was based on word association data published by Palermo and Jenkins (1964).

Control (C) words had not appeared in List 1 nor were they strong associates of any List 1 words. The 12 C words were equivalent in general frequency to the E words.

Repeated (R) words occurred in both lists and were valuable both for certain comparisons and to increase the face validity of the recognition task. Six R words were used.

Filler (F) words were inserted at the beginning and end of List 1 mainly to avoid any strong effects of serial position. The four F words at the beginning of List 2 provided warm-up trials. Six additional F words were interspersed within List 2.

The position of the 10 CS and 6 R words in List 1 was determined randomly and was identical for all *S*s. In List 2, E and C words were paired, with E words alternately appearing before and after the C words. Within each condition, words were randomly assigned to the various pairs.

Twelve *S*s pushed the toggle switch to the left for an old word and to the right for a new word. For the remaining eight *S*s this was reversed. Latencies were measured on a timer which could be read to the nearest hundredth of a second.

Results

The mean number of false recognitions per *S* was 2.70 for E words and 1.10 for C words. This difference of 1.60 is highly reliable, t (19) = 4.13, $p < .01$. This finding is consistent with the notion that the E words had occurred in the form of IARs during learning and that such occurrences may lead to their being falsely identified as having actually occurred in List 1. This result replicates previous findings (Davis, 1967; Underwood, 1965).

All response times were transformed to speeds by calculating the reciprocal of the latency in seconds. For each *S* the mean response speed was obtained for the last five F words to which *S* had responded correctly, i.e., judged the word to be "new." The overall means of these response speeds were .63 for the 12 *S*s who signalled new with a leftward switch throw and .70 for the 8 *S*s who used a rightward throw to signal new. The difference between these means did not approach statistical significance, t (18) = .20. Consequently, in all of the subsequent analyses to be described, data from *S*s in the two directions of switch throw are combined.

A major concern of this experiment relates to response speed differences between E and C words which were *not* falsely recognized. For each *S* the mean response speeds for E and C words judged new were obtained. The means of these means were .61 and .67, respectively. The difference be-

TABLE 1

Words and Their Functions

List 1 (Free Learning)				List 2 (Recognition)			
Word	Function	Word	Function	Word	Function	Word	Function
Music	F	Smart	R	Train	F	Pretty	C
Hand	F	Scissors	CS	Shoes	F	Cut	E
Tell	F	King	CS	Over	F	Baby	R
Smooth	F	Bed	CS	Moon	F	Come	F
Baby	R	High	CS	Mountain	R	Cook	C
Quiet	R	Slow	CS	Hammer	F	Woman	E
Blossom	CS	Bitter	CS	Fast	E	Low	E
Table	CS	Mountain	R	Read	C	Friend	C
Eagle	CS	Lamp	CS	Gold	C	Smart	R
Wish	R	Salt	F	Chair	E	Loud	F
Man	CS	Bath	F	Wish	R	Flower	E
Cry	R	Gun	F	Closer	F	Dry	C
Long	CS	Ocean	F	Dog	C	Street	C
				Light	E	Sweet	E
				Queen	E	Cry	R
				House	C	Thirsty	F
				Quiet	R	Fruit	C
				Mow	F	Short	E
				Bird	E	Sleep	E
				Strange	C	Warm	C

tween means was highly reliable, t (19) = 4.50, $p < .01$.

A second comparison of interest was that between R and E words judged "old." For those 16 *S*s who judged at least one E word old, the mean response speed was .68 for the R words and .48 for the E words. This difference was also highly reliable, t (15) = 3.81, $p < .01$.

Discussion

There are two sets of response-time relationships in this experiment that require consideration. The first relationship is that, on the average, *S*s take longer to make the response new to E words than they do to C words. The second is that *S*s take longer to make the response old to E words than they do to R words. Both these findings can be interpreted by a model of recognition memory performance which is merely a slight modification of one already described by Egan (1958) and Parks (1966). Assume that when a given word is presented to *S* in an experiment it is accompanied by the registration of its perceived "familiarity" or "oldness." Evidence on the ability of *S*s to judge the frequency with which words have occurred outside the laboratory (Underwood, 1966, pp. 177–179) supports this proposition. Prior to the presentation of List 1, the distributions of perceived frequency for the E, C, and R words will be essentially identical. This simply asserts that such words did not differ appreciably in their frequency of occurrence in the prior extralaboratory experience of the present *S*s. The presentation of the R words during List 1 may be expected to increment the mean perceived familiarity of each of the R words. In terms of the model being proposed, the distribution of perceived familiarity for the R words will be shifted somewhat toward the higher end of the continuum for perceived frequency. Further assume that the production of IARs during the presentation of List 1 increases the perceived frequency of the E words but that, on the average, this increment is not as great as that given to the R words. This means that, immediately after the presentation of List 1, three partially overlapping distributions arrayed along the perceived frequency continuum may be considered. These are, in order of increasing mean perceived frequency, the distributions associated with C words, E words, and R words. As with models of verbal recognition performance derived from the theory of signal detectability (Swets, Tanner, & Birdsall, 1961), the authors assume that *S* establishes a criterion on the perceived frequency axis. On any given recognition trial if the perceived frequency exceeds that criterion value, the word is judged old; if the perceived frequency on some trial is less than the criterion value, the word is judged new. The probability of false recognitions, i.e., old responses for C and E words, will depend on the area of the C and E distributions which exceed the criterion value.

A number of models have been proposed which use the concepts of signal detection theory to explain and predict various choice-time relationships in psychophysical situations (Bindra, Williams, & Wise, 1965; McGill, 1963; Sekuler, 1965, 1966). In keeping with such models, the authors propose the following simple mechanism for relating decision time to perceived oldness: The speed of judgment is a function of the distance between the criterion and the perceived frequency of a word in the recognition phase. This means that words with perceived frequency far in excess of the criterion value will be judged old more rapidly than words with perceived frequency only slightly in excess of the criterion value. Words with far less than the criterion value of perceived frequency will be judged new more rapidly than words whose perceived frequency is only slightly less than the criterion value. It will be recognized that this is simply a way of describing, somewhat mechanically, the well-known relationship between the difficulty of some discrimination and its associated decision time (Woodworth & Schlosberg, 1954, pp. 32–35). If the distributions of perceived frequencies for C, E, and R words are indeed arrayed along the perceived-frequency axis as described above, the mean location of those perceived frequencies exceeding the criterion in each distribution will increase as one goes from C to E to R distributions. Following the rule relating distance from criterion to decision time, the mean time to judge words old should decrease as one goes from C to E to R words. While there was not a sufficient number of old responses to C words in the present experiment to get a stable estimate of mean decision times associated with such cases, it was found that *S*s took longer to judge E words old than they did to judge R words old. Again, for each of the three distributions, the mean for words having perceived frequency less than the criterion increases in distance from the criterion as one goes from R to E to C. Following the choice-time rule given above, the mean time taken to judge words new should decrease from R- to E- to C-type words. It will be recalled that this study did find that *S*s took longer to make the response new to E words than they did to C words. Too few new responses were made to R words to permit estimation of the associated decision times.

Whatever the long-term utility of the above descriptive model, the response-time data clearly show that false-recognition rate does not fully reflect the rate with which the words have occurred as IARs. The fact that *S*s took longer to judge E words new than to judge C words new indicates that they frequently were able to distinguish correctly between the explicit vs. the implicit occurrence of a word, or between the word's occurrence as an RR vs. as an IAR. Whatever the bases for this discrimination, it appears that they are related to age: Hall and Ware (1968) have reported a higher rate of IAR-produced false recognition by 5- and 6-year-olds than by 8- and 9-year-olds. The alternative interpretation—that IAR production was greater for younger *S*s—seems highly unlikely in view of current concepts of verbal development.

REFERENCES

BINDRA, D. B., WILLIAMS, J. A., & WISE, J. S. Judgments of sameness and difference: Experiments on decision time. *Science,* 1965, **150,** 1625-1627.

DAVIS, G. A. Recognition memory for visually presented homophones. *Psychological Reports,* 1967, **20,** 227-233.

EGAN, J. P. Recognition memory and the operating characteristic. Technical Report No. AFCRC TN-58-51, AD-152650, June 1958, Indiana University, Hearing and Communication Laboratory.

HALL, J. W., & WARE, W. B. False recognition in children produced by implicit associative responses. *Journal of Experimental Child Psychology,* 1968, **6,** 52-60.

MCGILL, W. J. Stochastic latency mechanisms. In R. D. Luce et al. (Eds.), *Handbook of mathematical psychology.* Vol. 1. New York: Wiley, 1963.

PALERMO, D. S., & JENKINS, J. J. *Word association norms.* Minneapolis: University of Minnesota Press, 1964.

PARKS, T. E. Signal-detectability theory of recognition-memory performance. *Psychological Review,* 1966, **73,** 44-58.

SEKULER, R. W. Signal detection, choice response times, and visual backward masking. *Canadian Journal of Psychology,* 1965, **19,** 118-132.

SEKULER, R. W. Choice times and detection with visual backward masking. *Canadian Journal of Psychology,* 1966, **20,** 34-42.

SWETS, J. A., TANNER, W. P., & BIRDSALL, T. G. Decision processes in perception. *Psychological Review,* 1961, **68,** 301-340.

UNDERWOOD, J. J. False recognition produced by implicit verbal responses. *Journal of Experimental Psychology,* 1965, **70,** 122-129.

UNDERWOOD, B. J. *Experimental psychology.* New York: Appleton-Century-Crofts, 1966.

WOODWORTH, R. S., & SCHLOSBERG, H. *Experimental psychology.* (2nd ed.) New York: Holt, Rinehart & Winston, 1954.

(Received January 10, 1968)