The concreteness of attributes in concept learning strategies*

IRWIN D. NAHINSKY†, FRANK L. SLAYMAKER††, ARWA AAMIRY
and CORNELIUS J. O'BRIEN

University of Louisville, Louisville, Kentucky 40208

Ss were presented with conjunctive concept learning tasks using geometric stimuli in two experiments and using combinations of abstract characteristics in two other experiments. Evidence indicated that the conjunctive hypotheses for geometric stimuli were not mediated by component values but were sampled as unitized wholes. In contrast, conjunctive hypotheses for abstract attributes were sampled via independent combinations of component values. The differential processing was not found to be associated with the variation of stimuli on the verbal-nonverbal dimension.

Reitman (1970) has conceptualized memory behavior as the product of a complex strategy system operating with substantial amounts of stored information. He has pointed to the great difficulty involved in decoupling storage and retrieval processes from the cognitive apparatus required by a specific task. Hence, studies of storage and retrieval in the relatively limited context of the usual recall and recognition tasks may not produce a comprehensive picture of memory processes. The use of conceptual tasks could perhaps tap more complex activities where stimulus characteristics are manipulated in memory. Several investigators (e.g., Mandler, 1967; Tulving, 1962) have studied the organization of verbal material revealed in free recall. Mandler argued that recall experiments reveal cognitive structure, i.e., the manner in which memory is organized. Studies investigating organization in memory have generally centered around category groupings based upon some defining characteristics of subsets of words in a list. Other important questions can be raised, however. If the task is one of discovering a correct rule for classifying stimuli, are similar organizational processes involved? Is the type of stimulus material used influential in determining the nature of these processes? Insofar as concept learning and sorting tasks combine various memory processes and conceptual strategies, these approaches engender simultaneous study of memory, cognitive structures, and information processing.

The cognitive processes involved in approaching conceptual tasks may be influenced by the location of stimulus attributes on the concreteness-abstractness dimension. Paivio (1969) presented evidence that processing of material by visual imagery involves

essentially parallel processing, while processing in a verbal symbolic manner is essentially sequential. This outcome suggests that easily imaged material may be combined in a more integrative manner, while more abstract verbal stimuli, those not easily associated with images, may be processed in a more stepwise fashion, e.g., organized by characteristics in a hierarchical or quasihierarchical scheme. Nahinsky, Penrod, and Slaymaker (1970) reported a conjunctive concept identification (CCI) experiment with two relevant dimensions using geometric stimuli. The results indicated that there was a combination of attribute values in an integrative or unitizing fashion. Using methods which will be discussed, they found that Ss are no more likely to sample jointly two hypotheses with a value in common, e.g., "black circles" and "two black figures," than to sample jointly two hypotheses not overlapping on any attribute, e.g., "black circles" and "two figures surrounded by two borders." Further, they found that the probability of sampling a two-dimensional hypothesis with a given value was influenced in part by the other value of that hypothesis. Thus, the conjunctive hypothesis appeared to be a unit, perhaps mediated by some associated image, vague or incomplete as it might be.

In view of the fact that stimuli involved in the geometric-stimuli problem lead to processing of the type that might be attributed to visual imagery, it would be of interest to see if the results obtained would hold for verbal and more abstract material. The series of experiments reported here represents an attempt to explore the influence of certain stimulus variables, including the concreteness-abstractness dimension, upon the processing strategies involved in concept learning.

An explicit definition of the concreteness-abstractness dimension is required for application in the context of concept learning. In view of the fact that hypothesis testing is concerned directly with stimulus-attribute values, the definition specifies a relationship between the stimulus and its component attribute values. An attribute or dimension is considered concrete to the extent that its values can be directly derived from a visual representation of the stimulus. Thus, observing

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†Requests for reprints should be sent to Irwin D. Nahinsky, Psychology Department, University of Louisville, Louisville, Kentucky 40208.

††Now at Loyola University, Chicago, Illinois 60626.

Table 1
Illustration of Blank Trial Overlap Relationships and Hypothesis Assessments

Trial	Feedback or Blank	Stimulus				Positive or Negative Instance
1	Feedback	Honor	Anger	Joy	Competence	Positive
2	Blank	Bravery	<i>Anger</i>	<i>Joy</i>	Confidence*	Negative
3	Blank	<i>Honor</i>	Malice	Love	<i>Competence</i>	Positive
4	Blank	Loyalty	<i>Anger</i>	Happiness	<i>Competence</i>	Negative
5	Feedback	<i>Honor</i>	<i>Anger</i>	Love	Determination	Negative
6	Feedback	Honor	Anger	Joy	Competence	Positive
7	Blank	<i>Honor</i>	<i>Anger</i>	Happiness	Confidence	Negative
8	Blank	Bravery	Malice	<i>Joy</i>	<i>Competence</i>	Negative
9	Blank	<i>Honor</i>	Animosity	<i>Joy</i>	Determination	Negative

*Hypothesis assessed represented by italicized values.

Note—Order of each blank trial triplet is randomly permuted.

"two black circles" gives S direct information about the shape, shading, and number of figure attributes. Such attributes would be considered concrete. However, even if one sees a picture of Galileo, information about his occupation and era must be accessed from a store of additional information about him, although information about features, e.g., beardedness, are directly available. Thus, occupation and era would be considered abstract dimensions. In general, concrete attributes, defined in the above manner, should more readily provide the basis for formation of visual imaginal representations of attribute values and combinations thereof than would more abstract attributes. We believe this definition is consonant with current conceptualizations of the concreteness-abstractness dimension.

In Experiment I, a set of abstract attributes is derived to provide stimulus material and an attempt is made to see how conjunctive hypotheses are processed for such abstract stimulus material. Results of this experiment are compared with the results reported by Nahinsky et al (1970) to demonstrate qualitative differences in processing strategies for the different types of stimulus material. Experiment II extends the research reported by Nahinsky et al (1970) to include verbal descriptions of the concrete stimulus attributes in order to separate the verbal-nonverbal dimension from the concreteness-abstractness dimension. Finally, Experiment III involves concrete stimuli in the form of well-known individuals in a concept learning task with abstract characteristics in order to investigate the effects of a concrete stimulus upon the process of extracting abstract characteristics for hypothesis testing.

EXPERIMENT I

Scaling of Stimulus Attributes

Ten graduate students in psychology performed a sorting task modeled after Miller (1969). Instructions read to each S individually completely identified the methods and objectives. Seventy-five words with low imagery (I) and concreteness (C) ratings and high meaningfulness (m) ratings from the Paivio, Yuille, and

Madigan (1968) norms, typed on 1 x 3 in. cards, comprised the sorting deck. Each S was requested to "...sort the 75 words into as many groups as are necessary to allow for internally consistent categories, but as few as possible."

Following the sorting procedure, Ss were asked to name each category as a means of assessing conceptual dimensionality of the sort. Most groups were easily named. Words which did not fit into any category were placed in a miscellaneous group, and those data did not enter into the subsequent analyses. From 4 to 11 categories were required to sort the words.

Each S's sorting produced a square S matrix of Order 75 whose i, j th element was one or zero for Stimuli i and j sorted or not sorted in the same category, respectively. The mean of the S matrices provided a data matrix whose ij th element was the probability of common category placement of Stimuli i and j .

It was assumed that high off-diagonal values indicated the existence of a superordinate attribute category in which Words i and j belonged. The set of attributes assumed to underlie the data matrix were identified by isolating those triples (Words i, j , and k) which yielded uniformly high pairwise entries in the data matrix for the corresponding three pairings. The four attributes used in Experiment I were selected from this set by isolating triples which showed minimum intertriple sorting probabilities.

Table 2 shows four resulting attributes with their mean measures for I, C, and m. All attributes had mean intratriple sorting probabilities greater than .90 and minimal mean intertriple sorting frequencies (0.0 to 4.2 of a possible 10). It should be noted that this technique does not insure that all pairs within attributes are groupable under the same superordinate category, although at worst the different superordinates must be correlated. Further, the resulting attributes are nonorthogonal.

Method

Subjects

The Ss were 80 introductory psychology students who

participated in fulfillment of a course requirement. Ss were run individually.

Materials

Four-word compound stimuli were constructed using the four attributes of Table 1, with one word per attribute. Four examples of each stimulus were typed on 3 x 5 in. cards, one word centered in each quadrant. Words were assigned randomly to the quadrants in a pattern conforming to the rows of a 4 by 4 Latin square. Stimuli were selected at random from the four for inclusion in each protocol. The experiment was performed in an air-conditioned distraction-free room. Instructions were presented through a tape recording of E's voice. E and S were separated by a screen on which was displayed a replica of Table 1, with the scale values removed, throughout the experimental session.

Procedure

The Ss were required to attempt two two-value CCI problems in succession using a blank trial (BT) modification of the reception paradigm. In each problem, S was presented with a feedback-positive instance (PI) on the first trial, followed by a series of three BT stimuli. The BT series was followed by a feedback-negative instance (NI), which was in turn followed by a second presentation of the initially presented PI. This PI was followed by another series of three BT stimuli. No feedback stimulus was the same as any BT stimulus. The S was asked to guess the concept after the second BT series. Each S was informed of the correctness of his response after a feedback presentation but not after a BT presentation.

Each of the six BT stimuli overlapped the feedback PI by exactly two attribute values, with the six stimuli accounting for the six possible pairs of values on that PI. The first set of three BT stimuli contained three of these pairs; the second BT set contained the complementary set of three. In each BT series, two of the stimuli were chosen so that they had no value in common which overlapped the feedback PI. Thus, one BT stimulus overlapped the PI by values in each of two attributes and a second BT stimulus overlapped the PI by values on the other two attributes. Each of the preceding two BT stimuli and the feedback NI overlapped the third BT stimulus by one value common to the feedback PI. The feedback NI overlapped the feedback PI by exactly two values and overlapped one of the stimuli in the second BT series by the same two values. The latter stimulus was one of a pair of BT stimuli not overlapping on any values common to the feedback PI. Table 1 illustrates a typical stimulus series and the overlap relationship. For each of the six possible ways in which three of six overlapping value pairs could be assigned to one BT series, 16 complementary pairs of BT stimulus series were constructed. The complementary pairs of BT series were selected randomly from this pool to be assigned to each S problem and protocol position, with the feedback NI assigned in each case to meet the requirements specified above.

In view of the fact that the feedback NI logically eliminated only one of the six hypotheses compatible with the feedback PI, the two problems are merely specified by the corresponding two feedback PIs, "loyalty-malice-love-determination" and "honor-anger-joy-competence," with no one solution specified at the end of each series. These two problems were balanced with respect to order of presentation, with each appearing first for an equal number of Ss.

The task was presented to S in terms of a game in which he was required to determine which two characteristics (from the set of 54 possible pairs of values on the abstract attributes) the possession of which made a person a member of some hypothetical organization and the lack of which excluded him from it. This was done to make the four-word stimulus a single unit vis-à-vis a description of some person. It was assumed on the

Table 2
Abstract Dimensions Resulting from Category Sort Data

Dimension	Values	I	C	m
Patriotism	Honor	3.99	1.74	5.99
	Bravery	3.60	1.75	5.80
	Loyalty	4.40	1.93	6.44
		4.07	1.56	5.72
Aggression		3.92	1.60	5.19
	Anger	4.87	1.70	5.83
	Animosity	3.60	1.81	5.19
	Malice	3.30	1.30	4.56
Well-being		5.38	1.80	6.32
	Joy	5.43	1.66	6.52
	Happiness	5.13	1.94	6.00
	Love	5.60	1.80	6.44
Strength		3.31	1.68	4.48
	Determination	3.57	1.66	4.64
	Confidence	3.40	1.52	4.17
	Competence	2.97	1.86	4.63

basis of previous findings (Nahinsky & Slaymaker, 1969) that a positive response to any stimulus indicated that S had sampled (i.e., was considering as potentially correct) at least one hypothesis represented by that stimulus. Instructions to the S were sufficient to make clear the aims of the experiment in general and the specific requirements of the task. The BT procedure was clearly identified for S in a manner similar to that reported by Levine (1966).

Results

Dependence of Hypothesis Sampling on Individual Attribute Values

The first BT set contained one pair of stimuli which had no overlapping values in common with the initial PI. The remaining stimulus from the first BT set and the feedback NI shared one common value with the initial PI. The feedback NI was effectively "blank" relative to S's response to it, since no informative feedback which might alter S's hypothesis pattern preceded this response, as was true for the BT set. If hypothesis sampling is a unitizing process whereby attribute values interact uniquely in combination for each hypothesis sampled, then individual values should not mediate sampling independently of the other values. Thus, whether or not BT stimuli overlap in attribute values of potentially correct hypotheses, the classification response for one stimulus should be independent of response tendencies for the other. A chi-square contingency test was performed for all S problems to assess the relationship between classification responses for the feedback NI and the BT stimulus which overlapped it by one value common to the feedback PI. The result showed a highly significant deviation from independence [$\chi^2(1) = 7.79, p < .01$]. The probability of a positive classification on the feedback NI given a positive classification on the preceding overlapping BT stimulus was .64. The corresponding conditional probability given a negative classification on the overlapping BT stimulus was .40. Conversely, positive classification probability on the overlapping BT stimulus

was .73 given a positive classification on the feedback NI with the corresponding probability given a negative classification on the BT stimulus equal to .50. Therefore, there was a significant tendency for stimuli which overlapped on potentially relevant attribute values to be classified in a like manner. In contrast, the contingency analysis for the nonoverlapping BT stimuli, which compared the BT stimulus shown first with that shown second, resulted in a nonsignificant relationship [$\chi^2(1) = 1.43$, $p > .20$]. Thus, nonoverlapping hypotheses tended to be sampled independently. This result also indicates that the strong tendency for like classification of the one-value overlap stimuli cannot be attributed merely to overall differential sampling rates of dimensional combinations. The results suggest that Ss sample hypotheses by a process which involves separate consideration of the potentially relevant component values. Ss have a greater likelihood of responding in the same manner to two stimuli when hypotheses involved have a common value than when they do not. The results are not compatible with the notion of hypotheses as distinct units of uniquely combined cues.

It is of interest to note another factor which might be associated with joint classification of two stimuli. The proximity of two stimuli in the series could be related to joint classification probabilities through temporary response sets. Probabilities of the same classification for two stimuli zero, one, and two stimuli apart in the order were calculated for all S problems over both one-value overlap and zero-value overlap pairs. There was no significant dependence [$\chi^2(2) = 1.42$, $p > .30$].

Frequency of positive classification was tabulated for stimuli in each position, from the first BT through the feedback NI. A significant order effect was found [$\chi^2(3) = 16.083$, $p < .005$]. There was a strong primacy effect, with a positive classification probability of .779 for the first BT with those probabilities ranging from .531 to .569 for the next three trials. This effect could serve to lower joint classification probabilities for pairs of stimuli. However, both overlapping and nonoverlapping pairs should show such an effect. Thus, the prime factor which mediated joint classification appears to be amount of overlap on potentially relevant characteristics.

Analysis of response patterns on the second BT set provides insight into unitization tendencies in the processing and elimination of hypotheses. The second BT set contained stimuli which corresponded to two tenable hypotheses, the third having been shown to be untenable by the feedback NI. One of the two tenable hypotheses overlapped this NI by one value in common with the initial feedback PI, and the other had no such overlap. A tabulation was made of the positive classification frequency for stimuli overlapping the feedback NI and also for those not overlapping that NI. Cochran's Q test was appropriate, yielding a significantly lower positive classification rate for stimuli that overlapped the feedback NI [$\chi^2(1) = 3.95$, $p < .05$]. The probability of positive classification for a stimulus

that overlapped the feedback NI was .269, while the corresponding probability for stimuli not overlapping that NI was .363. Thus, the probability of eliminating a hypothesis was increased if it overlapped by one value a hypothesis known to be untenable. This was true even though the former hypothesis was still logically tenable. This outcome lends further support to the notion that value processing, as opposed to hypothesis processing, was prevalent.

Interaction of Attribute Values in Hypothesis Formation

Hypotheses of the sort considered do not exist as separate entities in the stimuli presented; rather, they must be extracted from the stimulus array. Such extraction requires recombination of stimulus elements within the processing system. For each problem, the distribution of proportion of positive responses to stimuli in the first BT set and the feedback NI was tabulated for stimuli containing any one attribute value (e.g., honor) of the initial feedback PI with each of the remaining three values (in this example, joy, anger, and competence). Problems were then pooled for an Analysis by Dimensional interaction. For example, the positive response proportion for BT stimuli and feedback NIs that involved a potentially relevant value on the patriotism dimension was tabulated for potentially relevant values on each of the other dimensions. Four separate contingency tables resulted, one corresponding to each dimension. However, each of the six separate dimensional combinations appeared in two tables. Resulting pairs of expected values were pooled to provide one overall contingency chi square involving these six combinations. The outcome revealed no significant dimensional interactions [$\chi^2(5) = 6.97$, $p > .90$]. Assessments were made for each of the four separate contingency tables for the corresponding dimensions, with only the strength dimension producing significance. Hypotheses that combine the strength dimension with the aggression and patriotism dimensions were sampled with higher probability than those combining the well-being and the strength dimensions. It is likely that the aggression and patriotism dimensions correlate more highly with strength than does well being. Overall contingency tests for the six-value combinations for each of the two problems showed nonsignificance in each case. Thus, despite the difficulty in deriving conceptually orthogonal dimensions, there was no strong evidence for value or dimensional choice being influenced by the presence of other potentially relevant values or dimensions. The sampling pattern results discussed in this section are summarized in Table 3. The results suggest that conjunctive hypotheses were sampled and rejected via independent component value choice and processing.

Table 3
Comparison of Hypothesis Sampling Patterns Over Four Experiments

Experiment	N	Dimensional Interactions in Hypothesis Sampling			Relationship Between Value Overlap and Hypothesis Sampling (χ^2 , df = 1)		
		Overall χ^2 (df = 5)	Dimension	Significant Individual Dimensional Interactions	First BT Set (One Value Overlap)	First BT Set (No Value Overlap)	Second BT Set
				χ^2 (df = 2)			
Nahinsky, Penrod, & Slaymaker (1970)	100						
Borders Condition		27.28††	Number of Borders	6.46**	1.18	4.89***a	1.53
			Number of Figures	9.45†			
			Shape	37.32††			
			Shading	19.69††			
Color Condition		9.96*	Color	7.10**			
			Shape	9.30†			
			Shading	8.81**			
Experiment II	90						
Verbal		10.65*	Shape	14.15††	.00	.00	.02
			Shading	9.48†			
Figures		6.06	Number of Figures	8.74**	.32	2.91*a	2.17
Both		9.25*	Shading	12.80†	.03	.11	.58
			Number of Borders	7.16**			
Overall		17.73†	Shape	11.33†	.004	.34	1.94
			Shading	18.14††			
			Number of Figures	15.29††			
Experiment I	80	6.97	Strength	7.83**	7.79†	1.43	3.95**
Experiment III	84						
Verbal		5.01			.01	9.44†	9.00†
Picture		5.95			3.22	.19	2.92*
Both		5.76	Era	6.06**	7.58†	.01	8.47†
Overall		6.24	Era	8.49**	8.50†	4.02**	23.03††

^aInverse relationship

* $p < .10$

** $p < .05$

† $p < .01$

†† $p < .001$

Comparison of Results with Those Involving Concrete Stimuli

In this section, analyses corresponding to those reported in the preceding sections are presented for results of a prior experiment by Nahinsky et al (1970). The task structure was formally the same as that of Experiment I. However, the four attributes involved characteristics of geometric stimuli rather than the abstract attributes of the experiment reported above. Two sets of stimuli were used, with each set used for two different problems. For the first set (border condition), the four attributes were: (a) shape of figures—crosses, circles, or squares; (b) shading of figures—black, striped, or open; (c) number of figures—one, two, or three; (d) number of borders surrounding the figures—one, two, or three. The second set of stimuli (color condition) was the same with regard to the first three attributes but substituted color of the stimulus card for number of borders as the fourth attribute, with values white, blue, and pink. The reader is referred to Nahinsky et al (1970) for complete details.

Analyses reported for Experiment I data were performed on data of this earlier experiment for

purposes of comparison. Results for effect of proximity of two BT stimuli and for position effects parallel those for Experiment I. Main results are summarized in Table 3 for direct comparison with Experiment I results. It is plain that the effect of component values upon joint sampling and rejection probabilities found in Experiment I is not evident here. The significant relationship for nonoverlapping pairs was an inverse one. The probability of positive classification on the second of these BT stimuli was .330 given that classification of the first was positive, while this probability was .506 given that the classification of the first was negative. This apparent inhibitory tendency is difficult to interpret in terms of mediation of hypothesis sample via single-value processing. If Ss tend to limit the hypothesis sample to some small finite set, sampling one hypothesis would reduce the probability of sampling the next one. A tendency to process single values could have been offset by sample size limitation in this experiment. At any rate, such a limitation tendency, if it did exist, did not offset single-value overlap effects in Experiment I.

The borders condition produced the highly significant overall dimensional interaction, although seven of the eight individual dimensional interactions over both

conditions yielded significance. The number-of-borders dimension proved to be the strongest unitizer, with the other three dimensions entering into a sampled hypothesis with this dimension more frequently than with any remaining dimension, with one exception. Sampling probabilities for the number-of-borders dimension ranged from .419 for number of figures to .633 for shape. The shape and shade dimensions combined with probability .658, while other combination sampling probabilities ranged from .177 to .286. When individual value interactions were assessed, only the hypotheses based upon the PI, "one striped cross with one border," produced significance [$\chi^2(5) = 22.93, p < .001$].

In summary, the geometric stimuli of the CCI problems just considered seemed to produce sampling of cue combinations as separate entities, in which values were not processed independently of each other but as mutually interacting parts. There is, then, strong evidence that the type of stimulus material used in a concept identification task may influence the process whereby component attribute values are combined to test hypotheses.

Although comparisons of the two experiments indicated differential processing for the different stimulus material, many questions about aspects of the stimuli relevant to the differences obviously remain unanswered. The abstractness-concreteness dimension is the most apparent source of the differences. An obvious confounding factor derives from the differences between the tasks compared on the verbal-nonverbal continuum. The geometric stimuli were not explicitly defined verbally, while the more abstract stimuli were comprised of verbal descriptions from the dimensions selected for the task. If the degree to which verbal material is involved is crucial, would not a verbal description of the geometric stimuli result in a hypothesis sampling process for such material akin to that for the abstract material?

To determine if the differential results obtained derive, at least in part, from a verbal-nonverbal distinction, Experiment II was performed. The geometric stimuli from Nahinsky et al (1970) were used in CCI problems, where certain problems involved a translation of the stimuli into verbal descriptions, while other problems involved the geometric stimuli accompanied by the verbal descriptions. Thus, the verbal-nonverbal variable was separated from the attribute-concreteness dimension. Latency data were also collected in an attempt to gain additional evidence about the processing sequence as well as about differences between verbal and nonverbal processing.

EXPERIMENT II

Method

Subjects

The Ss were 90 undergraduates, 86 of whom were

introductory psychology students who participated in fulfillment of a course requirement. The other 4 Ss were volunteers from another undergraduate class. Ss were run individually.

Stimuli

Stimuli were varied along four attributes with three values per attribute: (a) shape—square, circle, or cross; (b) shading of figures—black, striped, or white; (c) number of figures—one, two, or three; and (d) number of borders around the figures—one, two, or three. The stimuli were presented via a Kodak Carousel random access slide projector on 2-in. slides in one of three forms: the geometric representations themselves (figures), the verbal description thereof (words), or the geometric representations with the verbal descriptions (both). Thus, an S might see two white circles with one border, or the sentence, "Two white circles with one border," or the geometric representation with the descriptive sentence beneath it, depending upon the condition for the given problem. The slides were Kodalith negatives of photographs of the stimuli. Therefore, stimuli were seen as white line drawings or white print on a black background.

Design

The experiment involved two Greco-Latin squares in which three CCI problems were balanced with the three presentation forms and with presentation orders over three groups of 15 Ss each in each of the two squares. Squares were formed such that no problem or presentation form immediately followed any other problem or presentation form in more than one of the squares. The three CCI problems involved the solutions, "three black figures," "two crosses," and "white figures with one border."

Each problem consisted of a sequence of 27 stimuli divided into three modular subsequences of 9 stimuli each. The first stimulus was a feedback PI randomly selected from a set of 3 such stimuli at the start of a problem. This stimulus was followed by a sequence of 3 BT stimuli, which was in turn followed by a feedback NI, then the original feedback PI, and finally a series of 3 BT stimuli. The value overlap relationships within this subsequence were the same as those in Experiment I. The next module of 9 stimuli possessed the same internal structure, except that the feedback NI could start the subsequence or could occur after the first BT series in it as determined randomly. The subsequence was determined by random selection of a feedback PI from the remaining two such PIs. The final module was the same in structure as the second and was based upon the remaining feedback PI. All stimuli were presented in random permutations within constraints of the subsequences. S was run to a criterion of 10 consecutive correct responses on each problem provided a criterion run started before Trial 54, the end of the second cycle of the problem sequence. If S had not reached criterion by Trial 54, the problem terminated upon the first error following that trial and S was started on the next problem. In any event, S was never run more than 60 trials on a problem.

Procedure

Each S was seated before a Teletype in an air-conditioned distraction-free room. Stimuli were projected before him via a rear projection screen. Instructions were presented through a tape recording, and task requirements were specified as in Experiment I. S was told that problems would be presented in one of three forms as the description of stimuli indicated. Examples of each type of stimulus were available to him on a panel to his left. The extreme left key on the lower row of Teletype keys was designated the negative instance key, and the

extreme right key of that row was the positive instance key. Both keys were covered with colored tabs for easy identification. S was seated with corresponding hands poised by these keys and instructed to respond to the slides presented without taking too much time. Each response elicited a Teletype printout of his response followed by a question mark. He was asked to confirm the response by repeating it or was allowed to change the response at that point. Very few changes were made. S was then given feedback or instructed to await the next slide depending upon the feedback status of the stimulus. The slide remained on for 5 sec after S responded and was given appropriate feedback. Another 4 sec intervened between the disappearance of a slide and presentation of the next one. S was told which stimulus form would obtain for each problem before its presentation and was informed of termination of a problem by the Teletype. He was told the correct solution after each of the first two problems and was asked for his hypothesis at the end of the third problem. This procedure was followed to avoid inducing a set to encode material verbally during solution.

Presentation of stimuli and recording of data were controlled by a PDP-9 computer. Two projectors were used, one containing a carousel of geometric representation slides and the other a carousel of the corresponding verbal descriptions. The "both" condition involved simultaneous use of both projectors with corresponding images superimposed upon the screen with verbal descriptions below the geometric stimuli. Latencies of the first response to each stimulus were recorded to the nearest 100 msec.

Results

Dependence of Hypothesis Sampling on Individual Attribute Values

As in the experiments reported earlier, assessments of classification dependencies for the feedback NI and the overlapping BT stimulus in the first set were performed over all S problems for the three conditions. In all conditions, the results were nonsignificant, as shown in Table 3. This test performed for data over all conditions also yielded a nonsignificant result. The same tests performed for the pair of BT stimuli not overlapping on any potentially relevant values were nonsignificant save for figures, which produced an effect marginally significant ($p < .10$). However, the relationship was inverse with probability of positive classification for the second stimulus equal to .31 given positive classification of the first stimulus and equal to .53 given a negative classification of the first stimulus. Thus, the result is equivocal and certainly cannot be viewed as supporting individual value processing. Thus, as in the prior experiment with geometric stimuli, there was no evidence of dependence upon single potentially relevant attribute values in the sampling of hypotheses.

As before, contingency tests for the influence of proximity of stimuli in the series upon joint classification probability for overlapping and nonoverlapping stimulus pairs revealed no significant relationships for any of the conditions: for figures, $\chi^2(2) = 2.067$, $p > .30$; for words, $\chi^2(2) = .515$, $p > .70$; and for both words and figures, $\chi^2(2) = 3.518$, $p > .10$. There was also no significant effect of position in this four-trial sequence upon positive classification

probability in any of the conditions: for figures, $\chi^2(3) = 2.891$, $p > .30$; for words, $\chi^2(3) = 5.966$, $p > .10$; and for both words and figures, $\chi^2(3) = 2.459$, $p > .30$. Thus, none of the variables identified, including stimulus overlap on potentially relevant values, was found to influence joint classification on the sequence of trials formed by the first BT set and the feedback NI following it.

As in the preceding experiments, responses on the second BT stimulus set were examined to determine if stimuli which overlapped the preceding feedback NI were less likely to be classified positively than were those which did not overlap this instance. As in the prior experiment with geometric stimuli, none of the conditions yielded a significant effect as shown in Table 3. The overall test also resulted in nonsignificance. Thus, there was no evidence in any condition that a single potentially relevant value was influential alone in the elimination of a conjunctive hypothesis. In summary, the analyses of this section indicate that hypothesis processing rather than single-value processing was prevalent for this type of stimulus material. The conclusion holds for the pictorial stimuli as well as for their verbal representations.

Interaction of Attribute Values in Hypothesis Formation

As in the preceding experiments, the distribution of proportion of positive responses to stimuli in the first BT set and the feedback NI following it was tabulated for each problem in each presentation condition for stimuli containing any one potentially relevant dimension with each of the remaining such dimensions. The significant results of the associated contingency tests are shown in Table 3. Only the words and the both conditions yielded marginally significant overall dimensional interactions with $p < .07$ for words. However, several individual dimensional interactions were significant: one for figures, two for the both condition, and two for words. The overall dimensional test for all conditions produced a highly significant effect, with three of the four individual dimensional interactions being significant.

The significant results for all conditions combined reflected a major interactional trend common to all conditions. The number-of-borders dimension was a unitizer in all conditions. For each condition, the probability of sampling a hypothesis containing any of the three other dimensions was always greatest for combinations with number of borders being the remaining dimension. Sampling probabilities for hypotheses containing the number-of-borders dimension ranged from .507 for shape in the both condition to .716 for shade in the both condition, with an overall average sampling rate of .600 for hypotheses containing the number-of-borders dimension. In contrast, sampling rates for dimensional combinations excluding number of

Table 4
Means for Conditions With Significant Main Effects for Response Latencies in Seconds and Trials to Criterion for a Concept Learning Experiment With Concrete Stimuli

	Response Latencies	Trials to Criterion
Problem A (Three Dark)	5.54	33.60
Problem B (Two Crosses)	5.90	40.06
Problem C (White, One Border)	5.63	28.09
First Problem	6.17	41.58
Second Problem	5.63	30.32
Third Problem	5.27	29.84
Figures	5.39	
Both	5.64	
Words	6.05	

borders range from .250 for shape and shade in the words condition to .500 for shape and number of figures in the figures condition. The fact that the dimensional interactions trends for the verbally presented stimuli paralleled those for pictorially presented stimuli suggests that processing strategies for figural stimuli hold for their verbal translations also. When one considers that two of the three presentation conditions enabled S to have direct access to the stimuli in verbal form, the results strikingly favor a preference for the unitizing approach. The consistent unitizing effect of the number-of-borders dimension was responsible for the significant effects in this experiment, as was true for the data cited from Nahinsky et al. (1970). This correspondence suggests that much the same sorts of processes were at work in the two experiments.

Response Latencies and Trials to Criterion

Each S problem was scored for learning speed by recording the trial after the last error with the constraint that the highest score allowed was 54. An analysis of variance produced only two significant main effects, with condition means for significant comparison shown in Table 4. There were significant practice effects [$F(2,168) = 20.40$, $p < .01$] and problem effects [$F(2,168) = 16.59$, $p < .01$]. The specific effects of problem difficulty and problem order difficulty can be derived from Table 4, with these variables of minimal interest here.

Each S problem was scored for mean response latency over all trials. The analysis of variance of these mean latencies follows a pattern similar to that shown in the trials-to-criterion analysis with the addition of one more significant main effect, that for presentation conditions. [For problems, $F(2,168) = 3.31$, $p < .05$; for presentation condition, $F(2,168) = 10.83$, $p < .01$; and for order, $F = 20.02$, $p < .01$.] Inspection of Table 4 reveals that the words condition produced the largest average latency. Individual comparisons using the Newman-Keuls procedure as outlined in Winer (1962) showed that the words condition was significantly different from the other two [$t(168) = 6.50$ for figures

and 4.04 for both, $p < .01$ in each case with $SE = .10$]. However, the both and figures conditions did not differ significantly from each other. In view of the fact that processing time for words was significantly longer than for the other two conditions, it is reasonable to hypothesize that an added step may be required when verbal representations are used with no pictorial representation. If Ss found it necessary to encode pictorial information verbally in order to process hypotheses, one would expect that a direct reading of the verbal descriptions rather than of some verbal encoding would produce fast processing for the verbal condition. On the other hand, if S encodes verbal material in some visual imaginal form, the slower verbal processing can be accounted for. The hypothesis that Ss process the attributes as embodied in the geometric forms is supported by the fact that the both condition was not significantly different from the figures condition, although the stimuli were made available in both verbal and pictorial form to S. In view of the interactional and unitizing nature of hypothesis pattern data, these results support this notion that such processing is related to the use of visual imaginal representations.

Each S problem was scored for mean latencies over all trials with positive classifications and for mean latencies over all trials with negative classifications. On each trial, it might be hypothesized that Ss access memory for potentially correct value combinations based upon information from past stimuli. S then must scan the stimulus to test for the presence of an attribute-value pair compatible with some hypothesis in his working pool. Nahinsky and Slaymaker (1969) and Nahinsky (1970) have presented evidence which indicates that such a match leads to a positive classification. If S processes values individually and sequentially, every positive classification would require two search-and-verification tests, one for the presence of each value of some potentially correct hypothesis. On the other hand, a failure to find a value passing the test on an initial scan should result in a halt to the search and a negative classification. Such a process should result in longer latencies for positive classifications. (Each search-and-verification test could be rapid and exhaustive or self-terminating and by attributes.) If S narrows the hypothesis sample to one hypothesis, the search would involve only two possible attributes and the sequential aspect would be accentuated. An examination of the third BT set and the following stimulus was made. These stimuli were presented on Trials 11-14 or on Trials 12-15, depending upon the series randomization. Relative frequency of positive classification was assessed for each set of stimuli corresponding to a subset of distinct hypotheses, and this value was prorated to estimate the size of Ss' pool relative to the six hypotheses compatible with the first PI. In 116 of the 270 protocols, it was estimated that there were fewer than two hypotheses in Ss' pool during

these trials, suggesting that Ss often narrowed the pool to one hypothesis at an early stage. These results are compatible with those of Nahinsky and Slaymaker (1969). An analysis of variance was performed to assess overall positive-negative differences with resulting significance [$F(1,89) = 5.94, p < .05$]. Positive latencies were greater than negative latencies for all conditions: for figures, $\bar{x}(\text{positive}) = 5.59$ and $\bar{x}(\text{negative}) = 5.26$; for both, $\bar{x}(\text{positive}) = 5.74$ and $\bar{x}(\text{negative}) = 5.52$; and for words, $\bar{x}(\text{positive}) = 6.21$ and $\bar{x}(\text{negative}) = 5.93$. However, individual contrasts by conditions based on the overall error term ($MSE = 1.74$) revealed no significant effects save for a marginal effect for figures [$t(89) = 1.68, p < .10$]. In an overall comparison, $\bar{x}(\text{positive}) = 5.85$ and $\bar{x}(\text{negative}) = 5.57$, indicating that positive classifications resulted in a 5% increase in latency. Thus, the sequential effect accounted for a very small percentage of total processing time. Isolation of the verification stage from the hypothesis testing process should increase the relative contribution. These results assume more interest when compared with a similar analysis of Experiment III results.

Experiment II corroborated the findings of Nahinsky et al (1970), and in addition suggested that the concreteness-abstractness differences were not mere artifacts of a verbal-nonverbal difference in tasks. It still might be argued that the results for Experiment I may have stemmed in part from a perception of stimuli as a diffuse collection of unrelated characteristics. In Experiment III, there was an attempt to embody each collection of abstract values in a single concrete stimulus, a well-known person. In this way, it can be seen if the processing trends revealed in Experiment I hold when abstract stimulus characteristics are unitized in a single concrete stimulus, presented in verbal or pictorial form. In addition, S was allowed to control his own postfeedback interval such that both response latencies and postfeedback times were recorded in an attempt to throw further light on information processing strategies.

EXPERIMENT III

Method

Subjects

The Ss were 84 students, 72 of whom were introductory psychology students who participated in fulfillment of a course requirement. The remaining 12 Ss were paid \$1.65 for the hour's participation; 9 were undergraduates and 3 were college-bound seniors from a nearby high school.

Stimuli

The stimuli were well-known individuals and varied along four binary attributes: (a) occupation—soldier or scientist; (b) era—20th century (i.e., "contemporary") or pre-20th century (i.e., "historical"); (c) nationality—American or foreign; and (d) level of existence—real or fictional. The list of the 16 people is shown in Table 5. The stimuli were presented via a Kodak

Table 5
List of Individuals Used as Stimuli in Experiment IV

Beetle Bailey	William Westmoreland
Dr. Strangelove	Albert Einstein
Colonel Klink	Fidel Castro
Dr. No	Christian Barnard
Jubilation T. Cornpone	George Custer
Artemis Gordon	Alexander G. Bell
Ulysses	Napoleon Bonaparte
Dr. Frankenstein	Galileo

Carousel random access slide projector on 2-in. slides in one of three forms as in Experiment II—black line drawings of individuals on a white background with the name of the individual typed below it for rapid identification, a verbal description of the individual with respect to the four attributes with the name of the person typed above it, or both the pictorial representation and the verbal description appearing below it. The verbal description was centered below the person's name and appeared on two lines. The top line contained the value for the fictional-real dichotomy followed by the era, and the bottom line contained the nationality followed by the occupation.

Design

The experimental design was formally the same as that used in Experiment II involving the two 3 by 3 Greco-Latin squares. The three CCI problems had solutions "fictional soldier," "foreign and historical," and "real American" and were balanced with the three presentation conditions described above in 14 replications of the design.

Each problem consisted of a sequence of 17 stimuli starting with a feedback PI and followed by a set of three BT trials, which was in turn followed by a feedback instance. The four stimuli in this BT and feedback instance sequence had the same overlap relationship to the initial PI as in the prior experiments. As before, one pair of these stimuli overlapped on no values common to the initial PI, while the other pair overlapped on one such value. One of these four stimuli was a positive instance. The four stimuli were presented in four different orders with presentation order balanced according to a 4 by 4 Latin square. In this way, each of the four stimuli appeared in a randomly determined manner as the feedback stimulus 21 times for each problem, while the remaining three stimuli comprised the preceding BT set. These four stimuli were followed by another presentation of the initial feedback PI, which was in turn followed by two BT stimuli. These two stimuli overlapped the initial PI each by one of the remaining pairs of values not represented on the preceding BT feedback instance sequence. The two BT stimuli always overlapped by one value common to the initial PI. (The binary nature of the stimuli placed constraints upon the stimulus sets which made the overlap relationships of the previous experiments impossible in this experiment.) After these two stimuli, the remaining nine stimuli were presented in random order. If necessary, a repetition of the cycle was initiated. S was run to a criterion of 10 consecutive correct responses on each problem provided a criterion run started before Trial 30, the 13th trial of the second cycle of the problem sequence. If S had not reached criterion by Trial 30, the problem terminated upon the first error following that trial and S was started on the next problem. In any event, S was never run more than 34 trials on any problem.

Procedure

Each S was seated at a table containing a response panel in an air-conditioned distraction-free room. The panel had two response buttons with a third smaller one in between and slightly above the former two. The left button was for a negative

classification and the right was for a positive classification, and they were so labeled. The smaller button was labeled "next slide," which S was to press when ready for the following stimulus. Above the two response buttons were two red lights labeled "correct" and "incorrect" for appropriate feedback on feedback trials. Stimuli were projected before S on a white screen on the wall before him. Instructions were presented through a tape recording, and task requirements were specified as in Experiment II. A chart containing the pictures of all 16 individuals along with corresponding verbal descriptions was available throughout the experiment on S's right on a large screen separating E from S. S was explicitly instructed about the nature of the attributes and was allowed to study the stimulus population to his satisfaction. He was allowed to use whichever hand he desired in making responses. The appropriate feedback light followed the response immediately on feedback trials with no signal following BT responses. S was allowed to study the slide after his response and was instructed to press the next slide button when he felt ready for the next slide. The slide and feedback light (if on) went off and the next slide appeared in 20 sec. (This intertrial interval was used by E to record response and latency data.) As in Experiment II, S was told the correct solution after each of the first two problems and was asked for the solution at the end of the third problem.

Results

Dependence of Hypothesis Sampling on Individual Attribute Values

As before, assessments of classification dependencies were made for each S problem for the two overlapping stimuli in the set of four stimuli following the initial PI. In each condition, the relationship between classification responses for the presentations was nonsignificant save for the both condition as is shown in Table 3. Nonetheless, there was a consistent trend toward like classification of the two overlapping stimuli in the set. Thus, when results were combined over all conditions, a significant relationship was revealed [$\chi^2(1) = 8.497$, $p < .005$]. In the overall analysis, the probability of a positive classification of the second stimulus was .584 given a positive classification of its overlapping partner. In contrast, the probability of a positive classification on the second trial was .388 following a negative classification of the prior stimulus of the pair.

The same tests performed for the pair of stimuli in the set of four that did not overlap on any potentially relevant value were nonsignificant with the exception of the words condition, as Table 3 indicates. An overall test showed a significant relationship [$\chi^2(1) = 4.016$, $p < .05$]. Thus, there appears to have been a general response set which predisposed Ss to respond either positively or negatively with high probability regardless of stimulus characteristics. For the overall analysis, the probability of a positive response on the second stimulus given a positive response on the first was .500, while the positive response probability for Trial 2 of the pair was only .362 given a negative response for the first trial for the pair. This general tendency is confounded with whatever tendency there was to classify stimuli jointly on the basis of overlap on a potentially relevant value.

However, the joint classification tendency was stronger for those stimulus pairs which did overlap on such values than for those pairs which did not.

An analysis of response patterns to the second BT set lends support to the notion that single-value processing contributed to stimulus classification in an important way. The relationship was assessed between classification responses for the two BT stimuli following the second presentation of the initial PI. A contingency analysis was performed for each condition for joint classification behavior for instances in which the feedback stimulus which immediately followed the first BT set was a NI which overlapped both BT stimuli in the second set by exactly one potentially relevant value, i.e., a value common to the feedback PI. Since in such instances the information prior to the second BT set did not logically eliminate either of the hypotheses represented by stimuli in this set, joint classification behavior should have reflected a decremental effect of the single value associated with the preceding feedback NI. As Table 3 shows, the three analyses produced significance, although the analysis for pictures was marginal ($p < .10$). The joint classification trend was the same for all three conditions, and a combined analysis produced overwhelming significance as shown in Table 3. The probability of a positive classification of the second of these BT stimuli was .596 given a positive classification of the first, but the conditional positive response probability dropped to .165 given a negative classification of the first stimulus. In addition, there was a strong shift from joint positive classification on the first BT set to joint negative classification on the second BT set. The probabilities of positive classification for trials in the first set of four stimuli following the initial PI were .560 for the overlapping stimulus pairs and .538 for the nonoverlapping pairs. In contrast, the probability of a positive classification on the second BT set was only .349. In view of the fact that none of the stimuli in this set represented hypotheses that could logically have been eliminated by preceding information, this general shift may be attributed to a tendency to decide on the basis of a single value associated with negative feedback. At any rate, a general response set could not account for the shift in probability. Thus, the results suggest that single-value processing entered into Ss' strategies.

Interaction of Attribute Values in Hypothesis Formation

As before, sampling probability interactions were assessed for the four attributes. As Table 3 shows, no condition nor all combined revealed a significant interaction among the four attributes. Only the era attribute produced a significant attribute interaction in an assessment by single attributes. This effect was revealed in the pictures condition and in the overall

analysis. Examination of individual stimuli revealed that the era value "historical" had significantly higher sampling probability with "scientist" and "real" than with "foreign."

It is easy to see that saliency of particular stimuli might induce positive classification biases which would be reflected in significant interactions between potentially relevant values. Despite this possibility, there was no strongly discernible trend toward such interactions, certainly not as strong as the trend shown for the geometric characteristics of Experiment II. Hence, single-value processing seems indicated. Indeed, the specific stimuli contained no explicit information necessary for classification, but such information had to be abstracted from a specification of the identity of the given individual. Thus, although stimulus saliency may have facilitated the identification process, there was no direct relationship between the attributes and the stimulus in this experiment comparable to a relationship between, say, shape and its pictorial representation in Experiment II.

Latency Analyses and Trials to Criterion

Each S problem was scored for learning speed by recording the trial after the last error with the constraint that the highest score allowed was 30. The analysis of variance of these results produced two significant main effects: problems [$F(2,156) = 3.14, p < .05$] and order [$F(2,156) = 8.73, p < .01$]. Means for conditions with significant effects are shown in Table 6. Inspection of Table 6 suggests the nature of practice and problem effects which are of minimal interest here. The analysis of average response latencies revealed a practice effect [$F(2,156) = 21.59, p < .01$] for the only significant effect. There was no presentation condition effect for response latencies as in Experiment II. It seems likely that Ss consistently referred to verbal descriptions available regardless of presentation conditions.

Each S problem was scored for mean postfeedback time over all trials, and ensuing analysis of variance produced significant order and condition effects. For order, $F(2,156) = 8.50, p < .01$. The results parallel exactly those for trials to criterion and response latency. Thus, Ss improved significantly after the first problem in trials taken to learn and time spent with stimuli, both before and after feedback.

The most interesting results from the postfeedback data is the significant main effect for conditions [$F(2,156) = 56.83, p < .01$]. Individual comparisons using the Newman-Keuls procedure revealed that Ss take significantly less time for pictures than for either both words and pictures or words alone [$t(156) = 5.55$ for words and $t(156) = 4.27$ for both with $SE = .20, p < .01$ in each comparison]. The both and the picture conditions did not differ significantly from each other. The necessary information for classification is to be found in the verbal description, and Ss spent about 1 sec

Table 6
Means for Conditions With Significant Main Effects for Response and Postfeedback Latencies in Seconds and Trials to Criterion for a Concept Learning Experiment With Well Known People as Stimuli

	Response Latencies	Postfeedback Latencies	Trials to Criterion
Problem A (Fictional Soldier)			16.27
Problem B (Foreign & Historical)			15.36
Problem C (Real American)			13.20
First Problem	6.52	6.45	17.98
Second Problem	5.35	4.00	13.55
Third Problem	4.97	3.62	13.31
Pictures		4.02	
Both		4.89	
Words		5.15	

longer on the average examining the stimuli with the richer source of information when available. This tendency was independent of the presence or absence of pictorial representation to accompany the verbal information.

As in Experiment II, S problems were scored for mean latencies for positive classifications as well as for negative classifications. An analysis of positive classifications on the second set of BT stimuli, which was presented on Trials 7 and 8, was performed in the manner described for the third BT set of Experiment II. The resulting estimates of hypothesis sample size indicated that there were fewer than two hypotheses in the sample for 158 of 252 S problems at that point. Thus, there was evidence that S often narrowed the search to one hypothesis at an early stage. The overall analysis revealed a highly significant effect [$F(1,83) = 36.79, p < .001$] with consistent superiority of positive over negative latencies. In contrast to corresponding Experiment II results, all condition contrasts, based upon the overall error term ($MSE = 2.08$), revealed significance: for words, $t(83) = 5.12, p < .001$, $\bar{x}(\text{positive}) = 6.17$ and $\bar{x}(\text{negative}) = 5.03$; for pictures, $t(83) = 2.07, p < .05$, $\bar{x}(\text{positive}) = 5.94$ and $\bar{x}(\text{negative}) = 5.48$; and for both, $t(83) = 3.37, p < .001$, $\bar{x}(\text{positive}) = 5.97$ and $\bar{x}(\text{negative}) = 5.22$. A comparison of the overall means reveals a 15% average increase of positive over negative latencies with $\bar{x}(\text{positive}) = 6.02$ and $\bar{x}(\text{negative}) = 5.24$. Positive latency score was greater than negative latency score over the three conditions for 66 of 84 Ss in contrast to only 50 of 90 differences in that direction for Experiment II Ss. It appears that the trend predicted by sequential processing was notably stronger in Experiment III than in Experiment II, although both experiments manifested such a tendency. At any rate, the stronger Experiment III trend would be in keeping with the notion that abstract processing is more verbal and sequential than is imaginal processing. Perhaps a lesser sequential trend may be associated with some form of sequential processing with overlapping start times. Other investigators (Aiken, 1972; Trabasso,

Rollins, & Shaughnessy, 1971) have presented evidence for such sequential processing in experiments which involve a study of the verification process alone, and experiments of this nature will be necessary to explore concrete-abstract processing differences in detail free of the influence of information processing requirements of initial learning.

DISCUSSION

The results of the research have relevance for theories about the concept learning process. Concept learning models have not explicitly made provision for qualitative influences of stimulus variables. Research has indicated that certain variables have influenced the way in which Ss go about learning concepts. Johnson, Fishkin, and Bourne (1966) and Polson, Dunham, and Reeve (1971) have demonstrated how instructions influence the tendency to process information by dimensions or by hypotheses in reversal and interdimensional shifts. Heidbreder (1946) demonstrated a relationship between concreteness of concepts to be learned and learning difficulty. DiVesta and Rickards (1971) demonstrated an interaction between concept type and labeling and articulation upon the ease of learning concepts. Therefore, there is ample evidence that task variables should be considered in formulating theories of concept learning. The research reported here differs largely from other research in its emphasis on qualitative differences in response patterns in contrast to gross measures of performance efficiency. The findings suggest that important stimulus variables, and perhaps associated processing variables, are related to certain qualitative differences in processing mechanisms. Hence, it might prove to be more profitable to model different situations in different ways.

Certainly, problems of the influence of confounding variables can be raised. There is the general problem of scaling of attributes. Attributes need to be scaled for unidimensionality and for interdimensional association so that stimulus materials can be varied with respect to the concreteness (or imageability) dimension while remaining comparable with respect to "pureness" of attributes and degree of dimensional intercorrelation. It is possible that differences between processing strategies for the different types of stimuli would be even more pronounced if attributes were clearly independent. If attributes were orthogonal, abstract attributes could not exhibit unitizing tendencies which might result from interdimensional association alone. Slaymaker (1972) has developed a refinement of the attribute selection technique used in Experiment I which will be useful for dealing with scaling problems. He has developed methods for deriving dimensions in which the component values can provide measures of dimensionality and measures of association with other

dimensions. Subsequent research will use the approach to tease out other factors in the study of the concreteness-abstractness dimension.

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