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# Effects of Distinctive-Feature Training and Instructional Technique on Letter and Form Discrimination

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Techniques for facilitating alphabet letter discrimination were investigated within the framework of distinctive feature and attention theory. To compare the effectiveness of three instructional procedures for emphasizing distinctive features, experimenters gave separate groups of children either distinctive-feature training, highlighting of the features, or distinctive-feature training plus fading-in of the letter forms, along with a control, for each of three dimensions. The horizontal-slant, open-close, and straight-curve dimensions were chosen for study. Training effects were assessed by presenting corresponding alphabet letter pairs (*H-N, C-O, U-V*) and two sets of generalization forms. Results indicated that the three experimental groups performed better than the control, but did not differ from each other. All groups except fade-in readily generalized to other forms. These findings were discussed in terms of the educational value of distinctive feature analyses and the use of instructional methods.

To discriminate among complex visual forms, such as letters of the alphabet, the learner must become sensitive to the critical features that differentiate the graphic forms. In developmental studies, Gibson and her associates (Gibson, 1969; Gibson, Gibson, Pick, & Osser, 1962) have suggested that progressive improvements in discriminating letters and letter-like forms reflect various learning experiences that have led the children to discover and respond to the relevant distinctive features. In support of this, an error matrix analysis derived from a matching task with uppercase letters indicated that confusability tended to vary directly with the number of commonly shared distinctive features (Gibson, Osser, Schiff, & Smith, Note 1).

Although the analysis and identification of the distinctive features of alphabet letters are still incomplete, the dimensions of curve-straight, break-close, and relative diagonality seem reasonably well-established (Gibson, 1969, 1970; Guralnick, 1972). In addition, developmental researchers have indicated that the orientation dimension poses perhaps the most difficult discrimination problem with errors of reversal and rotation being very prominent, especially mirror-image type reversals (Gibson et al., 1962; Popp, 1964). As a consequence, various techniques have been devised to teach young and retarded children to attend to the relevant aspects of the orientation dimension (Bijou, 1968; Hendrickson & Muehl, 1962; Jeffrey, 1958; Koenigsberg, 1971).

In a matching-to-sample task utilizing letter-like stimuli, Tawney (1972) trained a group of 4-year-old Head Start children to attend to a wide range of critical features derived from the Gibson et al. (Note 1) matrix. Performance on tests of alphabet letter discrimination before and after training was compared with a group given similar training on noncritical features and a no-training control group. The results indicated that all groups made fewer types of confusion errors on the posttest as compared to the pretest, with the critical-feature group performing best, especially for highly confusable letter pairs.

Taken together, these training procedures are consistent with the Zeaman and House (1963) theory of discrimination learning, which emphasizes the role of attention. Although their formulations were derived mainly from research with retarded individuals, the effectiveness of distinctive-feature training upon alphabet discrimination learning for this population needs to be clarified. Moreover,

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experimental work is needed to determine which instructional techniques most readily focus the learner's attention on the critical features.

Accordingly, the present study was designed: (a) to determine if prior training on distinctive features relevant to the discrimination of specific alphabet letter pairs can facilitate later discrimination of those letter pairs, (b) to compare the effectiveness of three procedures for emphasizing the distinctive features, and (c) to evaluate the effects of this training on a transfer task using relatively complex non-letter forms.

## Method

### *Subjects*

Thirty-two handicapped children (Mean Peabody Picture Vocabulary Test [PPVT] IQ = 41.8) drawn from various schools participated. Initial selection of children was based on teachers' reports that the child had poor discrimination skills, did not demonstrate any knowledge of the alphabet, and that alphabet learning was not currently part of the child's curriculum. Presentation of certain key letters in a brief test confirmed that each child selected was unable to name any of the letters.

### *Procedure and Materials*

The task consisted of a two-choice matching-to-sample procedure in all segments of the experiment. Each subject was simply required to point out or touch the comparison stimulus that was the same as the sample. For each segment or level of the experiment, only pairs of stimuli were contrasted. For example, in the letter-discrimination task, only *H* or *N* could appear as the sample and comparison stimuli or, if one of the open-close comparisons was being presented, only those two forms would be part of the matching-to-sample task (see below). Sessions lasted for about 20 minutes and were conducted in a nearby classroom with only the child and experimenter present.

Pretesting and instruction using familiar objects and three sets of highly discriminable forms were provided to ensure that each child had the necessary matching concept. A Fellows' (1967) sequence was used here (and in all other parts of this experiment) to select both the sample stimulus for that trial and the position of the correct comparison stimulus.

A criterion of nine correct responses out of ten was employed for all phases and levels of the experiment. Feedback was provided on every trial. If the child selected the incorrect comparison stimulus or paused longer than 30 seconds following presentation of the materials and a verbal prompt to match, the experimenter said, "No, this is the one that is the same," and prompted the child to point to it. A brief time-out then followed, and no reinforcement was provided. If the response were correct, the child was praised and given a small candy which could be stored or consumed.

Following the pretest, children were randomly assigned to one of four groups: (a) control, (b) distinctive feature, (c) distinctive feature plus fade-in, and (d) highlighting. The mean PPVT IQ scores (and chronological ages) for the four groups were: 45.3 (8.25), 40.1 (8.75), 40.4 (8.5), and 41.2 (8.2), respectively. Each of the three experimental groups was presented with a separate training method designed to facilitate performance on specific letter-discrimination tasks. In addition, generalized effects were assessed in a transfer task using nonsense forms similar to those used by Gibson et al. (1962).

The overall design of the experiment is presented in Table 1. The rationale here was to

TABLE 1
SEQUENCE OF EVENTS FOR EACH GROUP

| Group/ Training dimension | Letters | Generalization[a] |
|---|---|---|
| Distinctive feature | | |
| Curve-Straight | U-V | N-1, N-2 (UV) |
| Open-Close | C-O | N-1, N-2 (CO) |
| Horizontal-Slant | H-N | N-1, N-2 (HN) |
| Distinctive feature plus fade-in | | |
| Curve-Straight | U-V | N-1, N-2 (UV) |
| Open-Close | C-O | N-1, N-2 (CO) |
| Horizontal-Slant | H-N | N-1, N-2 (HN) |
| Highlighting | | |
| Curve-Straight | U-V | N-1, N-2 (UV) |
| Open-Close | C-O | N-1, N-2 (CO) |
| Horizontal-Slant | H-N | N-1, N-2 (HN) |
| Control | | |
| Line drawings | U-V | N-1, N-2 (UV) |
| Line drawings | C-O | N-1, N-2 (CO) |
| Line drawings | H-N | N-1, N-2 (HN) |

[a]N-1 = nonsense form 1, N-2 = nonsense form 2.

train each child to attend to the relevant distinctive feature (dimension) by employing simplified forms and training procedures in order to facilitate transfer to letter stimuli and other complex forms. The curve-straight, horizontal-slant, and open-close dimensions were chosen for investigation. Each particular dimension was associated with a corresponding letter pair and two sets of generalization forms.

For example, each subject in the distinctive-feature group would, after random selection of the dimension (e.g., horizontal-slant) receive matching-to-sample training on that dimension, then be presented with the corresponding letter stimuli (*H-N*). Following this, the appropriate nonsense forms for that dimension would be introduced. A second dimension would then be randomly selected, and the same sequence of training, letter discrimination, and generalization testing would follow. Accordingly, this design generated three replications of the sequence within each group, one for each of the dimensions.

Separate sets of training forms were constructed for each treatment group. For the distinctive-feature group, three pairs of forms constituted the training materials. Each of the three levels (pairs) increased in difficulty for each dimension. For the curve-straight dimension, a straight vertical line was contrasted with curved lines, similarly oriented, with the degree of curvature decreasing (and similarity increasing) across the three levels. The top portion of Figure 1 illustrates the final level of the curve-straight dimension for the distinctive-feature group. The open-close dimension consisted of three pairs of curved lines, with the size of the gap for the open member progressively decreasing to the third level. Horizontal and vertical straight lines were initially contrasted for the horizontal-slant dimension, with one member then becoming increasingly slanted. In all cases, the training progression was from the easiest pair at Level 1 to the most difficult discrimination at Level 3.

The distinctive-feature plus fade-in group contained exactly the same three levels as the distinctive-feature group initially; however, three additional levels were added in order to permit fading-in of the letter forms. (Only the first three levels were used for data analysis for the training phase.) The line drawings were constructed such that the critical features of the

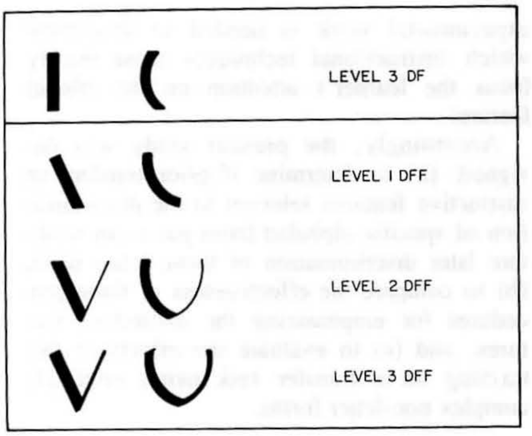


FIGURE 1. Training forms for the curve-straight dimension showing Level 3 of the distinctive feature (DF) group and the additional 3 levels used for the distinctive-feature plus fade-in (DFF) group.

appropriate alphabet letter discrimination were already in their normal position at the end of distinctive-feature training, thereby readily permitting fading-in of the nonessential elements. Figure 1 illustrates how this was accomplished for the curve-straight dimension which faded to the *U-V* discrimination. Similar techniques were used for the open-close dimension which resulted in the *C-O* letter pair, and the horizontal-slant dimension resulting in the *H-N* comparison. In each case, the faded-in final level lines were not as wide as those found on the letter forms themselves.

The three levels for the highlighting group consisted of the same alphabet letters to be used in the letter-discrimination test but modified by cues to highlight the critical-feature differences. Specifically, the critical segments of the letters, i.e., curved and straight portions, horizontal and slanted portions, and the open portion, were further contrasted by differentially coloring those segments. These cues were faded out as the child proceeded through the three levels, with only a small and narrow segment of the critical feature being highlighted at the last level.

Forms for the control group consisted of three pairs of highly discriminable line drawings. This was designed to provide the control subjects with practice in matching two-dimensional forms but not to focus their attention specifically on the selected critical features as in the experimental groups.

Stimuli consisted of black-line drawings, with each line being 1 mm wide and 10 mm high. This included the distinctive-feature training stimuli, the alphabet letters themselves (*C-O, U-V, H-N*), and the forms to be used in the generalization tests. These latter forms consisted of two levels of pairs constructed for each of the three dimensions and differing only in terms of a corresponding critical feature. The first level forms contained approximately four line segments, and the second level contained from six to eight segments.

## Results

Separate analyses of variance were carried out with respect to the number of trials-to-criterion for each phase—training, letter discrimination, and the two generalization tests. During training, criterion was reached at approximately the same rate for each group. (Significance level was set at .05 for all comparisons.) Although there was some tendency for the open-close dimension to be more difficult, neither the dimension effect nor the interaction term were significant. For the letter-discrimination phase, a marked effect was obtained for the group factor ($F = 39.86$, 3/28 *df*, $p < .01$) but no other effects were significant. As illustrated in Figure 2, the control group required approximately four times the number of trials to reach criterion than any other group. Individual comparisons using the

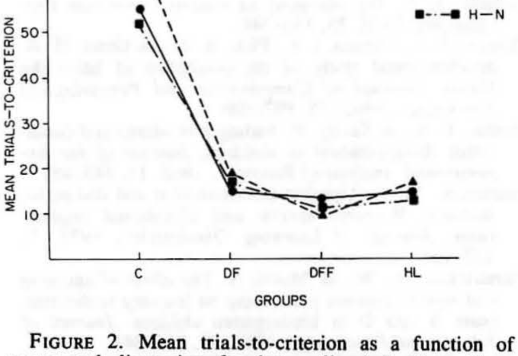


FIGURE 2. Mean trials-to-criterion as a function of group and dimension for letter discrimination. C = control, DF = distinctive feature, DFF = distinctive-feature plus fade-in, HL = highlighting.

Newman-Keuls test (Winer, 1962) revealed that, in fact, the only differences were between the control and each of the other groups.

As illustrated in Figure 3, the distinctive-feature plus fade-in group required nearly

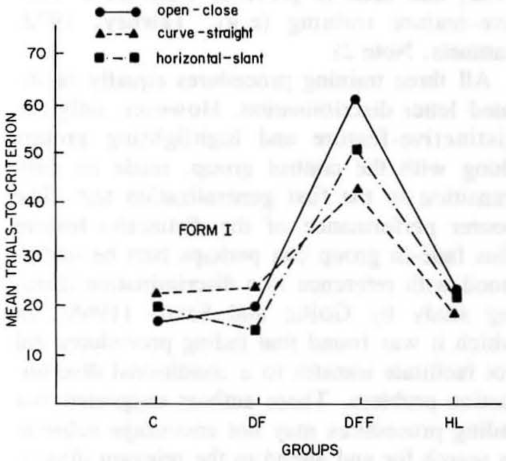


FIGURE 3. Mean trials-to-criterion as a function of group and dimension for first generalization test. C = control, DF = distinctive-feature, DFF = distinctive feature plus fade-in, HL = highlighting.

three times as many trials to reach criterion for the first nonsense form of the generalization test than the other groups. Analysis of variance indicated a significant group effect ($F = 23.37$, 3/28 *df*, $p < .01$), with neither the dimension variable nor the interaction approaching significance. The Newman-Keuls test further revealed that only the distinctive-feature plus fade-in group was different from each of the others.

For Nonsense Form 2, the group effect found for the first form was not obtained. However, a significant dimension effect did result ($F = 5.71$, 2/56 *df*, $p < .01$). The open-close and curve-straight dimensions tended to be more difficult across most of the groups, and the interaction was not significant. Since the dimension effects were not significant in the previous phases of the experiment, this result probably reflects the difficulty inherent in those specific forms.

## Discussion

The results of this experiment indicate that techniques designed to teach retarded children to attend to the distinctive features of certain alphabet letters facilitate later discrimination of those forms. In doing so, support is provided for the potential educational value of analyses in terms of distinctive features (Gibson et al., 1962) and adds to previous work on distinctive-feature training (e.g., Tawney, 1972; Samuels, Note 2).

All three training procedures equally facilitated letter discrimination. However, only the distinctive-feature and highlighting groups along with the control group, made an easy transition to the first generalization test. The poorer performance of the distinctive-feature plus fade-in group can perhaps best be understood with reference to a discrimination learning study by Gollin and Savoy (1968), in which it was found that fading procedures did not facilitate transfer to a conditional discrimination problem. These authors suggested that fading procedures may not encourage subjects to search for and attend to the relevant dimensions, especially within the context of the total stimulus field. Rather, responding may come to be controlled by a narrow feature established early in training, such as a specific angle or other absolute nondimensional stimuli (cf. Bryant & Weightman, 1969).

This analysis suggests that the children in the distinctive-feature plus fade-in group may have attended to the critical features during the first three levels of training, but, as a result of the fading procedure, failed to apprehend the relationship between these features and the forms within which they were embedded. This is supported by the finding that after the distinctive-feature plus fade-in group was required to search for the relevant features within a form in the first generalization test, they performed as well as the other groups on the second test. Moreover, the success of the control group on the generalization tests following letter-discrimination training can be similarly understood. It appears, then, that the effect of the other training procedures was to increase the likelihood of subjects attending to the relevant distinctive features when presented within the forms (Zeaman & House, 1963).

It should be noted that the alphabet letter pairs used in this study were relatively simple forms, consisting of only a few component lines and that the training procedures were comparatively brief. It is quite possible that when these techniques are applied to more complex graphic forms, such as the discrimination of cursive writing, more marked or differential effects of specific instructional techniques will emerge. In any event, it seems that a more complete analysis of complex visual stimuli in terms of distinctive features, in conjunction with techniques designed to focus attention on those features, is a useful means of enhancing discrimination learning.

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