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ABSTRACT

In a poststimulus cueing task subjects reported either the identity of items or their category membership. Results indicated that readout from Visual Information Storage (VIS) is not selective for conceptual categories. Rapid conceptual categorization of the type found in visual search experiments probably occurs at a processing stage subsequent to VIS readout. Another experiment demonstrated that subjects report category more accurately than identity when stimulus duration is 2 seconds, although there is no difference at .2 seconds. At the longer duration, superiority of category reports was correlated with subjective reports of processing strategy, suggesting that rapid categorization occurs when subjects encode and store information by category immediately after VIS readout. (Author/BJG)

Poststimulus cueing and conceptual categorization of visual information[1]

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Visual search experiments indicate that categorization of symbols can be a rapid process occurring prior to or without identification (Brand, 1971; Ingling, 1971, 1972; Jonides & Gleitman, 1972; Sperling, Budiansky, Spivak, & Johnson, 1971) and that such categorization can depend on conceptual differentiation and not on differentiation by the physical characteristics of the items (Ingling, 1972; Jonides & Gleitman, 1972). These experiments indicate the operation of a very rapid perceptual categorizing mechanism.

At what perceptual processing stage does rapid categorization occur? That it occurs prior to or without identification seems to indicate an early stage. The earliest stage to consider is scan from visual information storage (VIS), also called Iconic Storage or Sensory Register. Although the evidence is strong that items can be selected on the basis of physical characteristics such as location or color during scan from VIS, the evidence appears to conflict as to whether items can be selected from VIS on the basis of conceptual category. Three experiments testing this (Dick, 1969; Sperling, 1960; Von Wright, 1970) used poststimulus cues to indicate that Ss were to report either letters or digits. Dick's results

are inconsistent with those of Sperling and Von Wright. Sperling's and Von Wright's results indicate that items in VIS cannot be selected and scanned on the basis of conceptual category, for partial reports are not superior to whole reports. Dick's results, however, show that partial reports are superior to whole reports and, moreover, that partial report accuracy does not decrease as a function of cue delay as it usually does when selection is based on other characteristics.

A variation of the poststimulus cueing technique was used to resolve the conflict of Dick's results with Sperling's and Von Wright's. In these three experiments, cues indicate which category S should report, letters or digits, and responses are always identification of the items. Sperling and Von Wright predicted that if Ss are able to selectively scan items from VIS on the basis of conceptual category, then partial reports would be superior to whole reports. The present method uses cues to indicate which row of items S should report rather than which category. Under one condition S identifies the items in the row, but under another condition he reports only their categories. If we grant for the moment that Ss are able to selectively scan items from VIS on the basis of category, then reporting only category should be easier than reporting identify; when reporting the category there is less information per item, and fewer items need to be scanned. Category information will always require transmission of less information than item identity, since by definition there are fewer alternative categories than items comprising those categories. In the case of only two categories, letters and digits, only one bit of

information per item is needed. S could even consider one category as target items. Given a row of four items, two letters and two digits, S could consider digits as targets and scan only the locations of two digits from VIS, but he would report the category and location of all four items correctly. In contrast, when reporting identity, S must scan all four items and remember both location and identity.

Assuming from Sperling's (1963) model that information transmission is limited by scan rate from VIS and that scan rate remains constant under these conditions, then Ss who can selectively scan from VIS by conceptual category should report category more accurately than identity, and category performance should be superior in the proposed design. If Ss are not able to scan items from VIS selectively on the basis of conceptual category, then all four items must be scanned in both conditions and no difference in performance would be predicted.

The crucial test here is to vary the type of report to see if category reports are superior to identification reports. Poststimulus cueing by location was used to measure the information available in VIS.

PRELIMINARY EXPERIMENT

A preliminary experiment was done to test whether the rapid categorization found in search paradigms occurs when conditions are closer to those of poststimulus cueing, i.e., when stimulus duration is brief rather than prolonged, the task is recall rather than recognition, and the independent variable is the type of report rather than the stimulus properties. If there is significant variation among Ss in categorizing ability, this

experiment selects rapid categorizers for use in the Main Experiment.

Method

Subjects. The Ss were four men and six women with normal vision or vision corrected to normal.

Apparatus. A two-channel rear-projection tachistoscope with Uniblitz shutters was used. An Iconix timer controlled the shutters. The common source for both channels was a 500 w tungsten projection lamp. The background luminance was .17 cd/m^2; the luminance of the stimulus field was 100 cd/m^2. The fixation point was a low-contrast line drawing of a square on the back of the flashed opal rear-projection screen, subtending a visual angle of about 6 min and centered in the display. Each channel contained a 0-2 Inconel neutral density wedge in a plane conjugate to the source, thus avoiding any luminance gradient upon the viewing screen. The shutters were also in this plane.

Ss used a chin rest and viewed the field monocularly. They wrote their responses on a roll of paper tape, initiating each trial by depressing a button with the left hand. E selected stimuli with a manual slide changer.

Stimuli. Stimuli were 120 2 × 2 slides, each containing three rows of four symbols. White dry-transfer symbols (Deca-dry, Futura Bold, 96 pt capital letters, and arabic numerals) were mounted individually on black cards and photographed. The negatives were hand mounted in Kodak Ready-Mounts to assure good registration. Each symbol subtended a visual angle of .63 deg vertically. The entire matrix of 12 symbols

subtended a visual angle of 5.37 deg vertically and 3.13 deg horizontally.

Symbols were selected randomly with replacement from a set of the eight letters, A, B, C, G, S, Z, P, J and the eight digits 2, 3, 4, 5, 6, 7, 8, 9 with the restrictions that (1) the same symbol occur not more than once in a row, and (2) the same symbol never occur in two vertically adjacent positions. The eight letters were selected on the basis of general similarity of their physical features to those of the eight digits.

Upon each initiation of a trial by S, the stimulus appeared after .5 sec and remained on for 2 sec.

Design and Procedure. Each S served in both the Identification Condition and the Categorization Condition within a single session. In the Identification Condition Ss were instructed to report the 12 stimulus items in corresponding positions on a paper tape, responding for every item. S then advanced the tape so that his responses were not visible to him.

In the Categorization Condition Ss were asked to write an × in each position corresponding to that of a digit and a dash in each position corresponding to that of a letter. To encourage rapid categorization, E suggested that Ss consider digits as targets and focus on reporting the positions of these targets. E also stated "you do not need to notice what letters or numbers are there; you only need to notice which positions contain numbers."

The first three Ss participated in three sessions each. Since there was no consistent change in performance over these sessions, each of the remaining seven Ss participated in only one session.

In each of the two conditions there were 30 practice trials, followed by 60 test trials. Order of conditions was counterbalanced. Order of slide presentation was varied over Ss and over conditions.

Percent correct was determined for each S in each condition and the appropriate linear chance correction was used for each condition, $p_i = (p_i' - .50)/.50$ for the Categorization Condition, and $p_i = (p_i' - .06)/.94$ for the Identification Condition, where p_i is the true probability and p_i' is the observed probability (see Blackwell, 1963).

After each S completed the experiment, E asked him to describe how he had performed the categorization task, and then asked S whether or not he identified the items.

Results

A one-tailed t-test showed that even after chance corrections Ss responded correctly more often in the Categorization Condition than in the Identification Condition [$t(9) = 1.92$, $p < .05$]. The mean number correct was 7.8 items in the Categorization Condition and 6.5 items in the Identification Condition after corrections for chance.

Subjective reports were correlated with relative performance in the two conditions; the Spearman Rank Correlation Coefficient was $r_s(10) = .78$; $p < .01$. That is, the greater his advantage in the Categorization Condition, the more likely was S to report that he did not identify items specifically. These Ss described their processing method as encoding stimuli into a set of dashes and x's, which they remembered until writing their responses. Ss who showed little or no advantage in the

Categorization Condition, however, said that they did identify the numbers and letters specifically and remembered them by their identity until writing the responses.

Discussion

Results show that even when conditions are similar to those of a poststimulus cueing task and very different from those of the visual search experiments, Ss are more accurate at categorizing than identifying. Therefore it seems feasible to use a poststimulus cueing task to investigate rapid categorization.

Subjective reports indicate that rapid categorization, in this case categorization which is more accurate than identification, tends to occur when S can avoid identifying items and can remember them as a pattern of dashes and x's, but rapid categorization tends not to occur when S identifies items and attempts to remember the identity, encoding into dashes and x's as the response is made.

Since some Ss may be more capable of rapid categorization than others, Ss who show relatively large advantages in categorization in the Preliminary Experiment were used in the Main Experiment. This should maximize the probability of finding an effect if it exists.

MAIN EXPERIMENT

If it is possible for Ss to scan selectively from VIS on the basis of conceptual category, then the poststimulus cueing function for reports by category should lie above that for reports by identity. If Ss cannot scan selectively from VIS on the basis of conceptual category, there

should be no difference between the two functions.

Method

Subjects. Three Ss were selected who showed large advantages in categorization compared to identification in the Preliminary Experiment. These were 2 female and 1 male graduate students. They were not informed of the purpose of the experiment until all data had been collected.

Apparatus. The apparatus from the Preliminary Experiment was used with the addition of auditory cue apparatus. For two Ss the auditory cues were produced by two Sonalerts of 2900 Hz and 4500 Hz sounded singly or together, thus producing three different sounds. Since the third S could not reliably discriminate among the Sonalert sounds, auditory cues for him were produced by three single-frequency audio oscillators at frequencies he could easily discriminate.

Stimuli. Stimuli were those used in the Preliminary Experiment, but stimulus duration was decreased from 2 to .2 sec.

Design and Procedure. As in the previous experiment, each S served in Identification and Categorization Conditions. However, in this experiment S gave whole reports and also partial reports, which were cued at various time intervals. Stimulus duration was .2 sec rather than 2 sec.

For partial reports S reported only one row of stimulus items after a tone indicated which row to report. The high frequency tone indicated the top row; the middle or combined frequency tone, the middle row; and the low frequency tone, the bottom row. Onset of the tone occurred at any of four interstimulus intervals (ISI) with respect to offset of the visual

stimulus: -400, 0, +400, or +800 msec. For whole reports there was no cue and S reported all 12 items. The whole reports differed from those in the Preliminary Experiment only in stimulus duration.

Onset of the visual stimulus occurred .5 sec after S pressed a button to initiate a trial.

The 120 slides were divided into four sets of 30, and order of set presentation was balanced across test sessions. The four different ISIs were presented in blocks of 30 trials at each ISI, and the order of these was also balanced across test sessions and across slide sets.

The order in which auditory cues are presented can be critical since the poststimulus cueing design requires that the cues produce a random sample of information available to S. Each cue should occur equally often to avoid biasing Ss and to facilitate statistical analysis. Second, short permutations of cues which might allow a greater-than-chance probability of guessing the cue should be avoided. Third, order of presentation must vary sufficiently to avoid learning the order of cues. One obvious method of satisfying these three requirements, namely, the use of many different long permutations, would make hand-scoring cumbersome. Therefore, random permutations of three tones each occurring 20 times were divided into two lists of 30 items each, and six of these 30-item lists were used in random order to determine order of presentation for a single session. Thus each tone was presented an equal number of times, short permutations were avoided, the order was varied, and scoring was not difficult.

Each S participated in eight 1-hr sessions: four sessions in one

report condition, then three sessions in the other report condition, then one session with both conditions to provide a within-session comparison. Sessions 3, 4, 6, 7, and 8 were primarily test sessions; Sessions 1, 2, and 5 were practice sessions.

Session 1, a practice session, consisted of familiarization with the three tones until S recognized them quickly and correctly on every trial. This was followed by 60 trials in the whole report condition and three blocks of 30 partial report trials, each block at a different ISI.

All subsequent sessions began with a brief familiarization with the tones followed by blocks of 30 test trials. Ten practice trials in the appropriate stimulus parameters and response condition preceded every block of trials.

Sessions 2 through 7 contained one block of whole reports, then one block at each of the four ISIs, then another block of whole reports. Session 8, providing the within-session comparison of conditions, consisted of a block of whole reports followed by a block of partial reports at each of two ISIs, -400 and +800 msec, in each of the two experimental conditions. For each S, order of report conditions was reversed from the order used in earlier sessions.

Instructions were similar to those of the previous experiment except that in the partial report condition Ss wrote only 4 responses instead of 12. In place of the two unreported rows on each trial S placed a long dash. Thus, accuracy of response to the cues could be determined.

Results

Figure 1 shows the mean number correct after linear chance corrections as a function of ISI for the two report conditions. These poststimulus cueing functions are not unusual for cueing by location, nor is the level of whole report unusual (see Clark, 1969; Dick 1969; Sperling, 1960; Turvey & Kravetz, 1970; Von Wright, 1968).

In partial report conditions Ss reported a line other than the cued line on about 6% of the trials, producing a slight underestimate of information available to Ss in the partial report conditions.

A three-way analysis of variance (Report Condition × S × ISI) for partial report data showed that Ss did not perform significantly better in the Categorization Condition than in the Identification Condition. The only significant main effect was that of ISI [$F(3,6) = 59.2$; $p < .01$]. The significant interactions were the ISI × S interaction [$F(6,24) = 5.66$; $p < .01$] and the three-way interaction [$F(6,24) = 9.44$; $p < .01$].

A separate three-way analysis of variance, which eliminated data from -400 msec ISI, showed that the main effect of ISI is significant beyond the .10 level when cues occurring before stimulus offset are not considered [$F(2,4) = 5.47$].

A t-test on the whole report data showed that after chance corrections Ss responded no more accurately in the Categorization Condition than in the Identification Condition [$t(2) = .28$; $p > .30$]. The mean number correct was 4.7 items in the Categorization Condition and 4.4 items in the Identification Condition. Figure 2 shows whole report data from

this experiment (2.0 sec) and from the Preliminary Experiment (.2 sec).

A within-session comparison of conditions in Session 8 is consistent with the data from the intersession comparisons above. Since there were relatively little data and the S effect above was negligible, data for the three Ss were pooled to form a two-way analysis of variance, Report Condition × ISI. The only significant main effect was that of ISI [$F(1,8) = 104.0$; $p < .01$]. The interaction was not significant. The within-session comparison of whole reports also showed no significant difference between the two report conditions [$t(2) = .55$; $p > .30$].

In short, there were no significant effects of report conditions for either whole reports or partial reports. There were significant effects of ISI in partial report conditions.

Discussion

Results of these experiments show that (1) partial reports are no more accurate when only category is reported than when identity is reported (Main Experiment); (2) when whole reports are required at 2-sec stimulus durations, relative advantage in categorizing is correlated with subjective reports of encoding strategy (Preliminary Experiment); (3) there is an advantage in categorizing when stimulus duration is 2 sec, but no advantage at .2 sec (both experiments). The results suggest answers to two questions but raise a third question.

Can Ss Scan Selectively from VIS by Conceptual Category? For partial report data in the Main Experiment, report condition is not a significant effect. This indicates that Ss do not select and scan from VIS

on the basis of conceptual category, supporting Sperling's and Von Wright's results. Dick's results appear to be contradicted, but his work requires careful examination since his methodology differs and his interpretation is unique.

Probably the most important difference in methodology is that Dick does not compare partial reports with whole reports of the type used in this research and in the literature in general. Whole report usually refers to a condition in which S has been instructed before a block of trials to report all the items from the entire stimulus field. No cues are used. Whole report level then provides a baseline at the immediate memory level from which to measure the additional information available to S at very brief intervals after stimulus offset. This additional information is a measure of the capacity of VIS.

Dick, however, used a "delayed whole report." By this, he means that one of the poststimulus cues instructs S to report the entire stimulus array. Dick's delayed whole reports, like partial reports, are cued at various time intervals and are interspersed with other cues so that S does not know until the cue occurs whether a whole report or partial report will be required. Thus, delayed whole reports provide not a constant immediate memory level baseline but a function that varies with time of the cue onset, and the difference between partial reports and delayed whole reports is not a measure of VIS capacity.

It is not clear what is measured since such delays of instructions and interspersal with partial reports introduce variables not present in

standard whole reports. Delay of instructions until after the stimulus offset should impair performance in comparison with standard whole reports, thereby increasing the apparent difference between partial and whole reports. Also, delayed whole reports in effect compete against partial reports in such a way that effects of bias, set, or expectancy could be crucial in comparing report accuracy.

Dick's data show that partial report accuracy in the category condition does not decrease as a function of cue delay, but remains above whole report accuracy even to the 850-msec delay when VIS should have dissipated. Factors besides delayed whole reports that might elevate partial reports above whole report level in Dick's experiment are his failure to make chance corrections (Ss have 1 chance in 8 of a correct guess when cues refer to category, but only 1 chance in 16 when whole reports are given) and, possibly, predictability of cues. Cue predictability could be a factor since stimuli were presented in blocks of 24 trials where each of three cues occurred exactly once at each of eight time intervals.

Another difference in procedure is that Dick used relatively unpracticed Ss and verbal reports; Sperling, Von Wright, and the Main Experiment, above, all used practiced Ss and written reports.

In addition to an unusual methodology, Dick interprets his results differently than others who have shown poststimulus cueing functions, but predictions made for the Main Experiment, above, hold in either case.

Rather than concluding that Ss can select and scan from VIS on the

basis of conceptual category, Dick argues on the basis of Atkinson and Shiffrin's (1968) model that when cues refer to conceptual category Ss scan nonselectively out of a sensory register (SR), which is similar to VIS, but this scan occurs more quickly than when cues refer to physical information such as location or color. The information is transferred from SR into a short-term storage (STS) where it is classified after it is identified, and items are selected for rehearsal, reducing memory load and increasing accuracy. As Dick interprets his data, the benefit of partial report lies in STS, not in selective readout SR, and the benefit of category lies in faster scanning from SR.

The prediction for the Main Experiment, then, would be that S will scan information equally fast from SR into STS in both the Categorization and the Identification Conditions since both involve location. In the Categorization Condition he will select items for rehearsal in STS, thereby reducing memory load and increasing accuracy. In the Identification Condition he will attempt to rehearse all information nonselectively. Therefore, performance in the Categorization Condition will be superior to that in the Identification Condition. The Main Experiment, above, contradicts these predictions since no difference occurs between conditions.

<u>At What Stage in Processing Does It Now Appear that Conceptual Categorization Occurs</u>? It seems that conceptual categorization does not occur before or during readout from VIS. Visual search experiments indicate that categorization can occur at an early stage even before or in place of identification. If implications from these two lines of research

can be combined, then the range of processing stages in which categorization occurs has been narrowed.

Subjective reports of the Preliminary Experiment pinpoint the effect at an encoding step in which visual information is encoded into another form, either a visual pattern of X's and dashes, or a verbal naming code. Such an encoding step falls within the expected range. Also, it is a plausible locus of conceptual categorization for both search tasks and recall tasks. In both cases encoding into category would lead to a reduction in information which should simplify processing at subsequent steps and should improve performance.

Such a mechanism for rapid categorization has been proposed previously (Ingling, 1971). It may also apply to memory-search tasks, for Lively and Sanford (1972) have used a Sternberg memory-search task and shown that memory search is faster when positive and negative set items are from different categories than when they are from the same category. A category difference increases the rate of memory search, but rate of processing for presearch and postsearch stages does not vary. This evidence is consistent with the idea that when there is a category difference a special encoding strategy can facilitate search.

Why Does Rapid Categorization Occur for Whole Reports at a 2-Sec Stimulus Duration, but Not at a .2-Sec Duration? This problem needs further research. One possibility is that the number of items reported is a critical variable rather than duration itself. At the .2-sec duration Ss were able to report about four items correctly, a number within the span

of immediate memory. At the 2-sec duration, Ss reported six to eight items correctly, a number beyond the immediate memory span. Sperling (1963) has shown that letters up to the immediate-memory span are scanned from VIS much more rapidly than are subsequent letters. The later items, which are scanned more slowly, may be influenced by variables such as conceptual category which are irrelevant to the rapidly scanned initial items.

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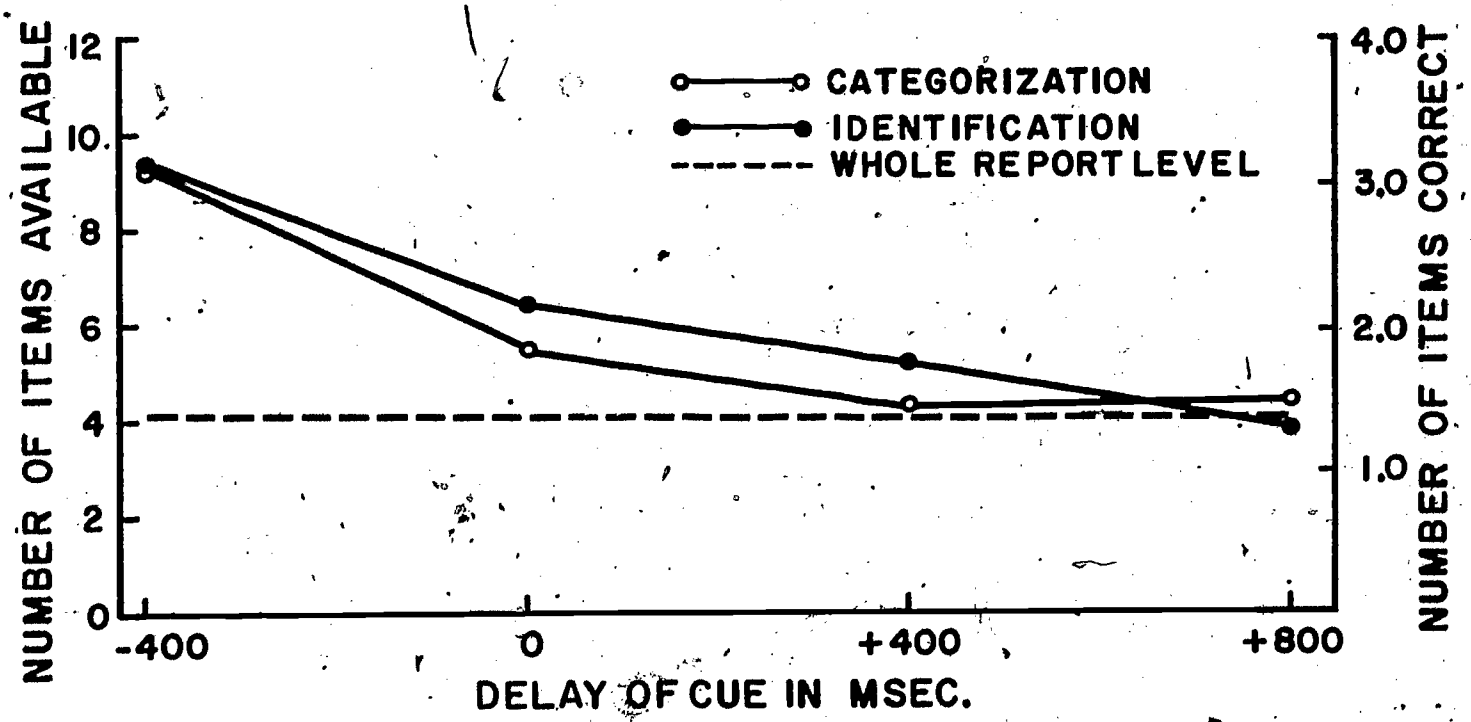
NOTE

1. These results were reported at the Annual Meeting of the Psychonomic Society, Boston, November 1974.

Figure Legends

Fig. 1. Number of items available in VIS (left axis) and mean number of items correct after linear chance corrections (right axis) as a function of interval between offset of test stimulus and onset of cue. Data are for partial reports from all Ss in Sessions 3, 4, 6, and 7 of the Main Experiment. Each data point represents 180 trials.

Fig. 2. Mean number of items correct in whole report conditions after linear chance corrections as a function of stimulus duration. Data for .2 sec are from the Main Experiment; data for 2.0 sec are from the Preliminary Experiment.


NUMBER OF ITEMS AVAILABLE
12
10
8
6
4
2
0
CATEGORIZATION
IDENTIFICATION
WHOLE REPORT LEVEL
4.0
3.0
2.0
1.0
NUMBER OF ITEMS CORRECT
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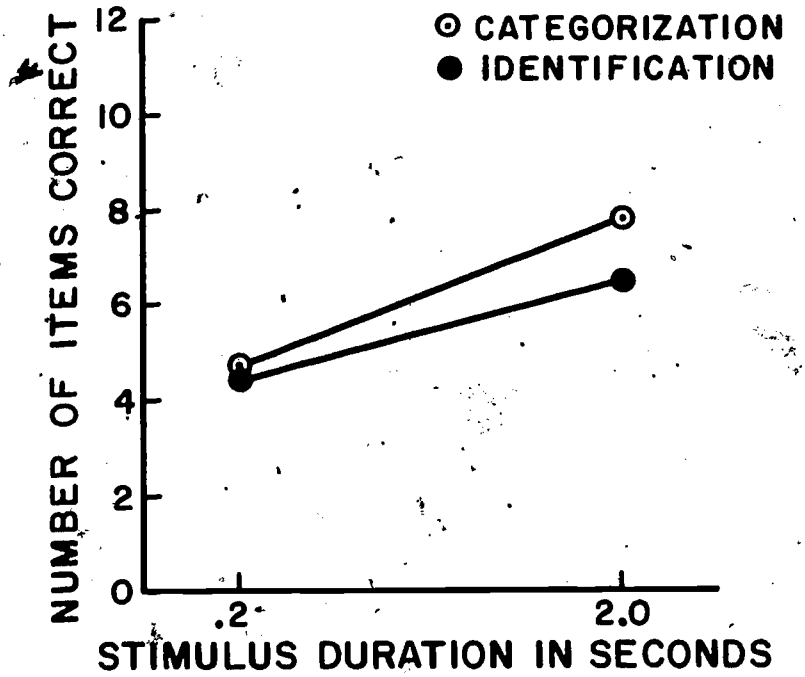
0
+400
+800
DELAY OF CUE IN MSEC.


CATEGORIZATION
IDENTIFICATION
NUMBER OF ITEMS CORRECT
12
10
8
6
4
2
0
.2
2.0
STIMULUS DURATION IN SECONDS