Subproblem analysis of discrimination-shift learning*

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A new analysis of discrimination-shift learning is presented which is applicable to reversal (RS) vs extradimensional (EDS) shift comparisons in which stimulus pairing is unaltered throughout training. The analysis focuses on trial-by-trial performance on the individual pairs appearing in RS and in EDS. Applications of the analysis are presented which reveal that young children are likely to learn the pairs as independent subproblems, while older Ss treat the pairs as instances of a single problem. The former solution mode is found to be correlated with fast EDS and the latter mode with fast RS.

Despite an enormous amount of work, there is intense controversy concerning both the major empirical phenomena and the theoretical interpretations associated with developmental changes in discrimination learning and transfer (Kendler & Kendler, 1969; Slamecka, 1968; Wolff, 1967). The present article presents a new analysis of one of the basic discrimination transfer designs encountered in this literature. As compared to conventional analyses, the method introduced here provides a more direct measure of the learning processes operating during solution of discrimination transfer problems by various groups of Ss.

The analysis was carried out on data from two recent studies of reversal shift-extradimensional shift learning (hereafter we will refer to RS and EDS) in young children, in which the shifts were conducted in the manner shown in Fig. 1 (after Kendler & Kendler, 1962, p. 5).

The Kendlers' description of the problem represented in Fig. 1 provides an excellent starting point for our discussion. "The stimuli (cups) for their first discrimination differed simultaneously on two dimensions (size and brightness). The subject is rewarded for responses to one dimension (e.g., large cup is positive, small cup is negative). The other dimension is irrelevant. After learning

the first discrimination, the subject is forced to shift to another response. In a reversal shift, the subject is required to respond to the same dimension on which he was originally trained, but his overt choice has to be reversed, e.g., he has to shift from a large cup to a small one. For a non-reversal shift the previously irrelevant dimension becomes relevant, e.g., black becomes positive after large had been positive [Kendler & Kendler, 1962, p. 5]."

This description (which is typical of many descriptions of discrimination learning to be found in the literature) assumes that the stimulus pairs constitute a single problem. While this description is an adequate and intuitively plausible account from the *E's viewpoint*, it is not necessarily a description of how the S learns the problem. It is at least logically possible that the S treats the stimulus pairs as independent subproblems which happen to occur on alternate trials in the course of training.

Let us assume for the moment that Ss might, under some circumstances, treat the stimulus pairs as independent problems. If we eschew existing models of discrimination learning and restrict ourselves to descriptive terminology, what would this imply about discrimination and shift performance?

Consider once again the stimulus arrangements depicted in Fig. 1. Note that for the reversal problem, the reward relations which obtain in the initial discrimination are reversed for *both of the pairs* (subproblems). For EDS, the reward relations are unchanged for *one pair* of stimuli and reversed for the other pair. Viewed this way, there is twice as much to learn for the RS; the EDS requires relearning of only one subproblem, while the RS requires relearning of two.

It would seem a straightforward matter to determine whether independent subproblem learning

characterizes the learning of the individual pairs in those situations where EDS is found to be easier than RS. However, for reasons linked to tests of single-stage vs mediational interpretations of discrimination learning, the problem presented in Fig. 1 has rarely been conducted in the way implied by the figure. Rather, Es have employed designs which restructure the problem at the point of the shift (alternative designs are discussed at length in Shepp & Turissi, 1966; Wolff, 1967).

For quite different reasons, we independently conducted two experiments which included groups of Ss whose treatments corresponded to those schematized in Fig. 1 (Cole, Gay, Glick, & Sharp, 1971; Tighe & Tighe, 1967). These experiments produced similar results in regard to subproblem learning. A reanalysis of the data presented in the paper by Tighe and Tighe can serve as an example of our analysis of the learning of subproblems during discrimination transfer.¹ The part of their experiment which concerns us involves the children (32 4-year-olds and 32 10-year-olds) who experienced the RS and EDS shift procedures with the irrelevant dimension variable within trials during both the initial discrimination and shift learning.

Figure 2 (A and B) contains the shift performance of each of the age groups in terms of our independent subproblem analysis. Each part of Fig. 2 shows the trial-by-trial learning functions for the changed pair in the EDS (EDS-C) and the unchanged pair (EDS-U), separately, along with the averaged functions for the two pairs of RS. Considering first the performance

Fig. 1. Example of a reversal and a nonreversal (extradimensional) shift.

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Fig. 2. (A and B) Learning functions of 4-year-olds (2A) and 10-year-olds (2B) on EDS-C, EDS-U, and RS. For RS, pair trial refers to successive presentations of both stimulus pairs.

of the 4-year-olds in Fig. 2A, we see that there is a marked difference in the learning of the two pairs, with Ss exhibiting a high proportion of correct choices on the unchanged pair throughout EDS, but a slow, gradual acquisition of correct responses to the changed pair. Significantly, performance for the RS pairs is very similar to that of EDS-C.

For the 10-year-olds (Fig. 2B), performance suffers on both EDS-U and EDS-C. There is a necessary initial drop in RS performance, but the RS curve quickly surpasses the two EDS curves.

Tighe and Tighe reported that under these conditions, an EDS was learned more rapidly than an RS by the younger children, but the opposite was true of the older children. Figure 2 localizes the source of this effect. For the 4-year-olds, each of the changed pairs (whether in RS or EDS) is learned at approximately the same rate. Since there are two such pairs for RS and only one for EDS, on the average (across subproblems), EDS performance is superior. For the older children, the identity of changed pairs no longer holds. This nonindependence of the subproblems is clearly seen in Fig. 2B in the marked drop in correct choices by 10-year-olds on the early trials with EDS-U. Ten of the 16 older children in this shift

condition reversed their choice on the first postshift exposure to EDS-U after experiencing nonreward on EDS-C. Nonreinforcement on EDS-C, then, caused these older Ss to change response to EDS-U, even though they had never experienced nonreinforcement on this pair. In contrast, only 1 of the 16 4-year-olds showed such "spontaneous reversal" of choice on EDS-U. In fact, 7 of these Ss never made an error on the unchanged pair throughout shift learning. In contrast, all of the older children made at least one error on EDS-U during learning. (A criterion of 9 correct out of 10 consecutive responses was used in both original learning and shift phases.)

The subproblem analysis, then, indicates that the younger children tended as a group to learn the constituent stimulus pairs as independent subproblems, while the older Ss were more likely to treat the stimulus pairs as instances of a single problem. These different patterns of subproblem learning indicate a difference in degree of dimensional control of choice behavior. However, studies showing faster learning of full reversal than partial reversal of unrelated stimulus pairs (e.g., Bogartz, 1965) suggest that single-problem learning may also be mediated on a nondimensional basis.

We suggest that where experimental procedures admit of such an analysis, the decomposition of "problems" into their subunits may provide new insight into the way in which discrimination learning and transfer are accomplished.

The correlation observed here between mode of subproblem learning and relative ease of RS-EDS is clearly relevant to theories of discrimination-shift learning (Kendler & Kendler, 1962; Tighe & Tighe, 1966; Zeaman & House, 1963) which relate ease of RS to degree of dimensional control of discriminative response. This pertinence to theory argues the extension of the analysis to a variety of S populations, stimulus dimensions, and training procedures.

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NOTE

1. The results of this reanalysis, which are presented here, are heretofore unpublished.