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Stimulus-form effects in recognition memory

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In two experiments, recognition memory was tested using memorized lists of items containing from 2 to 32 nominal concepts. Stimulus form was manipulated by using the names of the items on word trials and outline drawings of the items on picture trials. In terms of an information processing stage model of recognition memory, stimulus form affected only an identification or encoding stage of processing. Subsequent memory-search, decision, and response processes were largely the same for all stimuli once the words or pictures were encoded. The results are consistent with the hypothesized role of stimulus form in processes underlying long-term recognition. However, our results are inconsistent with those of a number of studies involving stimulus-form effects in short-term recognition memory.

Recognition memory tests typically involve decisions about whether a particular stimulus has been presented before. Depending on how the task is structured, however, recognition can depend on several different kinds of information (Posner, 1969). Recognition decisions can be based on purely physical aspects of the stimulus, and thus the perceptual encodings which reflect specific physical details, or they can be based on semantic and associative information elicited by the stimulus.

The present paper reports the results of two experiments designed to assess the roles of perceptual and conceptual information in recognition memory. Both experiments used variants of the Sternberg (1966) memory-search paradigm, with the first involving long lists of memorized words, and the second involving sets of from two to four memory items. In both experiments, the probe stimuli were simple outline drawings or names of common objects, and they were to be classified as belonging (positive trial) or not belonging (negative trial) to the memory set. In experiments of this type, response latency is typically found to increase linearly with the number of items in the memory set, and the increase is of the same amount on positive and negative trials (Sternberg, 1966, 1969). The model proposed by Sternberg to account for performance in this task is composed of four sequential processing stages: (1) The probe is encoded into a form comparable to the items in the memory set; (2) the encoded probe is compared to all memory set items; (3) a positive or negative decision is made; and (4) the respective response is selected and executed.

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The two parameters of the response latency function, the slope and the intercept, are psychologically meaningful when viewed in terms of Sternberg's model. The slope is an estimate of the time required to compare the probe against one memory item, and the intercept is an estimate of the total time required for the stimulus encoding, decision, and response stages. In accordance with the model, changes in the slope of the latency function are assumed to be mediated through changes in the internal representations of the stimuli being compared (cf. Cavanagh, 1972; Sternberg, 1967). Similarly, any variable which affects response latency without changing the slope of the function is assumed to have its effect localized in the stimulus encoding stage (to the extent that a reasonable case can be made against involvement of decision or response stages).

Atkinson and Juola (1973, 1974) have developed a more general recognition model to account for data from tasks involving lists of as many as 54 words held in long-term memory. The model is similar to Sternberg's, with the exception that the comparison process need not occur on every trial. Rather, encoding results in a subjective familiarity of the probe, which can lead directly to a positive or negative response for a high or low value, respectively. Probes resulting in intermediate familiarity values lead to a delay of the response until completion of a memory-search process similar to that proposed in Sternberg's model. Error rates are assumed to reflect relative familiarity values for various types of probes, since errors presumably result only from highly familiar negative probes and highly unfamiliar positive probes.

EXPERIMENT 1

The familiarity model of Atkinson and Juola (1973, 1974) has formed the theoretical basis for several studies on the effects of alternative stimulus forms on long-term recognition (Juola, 1973; Juola, Taylor, & Young, 1974). In these experiments, subjects memorized lists of words and were tested using word and picture probes. All probes were presented twice, with stimulus form varied for half of the repetitions (word-picture, picture-word) and held constant for the remaining half (word-word, picture-picture). Although latencies were faster for items presented in the same form on both tests, error rates for repeated items were independent of the forms used on earlier trials. Since all errors are assumed to result from decisions based on familiarity alone, the results indicated that the familiarity of a concept is independent of the form of the stimulus used to access that concept. Stimulus form could still play a role in processes following encoding, however. The first experiment addressed this possibility by manipulating probe form and memory-set size as within-subjects variables. If recognition processes which follow stimulus encoding are not affected by stimulus forms, then the effects of list length should be equivalent for word and picture probes.

Method

Subjects. The subjects were 40 undergraduates, who participated to fulfill a course requirement, and four graduate student volunteers. The data from eight subjects were discarded (six subjects exceeded an error criterion of either 22% in any single session or 15% over the three experimental sessions, and two subjects were discarded due to experimenter errors). Thus the data are based upon an N of 36.

Stimuli. The stimuli were drawings and names of 90 common objects, yielding a pool of 180 experimental stimuli. An additional 12 stimuli, six names and six drawings, were used as filler items to absorb practice effects and were presented early in the experimental sequence.

All stimuli were placed on white 15.2 x 22.9 cm cards. The words, ranging from three to eight letters in length, were typed with an IBM Selectric typewriter in Orator typeface (.76 cm $\leq$ word length $\leq$ 2.03 cm). The pictures were Xerox copies of original outline drawings of the objects named by each of the words; picture size ranged from approximately .8 cm to 3.8 cm in diam.

Apparatus. Stimuli were presented in an Iconix three-field tachistoscope equipped with a millisecond timer. The subject initiated each trial by pressing a footswitch. Two response buttons, each 3.2 cm in diam, were mounted on a panel 8.9 cm apart. Depressing either button stopped the timer. Assignment of positive and negative responses to right- and left-hand buttons was counterbalanced across subjects.

Procedure. Each subject participated on 4 consecutive days. On the first day, the task was explained in detail, followed by a practice session designed to acquaint the subject with the apparatus and procedure. Subjects were instructed to respond as rapidly as possible while being careful to be correct; speed/accuracy feedback was provided during the practice trials, but not during experimental trials. In the practice session, the digits 0-9 were each presented twice in random order; a positive response was required if the digit probe was from 0 to 4 inclusively and a negative response was required otherwise. This modified Sternberg task was also used as a warm-up preceding each of the three experimental sessions.

The sequence of trial events was identical for the practice and experimental sessions. At the beginning of each trial, the experimenter read aloud a two-digit number from which the subject counted backward for three consecutive numbers by threes. (The counting task was adopted to reduce processing variability in the experimental sessions; it was desired that responses be based on retrieval from long-term memory and not on contents of the short-term store.) The subject then pressed a footswitch which started the timer and illuminated the stimulus field. The tachistoscope was programmed to maintain a preexposure field with a central dark fixation point for 500 msec. The probe was then illuminated and remained visible for 400 msec.

At the end of each of the first three sessions, each subject was given a list of words to memorize in serial order before the next session. Days 2-4 began with a written serial recall test of the list of words which had been given on the previous day. In the event of an error in recall, the subject was allowed to study the list and then recall was again attempted. The process was continued until perfect serial recall was achieved. The practice session followed recall, and each subject was then run for 42 trials, using the list of words he had been given on the previous day as the memory set.

Study lists. Each subject had to master three lists of words containing 12, 22, and 32 items. The order in which lists were assigned to the 3 test days was counterbalanced across subjects. The first and last words in each list were filler items, one of which was tested as a picture and the other as a word. Three different sets of three study lists were used, and, over the experiment as a whole, all items were used equally often as positive and negative probes.

Test sequences. Each test sequence consisted of 42 trials regardless of the length of the corresponding study list. The first six trials of each sequence were designated as practice trials, and the resulting data were excluded from all analyses. The trials included two positive and two negative filler items along with the initial presentations of two experimental items. All experimental probes were presented twice, except for the last positive and negative items, which were presented only once.

Twelve of the words from each list were chosen for testing. All subjects were tested on all 12 items in the smallest list. To determine the items to be tested on the remaining lists, subjects were randomly assigned to a blocked condition or to a spaced condition. Ignoring the filler items for a monent, the 10 words on which subjects in the blocked condition were tested were those appearing in either the first or last half of the 20-word list; and, in the 30-word list, the tested words were those from the first, middle, or last third of the study list. In the spaced condition, the words chosen for testing were uniformly distributed throughout the study list. The order of probes in the test sequence was random, with the constraint that no item was repeated with a lag of less than three or more than nine intervening trials from its initial test. The order of the probes and their test representations as either a word or a picture (the same form was used on both presentations) were randomized for each subject. No item was repeated across days for any subject.

Results

A 2 by 3 by 2 by 2 by 2 mixed analysis of variance was performed on the mean correct response latencies for each subject for each trial type; corresponding factors are Blocked-Spaced, Set Size, Response Type, Stimulus Form, and Presentation Number.[1] The first of the factors was manipulated between-subjects and the remaining variables were within-subjects. The mean correct reaction times and error proportions for all combinations of the within-subjects factors are presented in Table 1. Subject errors and outliers were excluded from the response latency analysis; an outlier was defined as any observation that was at least twice the size of the mean of the remaining correct observations in one cell of the design. The mean error percentage was 7.5, and the number of outliers was less than 3% of the total trials.

Table 1
Mean Response Latencies in Milliseconds and Error Proportions for All Combinations of Within-Subjects Variables: Experiment 1

		Memory-Set Size					
		12		22		32	
Response	Probe Form	Latencies	Errors	Latencies	Errors	Latencies	Errors
		First Presentation					
Positive	Word	754	.110	859	.215	859	.108
	Picture	854	.060	887	.161	937	.165
Negative	Word	771	.026	795	.011	875	.012
	Picture	1010	.029	1081	.079	1133	.086
		Second Presentation					
Positive	Word	640	.036	664	.043	657	.018
	Picture	638	.033	660	.025	684	.042
Negative	Word	802	.131	785	.086	801	.147
	Picture	740	.072	742	.051	775	.049

The analysis showed response latency to increase with the size of the memory set [$F(2,68) = 5.49$, $p < .01$, MSe = 53,392], and to decrease for repeated items [$F(1,34) = 184.54$, $p < .001$, MSe = 40,317]. The set-size effect was more powerful on initial test presentations than on second tests [$F(2,68) = 5.83$, $p < .005$, MSe = 19,983]. The slope of the best-fitting linear function for the first presentation data is 5.2 msec/item, whereas for the second presentation data the slope does not differ significantly from zero ($t < 1$).

Two other main effects reached significance: Positive responses were faster than negative responses [$F(1,34) = 64.83$, $p < .001$, MSe = 34,295], and responses to words were faster than those to pictures [$F(1,34) = 27.42$, $p < .001$, MSe = 42,247]. These two factors were components of the significant interactions of Response Type by Stimulus Form [$F(1,34) = 7.24$, $p < .025$, MSe = 37,634] and Response Type by Stimulus Form by Presentation Number [$F(1,34) = 24.82$, $p < .001$, MSe = 32,082]. The two-way interaction indicates that the difference between response times to words and to pictures was much larger for negative than for positive probes. The three-way interaction indicates that, although latencies were reduced on second tests for all combinations of response type with stimulus form, the mean decrease for negative word probes was very small (18 msec) when compared to the decrease for negative pictures (322 msec), positive pictures (233 msec), and positive words (170 msec). The decrease in response latency over repeated tests was greater for pictures than for words [$F(1,34) = 85.62$, $p < .001$, MSe = 21,172]. No other interactions or main effects were significant in the response latency analysis.

An identical analysis to the one performed on the response latency data was done on the arc sine transformed error proportions for each trial type. Presentation number was the only significant main effect [$F(1,34) = 11.27$, $p < .005$, MSe = .1655], with more errors occurring on first tests than on second tests. Presentation number interacted with set size [$F(2,68) = 8.16$, $p < .001$, MSe = .1654]; the error rate on the first tests of items from List Size 12 was slightly less than on second tests, but for the remaining set sizes this trend was reversed.

The error rate for positive probes decreased from 13.6% to 3.3% over successive tests, whereas errors to negative probes increased from 4.0% to 8.9% [$F(1,34) = 77.54$, $p < .001$, MSe = .2201]. The effect of repeated tests was to reduce the overall error rate to pictures from 9.7% to 4.5%, but errors to words remained fairly stable (8.0% vs. 7.7%) [$F(1,34) = 7.88$, $p < .01$, MSe = .2346]. However, both of these interactions as well as the main effect of presentation number must be interpreted in light of the significant interaction of Response Type by Stimulus Form by Presentation Number [$F(1,34) = 14.35$, $p < .001$, MSe = .2068]. For positive probes, repeated tests have the same effect regardless of the form of the probe, reducing error rates from 14.4% to 3.2% for words, and from 12.9% to 3.3% for pictures. For negative probes, the effect of repeated tests on error rates is dependent upon probe form; errors for pictures decreased from 6.5% to 5.7% over successive presentations, while errors for words increased from 1.6% to 12.1%. The significant interaction of Set Size by Response Type by Stimulus Form [$F(2,68) = 3.59$, $p < .05$, MSe = .2287] has no straightforward interpretation.

Discussion

The data from Experiment 1 provide no evidence that alternative probe forms give rise to different coded versions of the test items for the purpose of long-term memory search. Taken together, the additivity of probe form and set size in the response latency analysis and the lack of a systematic relationship between stimulus forms and set size on error rates imply that the comparison process underlying recognition memory for items in long memorized lists does not differ for word and picture probes. These results offer additional evidence that long-term recognition processes following stimulus encoding need not depend on perceptual characteristics of a given stimulus (Juola, Taylor, & Young, 1974).

One effect of probe form on encoding processes is apparent in the data from initial stimulus presentations. Specifically, in opposition to findings of Lawrence and Coles (1954) and Pachella (1975), the prior study of word lists facilitated processing of the pictures used as positive probes. This conclusion is based on the fact that for positive probes, the difference in response latency between pictures and words (69 msec) was less than the corresponding latency difference between negative pictures and words (261 msec). The facilitative effect of prior word study is further indicated by the fact that, for positive probes, error rates to pictures (12.9%) and words (14.4%) did not differ, whereas, for negative probes, disproportionately more errors were made to pictures (6.5%) than to words (1.6%). These facts, combined with the result that the slopes of the response latency functions were equivalent for all combinations of stimulus form and response type, argue against localizing the effect in search or decision processes, and suggest that the facilitation occurs in the encoding process.

The processes underlying recognition of repeated items appear to be qualitatively different from those involved on initial tests and also somewhat different from the repetition effects found in comparable studies (e.g., Atkinson & Juola, 1973). Perhaps the most striking result is the lack of a significant set-size effect in the data for repeated items. Whatever the basis upon which classification decisions were made for items presented a second time, it did not depend upon the size of the memory set. According to the Atkinson and Juola model, the set of all recognition responses is separable into two mutually exclusive and exhaustive subsets: (1) those responses which are based upon list search, and (2) those that are based upon familiarity evaluations alone. In the present study, responses to items on the second tests clearly do not belong to the former subset, given the absence of a set-size effect. Neither can responses on second tests be based upon familiarity alone, as evidenced by the pattern of results for negative probes. According to the model, the effect of repetition for negative probes is to shift a larger proportion of the familiarity distribution into the search area, resulting in a greater proportion of list searches and hence an *increased* effect of set size on response latency. The fact that repetition of negative probes *decreased* the effect of set size makes familiarity as developed within the model untenable in accounting for the data from second presentations.

The familiarity model might be modified to account for the second presentation data by allowing for the possibility that response information can be accessible from or linked to the conceptual code corresponding to the probe. The processes involved in object naming illustrate this idea: A perceptual input is mapped onto the appropriate concept, from which the response, in this case a spoken word, is directly accessible. In the recognition task, memory for the previous response to a given stimulus could be immediately accessible after encoding, and reaction time should then be independent of the size of the memory set. If the appropriate response code is available for only a limited time after the probe is presented, then the lack of a set-size effect for repeated items could be due to the relatively short lag between repeated items in the present study (averaging 4.5 trials). A recognition model which explicitly incorporates a direct pairing of stimulus with response has been developed to account for short-term recognition performance (Theios, 1973; Theios, Smith, Haviland, Traupmann, & Moy, 1973), giving extraexperimental support to the hypothesized short-circuiting of long-term memory search by a limited, short-term response memory. The desirability of elaborating the familiarity model of Atkinson and Juola to include such a stimulus-response buffer has been noted elsewhere (Theios & Walter, 1974).

EXPERIMENT 2

The results from Experiment 1 were supportive of the hypothesis that stimulus-form effects in long-term recognition memory are localized in encoding processes, leaving processes following stimulus encoding unaffected. There is evidence that this is not the case in short-term recognition performance, however. Sternberg (1967) reported an application of the memory-scanning paradigm to the investigation of stimulus-form effects in recognition memory for sets of digits. Sternberg found that when visual noise was added to a probe digit, the slope as well as the intercept of the latency function increased (although the slope difference was attenuated with practice). He concluded that the encoding process faithfully reproduced some physical features of the stimulus such that degraded probes were not compared as efficiently with memory-set items as were intact stimuli. Using letters as stimuli, Chase and Calfee (1969) varied the presentation modality such that the memory sets and probes were either both aural or both visual on half the trials, and, on other trials, the modalities differed. The slope of the latency function was significantly less for same-mode trials than for trials on which the modality of memory set and probe differed. Chase and Calfee concluded that perceptual features were maintained long enough to affect the comparison process in short-term recognition. Data provided by other investigators (Cruse & Clifton, 1973; Klatzky & Atkinson, 1970; Klatzky, Juola, & Atkinson, 1971), using somewhat different stimuli and variations of the basic paradigm, support this conclusion. These results are consistent with the idea that the codes representing stimuli in short-term recognition memory are composed of perceptual as well as conceptual features, and that, for the most part, perceptual features are relevant for the comparison process between the probe and memory-set items.

Experiment 2 was designed to test the generality of the "perceptual comparison" hypothesis with word and picture stimuli. Both words and pictures were used in the memory sets, with two, three, or four items presented on every trial. The probes were also either words or pictures, and the comparison of interest involves trials on which probe form and memory-set form match vs. trials on which they do not match. Expectancy was also manipulated by holding the probe form constant (either all words or all pictures) in some trial blocks and varying the probe forms randomly in other blocks. The manipulations were introduced in order to find conditions that promote (or inhibit) the use of perceptual features in the comparison process, which would be reflected in differential slopes of the functions relating response latencies to memory-set size in the various conditions.

Method

Subjects. The subjects were 24 University of Kansas undergraduates who participated to fulfill a course requirement.

Stimuli. The experimental stimuli consisted of line drawings and typed names of each of 72 common objects. Of the 72 pictures, 28 were drawn from the pictures used in Experiment 1 and the remainder were drawn from the Peabody Picture Vocabulary Test. A separate set of 26 different stimuli were used for practice trials. All drawings were photographed for presentation via slide projector. The words, ranging from three to nine letters in length, were typed directly onto slide transparencies using an IBM Selectric typewriter and Elite typeface.

Design and test sequences. The design was a 2 by 2 by 2 by 2 by 3 factorial, with all factors manipulated within-subjects. Factors correspond to probe-form expectancy (blocked, mixed), probe form (picture, word), memory-set form (picture, word), response type (positive, negative), and set size (2, 3, 4). For half of the trials, picture and word probes were intermixed such that the form of the probe varied randomly from trial to trial. For the remaining trials, the form of the probe was blocked such that for one series of trials the probes were all pictures, and, for another series, the probes were all words. Thus, there were three trial blocks, corresponding to word probe only, picture probe only, and intermixed word-picture probes. The first two of the blocks consisted of 36 trials each and the latter, 72 trials. The order in which the three trial blocks were presented was counterbalanced across subjects. Within each of the three blocks, the levels of all remaining factors were randomized, with the constraint that the same response was not required for more than three consecutive trials. On positive trials, each serial position in the memory set was probed approximately equally often. Four different test sequences were constructed and assigned to six subjects each. The test sequences were new randomizations of both the ordering of trial types and the items which made up the memory sets and probes.

Apparatus. Slides were rear-projected onto a 25-cm wide by 23-cm high screen by a Kodak Carousel projector. Subjects responded by depressing one of two telegraph keys located 13 cm apart. Depressing either key stopped a millisecond timer, and a light indicated which key had been pressed. A random half half of the subjects made positive responses with their left forefingers and half with their right. The timer, indicator lights, and experimenter were separated from the subject by a wooden panel.

Procedure. The experimental session began with 12 practice trials. No probe-form information was given, and both word and picture probes were presented. Subjects were instructed to make a positive response if the probe matched one of the members of the target set and a negative response otherwise. It was emphasized that the match was to be made on a conceptual level; that is, if a word and a picture referred to the same object, a positive response was required. Subjects were instructed to respond as rapidly as possible while making no errors; speed/accuracy feedback was provided only during practice trials. The three experimental blocks followed the practice trials after a brief rest period. Each block was preceded by instructions indicating whether the probes in the upcoming block would be words only, pictures only, or a random mixture of both.

Each trial began with a preparatory blank slide, followed by either two, three, or four slides which comprised the memory set. A red slide followed the last memory-set item, warning the subject that the next item to be presented would be the test item for that trial. Each slide was presented for 1 sec, with approximately 500 msec off-time between slides. The onset of the probe was simultaneous with the activation of the response timer; the subject's response stopped the timer, and the experimenter recorded the latency and the response and then initiated the next trial.

Results

The mean correct response latency in each cell of the design for each subject was entered into the analysis. Any latency which exceeded the mean of the remaining scores within a cell by twice or more was rejected as an outlier; less than 1% of the data were so rejected. Also excluded were the 3.1% of the data which were subject errors.

The analysis of variance found that response latency increased with the size of the memory set [$F(2,46) = 49.01$, $p < .001$, MSe = 13,165]. Memory-set size was a component of two significant interactions: Set Size by Probe-Form Expectancy [$F(2,46) = 3.92$, $p < .05$, MSe = 10,390] and Set Size by Probe-Form Expectancy by Memory-Set Form [$F(2,46) = 3.78$, $p < .05$, MSe = 7,820]. The interactions appear to result from the fact that, for word sets, the set-size effect was greater in the blocked condition than in the mixed condition. Latencies to word probes were significantly faster than latencies to picture probes [$F(1,23) = 6.82$, $p < .025$, MSe = 28,485]. Probe form interacted with memory-set form [$F(1,23) = 29.95$, $p < .001$, MSe = 7,316]; responses were faster for word probes than for picture probes when words were used as memory-set items, whereas for picture sets, probe form had no effect. No other main effects or interactions reached significance.

Since response type did not produce a significant main effect or enter into any significant interactions, the latency data were collapsed across the levels of this factor. The mean correct latencies and error proportions for all other conditions are presented in Table 2. An analysis of variance found no significant main effects in the error data; four interactions, unsystematic and uninterpretable, reached statistical significance: Set Size by Memory-Set Form [$F(2,46) = 4.97$, $p < .025$, MSe = .1633]; Probe-Form Expectancy by Set Size by Probe Form [$F(2,46) = 3.44$, $p < .05$, MSe = .1323];

Table 2
Mean Response Latencies in Milliseconds and Error Proportions for Short-Term Recognition Memory for Words (W) and Pictures (P): Experiment 2

Stimulus Forms		Set Size 2		Set Size 3		Set Size 4	
Memory-Set	Probe	Latencies	Errors	Latencies	Errors	Latencies	Errors
				Blocked Probe Form			
W	W	609	.007	670	.035	713	.056
P	P	645	.062	713	.021	712	.062
W	P	640	.014	730	.035	772	.042
P	W	630	.000	703	.014	716	.007
				Mixed Probe Form			
W	W	658	.018	674	.035	714	.021
P	P	637	.049	713	.021	710	.014
W	P	720	.010	733	.090	764	.034
P	W	656	.028	696	.012	738	.042

Probe-Form Expectancy by Probe Form by Memory-Set Form [$F(1,23) = 5.58$, $p < .05$, $MSe = .1753$]; Probe Form by Memory-Set Form by Response Type by Set Size [$F(2,46) = 4.90$, $p < .025$, $MSe = .0918$].

Discussion

Somewhat surprisingly, the expected interaction of Probe Form by Memory-Set Form by Set Size did not emerge. The slopes of the same-form and different-form response latency functions did not significantly differ. In terms of the recognition model, the implication is that the comparison rates for the various sets of stimulus forms (and hence the form of the representations being compared) did not differ. Previous short-term recognition memory studies have found that, when the probe item and the memory-set items are drawn from different form classes, slopes of the response latency functions tend to be greater than when these items are drawn from the same class (Cruse & Clifton, 1973; Chase & Calfee, 1969). Either the present study was less sensitive in detecting this difference, or interactive effects between stimulus forms on memorial comparison times are not universal in short-term recognition memory performance.

The data lead to the localization of stimulus-form effects in the encoding stage of the model. The lack of an interaction of set form or probe form with response type makes the decision stage an unlikely candidate for the source of the effect (Sternberg, Note 1). Probe encoding does appear to depend somewhat upon the nominal form of the memory-set items. For picture sets, latencies for word and picture probes were not different; however, when the memory set was composed of words, latencies for word probes were much faster than those for pictures. The possibility that the internalized representations of picture memory sets were different from the internalized representations of word sets is unlikely, due to the absence of an interaction of stimulus form with set size, and one is left to speculate that the observed stimulus-form effect is due to the activation of different processing routines for the encoding of the different stimulus forms (cf. Bower, 1972).

Foreknowledge of probe form had a surprisingly small effect. Given the small variation in latencies for all combinations of set form with set size between the two expectancy conditions (with the single exception of two-word memory sets), it appears that prior knowledge of the form of the probe facilitated neither encoding time nor comparison rate, indicating that the coding of items for subsequent short-term recognition, at least for the stimulus-form classes of the present study, was largely an automatic process (cf. Posner & Snyder, in press).

GENERAL DISCUSSION

Two experiments were designed to study characteristics of the internalized representations of stimuli involved in long- and short-term recognition memory. The finding of major interest was that the response latencies did not evidence an interaction between stimulus form and memory-set size in either study. Interpretation of the latency data in terms of the models of Sternberg (1969) and of Atkinson and Juola (1973, 1974) led us to conclude that the processes following stimulus encoding were independent of the physical forms of the stimuli.

The data from the short-term recognition study also indicated that neither comparison time nor encoding time was affected by prior information about the form of the probe. If the encoding of the memory set was an automatic process resistant to strategic intervention, then the variable of probe-form expectancy might not be expected to influence the recognition process. However, one question remains: Why did the expected interaction of stimulus form with set size fail to emerge? The present authors believe that the answer lies in the associative relationship between the stimulus-form classes involved, that is, in the ease with which a member of one class elicits its corresponding member in the second class. For instance, in an experiment by Cruse and Clifton (1973), stimulus equivalence was defined by establishing an arbitrary associative relationship between elements of two stimulus-form classes, in this case between digits and letters, such that A = 1, B = 2, and so on. Klatzky and Atkinson (1970) used three probe forms (letter, word, and picture) and required a positive response if a single letter, the first letter of a word, or the first letter of the name of a picture matched any of a small set of target letters. The magnitude of the slope differences produced by the form translations used by Klatzky and Atkinson (1970) was smaller than that reported by Cruse and Clifton (1973, Experiment 1), and the translation effect was larger in both of these studies than in the present experiments. It could be that the degree of associative learning involving familiar objects and their common names promotes the rapid access of a common name or conceptual code for either stimulus form. This code is then used for subsequent memory search and decision processes; thus, only the encoding stage of recognition for items in memorized lists is affected by word and picture form manipulations. This is not to deny the fact that recognition differences can exist for words and pictures, as in studies which require recognition decision to be based on stimulus form (e.g., Snodgrass, Wasser, Finkelstein, & Goldberg, 1974). Whereas our results by no means provide a test of the hypothesized effect of associative learning on recognition memory performance, they are in agreement with such a hypothesis and warrant further exploration of this variable.

The associative relation between corresponding members of two stimulus classes alone cannot account for all stimulus-form effects in recognition, as Chase and Calfee (1969) have shown. A second, but related, approach to the analysis of stimulus-form effects is to cast the internal representations of stimuli in terms of their perceptual and conceptual features. A possible view of the Chase and Calfee results would be that when stimuli are presented via two distinct sensory modalities (e.g., vision and audition), each of which has its own peculiar characteristics (e.g., duration of the stimulus image), the perceptual characteristics of those stimuli are much more contrastive, and hence could be more salient in the recognition process, than when different stimulus forms such as pictures and words are presented to the same perceptual system. Semantic similarity, perceptual similarity, and degree of associative learning are only some of the variables which undoubtedly play a significant role in the representation and processing of information in memory. Convergent empirical investigations are necessary to arrive at more specific hypotheses concerning the effect of these and other variables on the information upon which recognition decisions are based.

REFERENCE NOTE

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NOTE

1. Conventional F tests were used in both experiments. Whereas the number of stimuli was large, the stimuli were not randomly selected and the "larger population" from which they could be treated as a random sample is elusive (see Wike & Church, in press). The items used in the two experiments also taxed the limits of the number of concrete nouns for which a simple yet uniquely nameable picture could be drawn.

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