Shifting from a simple to a conjunctive concept

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Shifting from a simple concept (e.g., color) to a conjunctive concept was easier when the conjunction was confined to the same dimension (color-color conjunction) than when the conjunction was either confined to another dimension (shape-shape) or spread over both dimensions (color-shape). Of the two difficult conditions, the two-dimensional one tended to be harder than the one-dimensional one.

In concept attainment experiments, S is usually required to categorize a series of stimulus cards into positive and negative instances of a concept defined by E. The stimulus cards may be described in terms of their attributes, which in turn may be described in terms of the dimensions represented and varying in the design (e.g., shape, color) and the particular values of these dimensions present on any given card (e.g., square, circle; red, green). Concepts themselves may be simple or complex. A simple concept is defined by the presence (or absence) of one particular value on the card; this corresponds to Neisser & Weene's (1962) Complexity Level 1. Any other definition renders the concept complex; obviously there are many kinds of complex concept, including the familiar conjunctive and disjunctive types (Bruner, Goodnow, & Austin, 1956).

Simple concepts have been much used to study the transfer effect of learning one concept on the subsequent learning of another. A potent variable here is whether the two concepts are defined by different values of the same dimension (intradimensional or ID shift) or of different dimensions (extradimensional or ED shift). For human adults, at any rate, the latter is generally found to be the more difficult (Wolff, 1967).

Complex concepts have seldom been used in studies of concept shifts (see, however, D'Amato & Ryan, 1967). The reason for this is that most sets of stimulus material are so designed that only a single value of any dimension is present on any one card. Consequently, any complex concept applicable to such material, requiring at least two values in its definition, must involve at least two different dimensions. There is no reason why transfer between two-dimensional concepts, with and without change of the relevant dimensions, should not be studied experimentally, although this does not appear to have been done. Nor is there any reason why one should not use one-dimensional complex concepts, which a slight change in stimulus materials would make possible. The present experiment makes a small beginning by requiring Ss to shift from a simple to a one-dimensional conjunctive concept, both intradimensionally and extradimensionally. In addition, a shift from a simple to a two-dimensional conjunctive concept, which has already been examined by D'Amato & Ryan (1967), is included.

DESIGN

The experiment consisted of two phases. Each S served in one of two conditions in Phase 1 and one of three conditions in Phase 2. Thus there were six different treatments in all. In Phase 1, S learned either a simple color concept or a simple shape concept. The concepts learned in Phase 2 were the conjunction of two colors, the conjunction of two shapes, and the conjunction of one color and one shape. In all six treatment groups, then, Ss shifted from a simple to a conjunctive concept. For two groups, the conjunction was one-dimensional with the same dimension relevant (ID shift); for two, it was one-dimensional with a different dimension relevant (ED shift); and for two, it was two-dimensional, involving the same dimension and a different one (2D shift). See Table 1.

Table 1
Positive Values and Types of Shift in each Treatment

Phase 1	Phase 2		
	yellow and blue (color-color)	circle and elipse (shape-shape)	yellow and elipse (color-shape)
violet (color)	ID	ED	2D
square (shape)	ED	ID	2D

MATERIALS

The stimulus material took the form of cards bearing designs which varied on three dimensions, the color, shape, and number of spots.

In Phase 1, four values of each dimension were used. These were: for color, violet, red, pink, and brown; for shape, square, triangle, cross, and semicircle; and for number of spots, 1, 2, 3, and 4. Each card sampled two values of each dimension, e.g., a sample card bore three violet triangles on the left half and one green square on the right half of its face. The two halves of a card never bore the same value on any dimension. There were 1728 different possible designs. Cards bearing 60 of these were prepared for use in the color-concept condition of Phase 1. The designs were selected so that half of the cards were positive instances (i.e., one of the two colors was violet), while the other three colors, and the four shapes and four numbers were used with approximately equal frequency. The cards were arranged in a standard order whereby all possible incorrect hypotheses were not logically eliminated until Card 16. A second deck of 60 cards was prepared for use in the shape-concept condition. The designs on these cards corresponded to those in the color-concept deck, with the color and shape values interchanged (i.e., whenever violet appeared in the first deck, square appeared in the second, and so on).

For Phase 2, a closely similar arrangement was adhered to. The designs again varied on the dimensions of color, shape, and number of spots, with four values of each dimension in use. The number values 1, 2, 3, and 4 were retained, but different colors (yellow, blue, green, and gray) and shapes (circle, ellipse, diamond, and irregular quadrilateral) were introduced. Three separate but parallel decks of 60 cards were prepared, one for each condition. Half of the cards bore positive instances, irrelevant values were used with equal frequency, and a standard order of presentation delayed logical elimination of all possible incorrect hypotheses until Card 16. The only substantial departures from the Phase 1 material were the use of different colors and shapes, and the necessity of two specific values being present on each positive instance.

SUBJECTS

A total of 60 university students served as Ss. There were five men and five women in each of the six treatment groups.

PROCEDURE

The Ss were told that E would present a series of cards showing different combinations of numbers, colors, and shapes. Throughout the series, E would have a particular concept in mind, and some of the cards would be examples of this concept. As soon as each card was presented, S was to say whether he considered it to be a positive or a negative instance; E would then tell him whether he was right or wrong.

Table 2
Trials-to-Criterion Data for both Phases

	N	Median	Range
Phase 1			
Color concept	30	57.5	6-121
Shape concept	30	46.0	3-166
Phase 2			
ID shift	20	16.5	1-33
ED shift	20	26.5	13-156
2D shift	20	73.0	13-149

The criterion of attainment was 10 successive correct judgments. If S required more than 60 trials, the stimulus cards were randomly shuffled and used again.

RESULTS

The data consisted of trials-to-criterion scores in both phases, and excluded the 10 criterion trials. Because of nonnormality of distributions, the Mann-Whitney U test was used for all the analyses reported below.

In Phase 1, there was no significant difference between the color-learning and shape-learning groups. See Table 2.

In Phase 2, Ss are grouped, not according to the concepts they learned, but in terms of the kind of shift involved (ID, ED, 2D). In fact, there were no significant differences between the subgroups within these three conditions, so that the type of concept learned in Phase 1 may appropriately be disregarded in analysing Phase 2 results. These results are shown in Table 2. The ID group performed markedly better than both the ED ($p < .02$) and the 2D ($p < .002$) groups. The ED group did better than the 2D group, but because of the very wide range of scores in both groups, this difference only approaches significance ($p < .10$). (All p values are two-tailed.)

DISCUSSION

The difference between ID and ED shifts is in agreement with much previous work comparing such shifts using simple concepts only and requires no extended discussion.

The findings relating to the 2D shift, however, are more interesting. It may seem intuitively obvious that the 2D concept presents a more difficult task than either the ID or the ED condition, simply because it has two relevant dimensions to their one. To our knowledge, there is no evidence either for or against this supposition. Two-dimensional conjunctive concepts have sometimes been compared with one-dimensional simple concepts (Davis & Bourne, 1965; Neisser & Weene, 1962; Shepard, Hovland, & Jenkins, 1961; Wallach, 1962), and are generally found to be more difficult. (Not invariably, however; in some of their experiments, Shepard et al found no significant difference, and Neisser and Weene's Ss showed a significant difference only after they had become practiced.[1]) But no one apparently has compared the learning of one-dimensional and two-dimensional conjunctive concepts. If these tasks do differ in difficulty, then our Phase 2 results become difficult to interpret, since the transfer effects of Phase 1 should be measured against different and unknown baselines. Our analysis tacitly assumes that all Phase 2 tasks have the same baseline (level of difficulty in a zero transfer situation).

A major attempt to explain the relative difficulty of different types of concept shift has been made by the advocates of mediational theory (Goss, 1961; Kendler & Kendler, 1962). These authors have analyzed simple concept learning into two components, the learning of a mediator which corresponds to the relevant dimension, and the learning of a terminal choice (approach) response corresponding to the correct value on that dimension. This analysis is used to explain the difference in difficulty between ID and ED shifts, in that both require the acquisition of new choice responses, but the ED shift in addition requires the extinction of the original mediator and the learning of another, while the ID shift allows retention of the original mediator. In our experiment, all three conditions involve the acquisition of new choice responses, but they differ with respect to the mediator. In the ID shift, the Phase 1 mediator is retained; in the ED shift, it is eliminated and a second mediator is learned in its stead; in the 2D shift, the second mediator must be acquired, but the original one is not eliminated. Hence, if we rank the conditions in terms of the severity of mediator-change required, we obtain the order ID, 2D, ED, and mediational theorists might be expected to predict this order of difficulty for the three conditions in the present experiment. Such prediction, of course, is not sustained by our results.

The argument leading to the above prediction is not wholly speculative. D'Amato & Ryan (1967) have already demonstrated that there is positive transfer from prior learning of a simple concept to the subsequent learning of a two-dimensional conjunctive concept. Their procedure differed from our 2D shift in that they retained the same values as well as the same dimension in the transfer task. Their Ss in this condition performed significantly better than a control group, and better than a group shifting to a two-dimensional conjunctive concept for which the previously relevant dimension was irrelevant.

In the light of these findings, it is possible to offer an interpretation of the present results which might accommodate them within the general mediational account of concept shifts. In this interpretation, both the ID and 2D shift conditions produced positive transfer effects in Phase 2, while the ED shift produced negative transfer (as required by mediational theory); but two-dimensional conjunctive concepts are inherently much more difficult to learn than one-dimensional conjunctive concepts, so that the facilitated performance on the 2D shift was no better, in absolute terms, than the retarded performance on the ED shift. If this interpretation is sound, the number of dimensions involved in a conjunctive concept must have a massive effect on the ease of concept learning. Whether this is so, only further experimental work can reveal.

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NOTE

1. Neisser and Weene used alphabetic stimulus material which does not lend itself to unambiguous interpretation in terms of dimensions and values. Our discussion assumes that their material consisted of five dimensions (J, Q, V, X, Z) each of which had two values (present, absent), one of which was sampled in each instance. But it could equally be interpreted as having one dimension (presence) with five values (J, Q, V, X, Z), of which 1, 2, 3, or 4 (but never 0 nor 5) were sampled in each instance. If the latter interpretation is preferred, then Neisser and Weene's results cease to be an exception to the general run of findings, and provide the only evidence on the relative difficulty of a variety of one-dimensional concepts.