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Memory and encoding in a letter-matching reaction time task

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Thirty subjects participated in a letter-matching reaction time task requiring physical identity and vowel/consonant judgments. Stimulus onset asynchronies (SOAs) of 100, 200, and 500 msec were used. For the continuous group, the first letter remained on through the trial; for the discrete group, the first letter was presented for 50 msec; for the white field group, the first letter was presented for 50 msec followed immediately by a 40-msec white field. In all groups, physical matches were faster than vowel/consonant matches. Reaction times for the continuous and discrete groups decreased to a minimum at 500 msec SOA. For the white field group, fastest reaction times occurred at 100 msec and increased to a maximum at 500 msec SOA. The difference in functions was attributed to differential memory demands in the groups.

Reaction times (RTs) in a binary decision task have been used by Posner and his associates (e.g., Posner, 1969; Posner & Boise, 1971; Posner, Boise, Eichelman, & Taylor, 1969) to examine encoding processes. In a typical task, two letters are presented in close succession and the subject must judge whether or not they represent a match by pressing an appropriate key. Three different dimensions have been used at various times to define a match. First, a physical match indicates the physical identity of the two letters, e.g., A and A. Second, a name match indicates the same verbal label but not necessarily physical identity, e.g., A and a. Third, a vowel/consonant match indicates that both letters are members of the same phonological class, e.g., A and E, or M and R.

Posner and Boise (1971) reported that RTs increased with increased complexity of the judgment, physical matches requiring the least and phonological matches the most time. For all three match dimensions, the lowest RTs occurred when the stimulus onset asynchrony (SOA) was 500 msec, with greater and lesser SOA values associated with longer RTs. In their procedure, both letters remained visible during the trial from the time each was presented until a response was made. The memory requirements of the task were, therefore, of a relatively minimal nature. In the present study Posner's procedure was slightly modified in an attempt to have the subject place the first stimulus in memory.

METHOD

Thirty Sacramento State introductory psychology students fulfilling a course requirement were run on an Iconix No. 6137 tachistoscope. All subjects had normal or corrected vision. The stimuli were black on white upper case letters 1.91 cm high and .48 cm thick. All letters except Q (because of its potential confusion with the letter O) and Y (because of its potential confusion as a vowel) were used.

For subjects in each of the three groups, letter pairs were presented at SOAs of 100, 200, and 500 msec for physical and vowel/consonant matches. The six SOA-match combinations were run in 20-trial blocks, one combination per block, with block order randomized for subjects within a group and yoked across groups. Thus, a single order of trial blocks was experienced by one subject in each group. In each physical match trial block 10 matched and 10 nonmatched letter pairs were randomly presented. In each vowel/consonant match condition five pairs of each possible letter array (vowel-vowel, consonant-consonant, vowel-consonant, consonant-vowel) were randomly presented.

All subjects were tested individually in a dimly illuminated room following 15 min of dark adaptation. Thirty practice trials were run, 10 on the physical and 20 on the phonological judgment, i.e., five trials on each possible type of letter combination for each kind of match.

A trial began with the experimenter verbally signaling the subject, followed by a 50-msec exposure of a blank stimulus card. This 50-msec exposure allowed subjects to fixate in the direction of the stimulus field and constituted a warning signal for the appearance of the first letter. The first letter occurred 500 msec following the warning signal. Second letter onset started a Hunter digital Klockounter (No. 220-C). Subjects pressed one switch with their right hand and another with their left to indicate a match or nonmatch judgment. The hand corresponding to a particular judgment was counterbalanced across subjects. Depressing the switch both stopped the clock and terminated the visual display. The intertrial interval was 20 sec, with 5-min intervals between each trial block.

Three independent groups were distinguished only on the "fate" of the first letter. For the continuous group, the first letter once presented remained visible throughout the entire trial, which essentially duplicated the procedure used by Posner and Boise (1971). For the discrete group, the first letter was presented for only 50 msec followed by the normally dark field until the next letter was seen. It would thus be possible for these subjects to maintain an iconic representation of the first letter. For the white field group, the first letter was presented for 50 msec and was immediately followed by a blank white field for 40-msec duration. The field then became dark until the second letter was presented. It was expected that the illuminated

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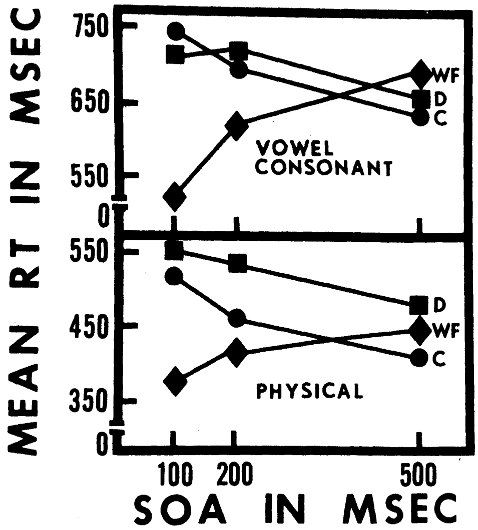

Figure 1. Mean RTs as a function of SOA for the continuous (labeled as C), discrete (labeled as D), and white field (labeled as WF) groups performing physical and vowel/consonant letter matches.

field would disrupt the iconic storage of the first letter. To minimize errors, subjects in this group would presumably need to transfer first letter information into a more stable memory store.

RESULTS

For each of the three groups, the error rate approached 0%. The primary results of the experiment are shown in Figure 1. For each of the three groups, vowel/consonant judgments yielded higher RTs than the physical judgments, although for each group the function over SOAs in each type of judgment are quite similar. Subjects in both the continuous and discrete groups responded with greater speed as SOA increased to 500 msec. By contrast, subjects in the white field group responded more rapidly at 100-msec SOA and increased their RT as the SOA increased to 500 msec. All of these differences were substantiated by F ratios significant at better than the .01 level of confidence.

DISCUSSION

The present results for the continuous and discrete groups essentially replicate the data reported by Posner and Boise (1971). In both cases, phonological matches require more time than physical matches, and both demonstrate optimal encoding times of 500 msec, although this represented the upper limit of our SOA range. Posner and Boise suggested that the interval between the two letters reflects the transformation of information contained in the first signal into a convenient form for processing the second signal. Improvement in performance as the interval increases presumably indicates a continuation of the transformation process until some optimal form is achieved after 500 msec. The nature of these transformations or a description of the optimal transformational form was not outlined.

While subjects in the white field group also showed greater RTs on the vowel/consonant than on the physical judgment, the encoding function for this group was of a completely different shape. This latter finding indicates, at the very least, that Posner's general analysis (e.g., Posner, 1969; Posner & Boise, 1971) is somewhat limited to the procedures he has used to study encoding. The primary difference between the white field condition and the others is that the former can be considered more of a memory condition than the latter, on the assumption that iconic storage of first-letter information was either partially or wholely disrupted by the white field. In order to retain information regarding the first letter, subjects perhaps transferred this information into primary memory. Once in primary memory, coding processes would operate on the information rapidly and efficiently. Overall differences between the white field procedure and the other generally comparable procedures would, then, suggest that a more rapid rate of processing occurs for information intentionally transferred into primary memory. Information still peripherally available, as in the continuous and discrete conditions, may be processed at a less rapid rate, perhaps because the system is attempting to process portions of the physical display that are unrelated to the task at hand as well as trying to encode the information in a form most useful for comparison with the soon to be presented second letter.

Under the white field procedure, RTs increased with increases in the SOA. We may speculate that first letter information once placed into primary memory undergoes continued and, from the point of view of the task, largely irrelevant processing. When the second letter is presented, the relevant data must be retrieved from a relatively large set of information. As the SOA increases, the subject must retrieve task relevant information from an increasingly larger set, thereby requiring increasingly more time. Since the encoding functions of all three groups in the study tended to converge in RT at 500 msec, we can assume that those factors reducing the efficiency of processing are of approximately equal magnitude at this particular interval.

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