The Discrimination of Three Types of Graphic Stimuli

Henry G. Timko

Forty 4-year-olds and forty 6-year-olds were tested on a matching-to-sample discrimination task to determine the relationship between social class status and the visual perception of graphic stimuli which were matched according to critical feature transformations. English letters, letter-like forms, and line-drawings of faces with embedded letters were equally divided into two confusability levels and three task levels. Analysis of variance on error scores revealed differences between age groups, stimulus types, confusability levels, and task levels. Social class differences were observed on highly confusable English letters among 6-year-olds but not among the 4-year-olds. No significant age by social class differences were found on letter-like forms or faces.

Research on the relation between visual perception and reading ability has raised a significant issue. To what extent is the correlation between visual discrimination and reading performance dependent upon the types of stimuli employed? This question is of particular importance to the identification and remediation of potentially retarded readers. Most reading-readiness tests in present use, for example, include stimuli other than letters and words in their discrimination tasks. Underlying the inclusion of these stimuli is the implicit assumption that discrimination ability on these types of stimuli is related to later reading performance.

Although research findings by Ashlock (1), Gates (5), Goins (8), Katz, and Deutsch (9) consistently demonstrated a significant relationship between the discrimination of graphic stimuli such as letters and words and reading performance, studies employing stimuli other than letters have been equivocal. Gates (5), Phelan (11), and Riley (13) found negligible correlations between tests of the discrimination of stimuli such as numbers, geometrical forms, and pictures and reading performance. On the other hand, investigations by Ashlock (1), Barrett (2), and Goins (8) indicated a significant

Visible Language, VII 1 (Winter 1973), 63–72.

Author's address: Faculty of Education, University of Victoria, Victoria, B.C., Canada.

relation between the discrimination of these types of stimuli and reading ability.

One possible cause of variance in the findings above may be the nature of the stimuli utilized. It seems that little attention has been given to isolating those stimulus dimensions which are mutually shared by letters and other types of two-dimensional stimuli. Studies employing sets of stimuli which differ along the same dimensions of transformation seem to incorporate the logical approach to this problem. The research question then becomes, "How well does the discrimination of stimuli other than letters relate to reading performance when transformational differences of the two types of stimuli are regulated?"

Such regulation was realized in a study by Gibson, Gibson, Pick, and Osser (7). As a result of their analysis of the distinctive feature differences of letters, these authors concluded that letters differ essentially along certain transformational dimensions. These are changes in straight line to curved line, broken to closed line, perspective, and reversals or rotations. In testing children who ranged in age from 4 to 8 years, these researchers found that the discrimination of letter-like forms which differed along the dimensional changes cited above is a direct function of age. However, the improvement in discrimination performance was variable across transformations. Although error attributable to changes in line to curve, break to close, and reversals and rotations dropped significantly, errors on perspective changes remained quite high at the 8-year age level.

A replication of the same study using English letters as stimuli indicated a correlation of ·87 between confusions of the same transformations in "real" letters and letter-like forms. The authors interpreted these findings in terms of a distinctive features hypothesis. The children learned to attend to those critical features of letter patterns which facilitate their discrimination.

The above finding is significantly related to the controversy over whether the discrimination of two-dimensional stimuli other than letters or words is related to reading performance. On the basis of the Gibson, et al. (7) results, the answer appears to be yes; if the stimuli in question resemble letters and if they contain the same critical feature differences as those found in letters.

Could there be circumstances, however, in which a beginning reader performs at a normal level for his age on the discrimination of stimuli which possess the same number and kinds of transformations as those in letters and still have abnormal difficulty with the discrimination of letters? This was the major question investigated in the present study.

Attempts to determine what an effective reader learns are of particular importance to the study of children who are potentially retarded readers in our schools, i.e., lower-class children. Following Gibson's (6) analysis of the reading process, the logical place to begin a search for the factors causing reading problems in children is the prerequisite ability to discern subtle differences between two-dimensional visual stimuli. As a theoretical underpinning for the generation of hypotheses in this research, it was postulated that any inferiority on the part of lower-class children in the discrimination of letters is not the result of a maturational lag as Vernon's (5) review might suggest, nor is it caused by innate perceptual or cognitive incapacities. Instead, it is theorized that any social class differences in discrimination performance are simply the product of variable background experiences with the test stimuli used. This is based upon the contention that the relative scarcity of writing materials and reading matter in the lower-class home Deutsch (4), Bloom (3) adversely affects the discrimination learning of letters more so than the discrimination of other types of stimuli.

To test this theory as it relates to discrimination skills in early reading, the present investigation utilized not only letters and letter-like forms, but also line drawings of faces. The choice of the latter stimuli was based upon the assumption that these symbols have possessed equal familiarization value for both social class groups under consideration.

It was hypothesized that middle-class children will demonstrate superior discrimination performance on the letters and letter-like forms, but that there will be no significant social-class differences on the discrimination of line drawings of faces. It was also predicted that these differences will be significantly greater among the 6-year-olds than among the 4-year-olds.

Subsidiary hypotheses concerning the types of errors made were also stated. The sets of response alternatives in this study contained an equal number of stimuli designated as high confusability and low confusability items. Based upon Gibson's (6) distinctive features hypothesis, those response alternatives which have elements containing one and only one transformational difference from the sample stimuli will be classified as highly confusable (HC) and those including two or more feature differences from the sample will be designated as low confusability (LC) items. It was hypothesized that there will be a significant difference between the error scores on HC and LC trials. In addition, since Marchbanks and Levin (10) found that the most salient cues in the word recognition of children who were just beginning to read are the terminal letters of words, it was predicted that response trigrams possessing first or last letters identical to the sample stimulus will produce significantly more errors than those trigrams which do not.

Subjects

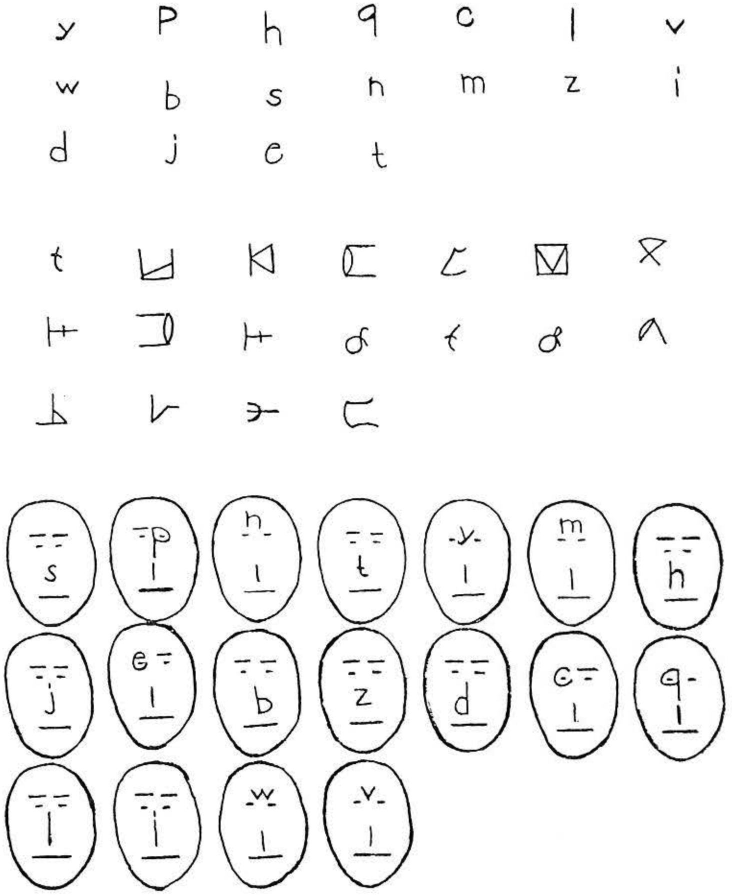
The subjects were 80 children from the Champaign-Urbana, Illinois, area. They included an equal number of 4- and 6-year-olds from the lower and middle social classes. Socioeconomic status was determined by a weighting formula involving the educational attainment and occupational status of the parents of the children. The 6-year-old children were drawn from kindergarten classes in an elementary school. Of the 4-year-olds, 36 children came from homes in the same district as the 6-year-olds and four subjects were drawn from the Bereiter-Engleman preschool program at the University of Illinois. Seventy-eight children were Caucasian and two were Negro.

The stimuli were presented on 5 by 8 inch plain white cards enclosed in looseleaf notebooks. The study used a matching to sample technique involving simultaneous discriminations. The sample stimulus was presented on the left page and three response alternatives were observed simultaneously on the right page of the notebook. The sample stimulus always appeared in the center of the sample page and the responses were vertically positioned on the right page.

The stimuli included an equal number of printed lower-case English letters, letter-like forms, and line drawings of faces. The letters were drawn in a style comparable to that which is used on typewriters for partially-sighted readers. The letter-like forms were some of the same as those used in the Gibson, et al. (7) study. The faces used were devised by the author. Since the facial outline and mouth were invariant across stimuli, critical feature differences of the faces involved the shapes of the eye-brows and noses. The latter features were composed by imbedding letters identical in number and kind to those used in the English letter stimulus set into the facial context. Thus, in one face, the nose may have been a "b", in another face the eyebrows an "m".

The letters and letter-like forms were one fourth inch in size. The number and types of transformational changes were constant across all three types of stimuli. The letters were drawn from the list of letter pairs which were most often confused and those which were least confused by prereading children in Popp's research (12). Figure 1 presents a list of each stimulus set which was used.

Figure 1. The three sets of stimuli.



Task Levels and Item Difficulty

To determine not only the extent to which various types of graphic symbols are confused, but also to investigate the degree of confusability when these symbols are combined in a sequence, three levels of task complexity were utilized. The first level included single element matching (SEM) trials in which the *S* compared a single element sample (one letter, one letter-like form, or one face) with three single element alternatives.

The second and third levels contained trials composed of sets of three stimuli combined in a horizontal sequence. The second level, triple element replacement (TER), possessed incorrect response alternatives in which either the first or the last element was replaced by a symbol other than that included in the sample. The third level, designated triple element sequencing (TES), was composed of alternatives which contained the same elements as in the sample, but which differed according to their sequencing.

There was a total of 36 trials with an equal number devoted to each task level. Within each task level there was an equal number of trials containing letters, letter-like forms, and faces which were sequenced in a randomly mixed order. This mixing of stimuli was incorporated to insure that order, learning-to-learn, or fatigue effects would not artificially inflate performance on any one stimulus type.

Expected item difficulty was assigned to each of the trials on the basis of Gibson's, et al. (7) and Popp's (12) findings and the results of a pilot study conducted by the present author. Since Popp found that confusions between letter pairs involved the same types of transformations which were related to error scores on Gibson's letter-like forms, and since the pilot study suggested the same relationship when facial features were transformed along the same dimensions, half the items possessed response alternatives which were unidimensional transformations of the sample stimulus and half did not. Thus the SEM and TER task levels were divided into an equal number of high confusability and low confusability trials. The low confusability trials (i.e., those trials containing incorrect response alternatives which differ multidimensionally from the sample) were included for only motivational purposes. Their inclusion was not intended to contribute materially to the confirmation of the hypotheses.

Expected difficulty levels for the TES level were determined by the position of the first and last element in a response alternative. Those trials containing incorrect responses in which either the first or the third element in the sequence was located in an identical position to that in the sample were classified as high confusability trials. High confusability and low confusability trials following this rule were equally distributed across the triple element sequencing level.

Warm-up trials consisting of the line drawings of familiar objects such as bat, bird, shoe, etc., preceded performance on the test stimuli. On each test trial, the child was asked to put his finger on the response alternative that looked most like the sample stimulus. Plastic chips were used as token rewards for every correct response. These were traded for miniature Tootsie Rolls at the end of testing. Where multiple responses occurred, only the first was recorded.

Results

A factorial design employing chronological age, socioeconomic status (SES), confusability level, stimulus type, and task level was used. There were repeated measures on the last three factors. The analysis of variance and the Newman-Keuls method for multiple comparisons revealed the following significant differences:

1. Older children made fewer errors than younger children ($p < \cdot001$).
2. High confusability trials produced more errors than low confusability trials ($p < \cdot001$).
3. There were more errors made on triple element trials than on single element trials ($p < \cdot05$).
4. The errors made on English letters were significantly less than the errors made on line drawings of faces ($p < \cdot05$). No differences were found between Gibson letter-like forms and faces.
5. On high confusability single element (SEM) trials, there was a significant reduction in errors with an increase in age ($p < \cdot05$) for middle-class children but not for lower-class children (Figure 2).
6. At the 6-year-old age level, lower-class children made more errors than middle-class children on high confusability English letters ($p < \cdot05$). This SES difference was not found on letter-like forms or faces (Figure 3).
7. The significant difference between lower-class and middle-class children at the 6-year age level on high confusability English letters was attributable to differences on SEM trials only.

Discussion

The significant decrease in the number of discrimination errors as a function of age is an indication that children improve in their ability to discriminate letters, letter-like forms, and line drawings of faces (with imbedded letters) prior to formal reading instruction. As a result of certain preschool experiences and/or maturation, these children have learned to attend to and discriminate between some of the feature differences of these stimuli. The significant differences noted between high and low confusability items suggests that particular emphasis should be placed on unidimensional transformational differences between graphic stimuli in beginning reading programs.

Figure 2. The age by social class interaction on high confusability SEM trials.

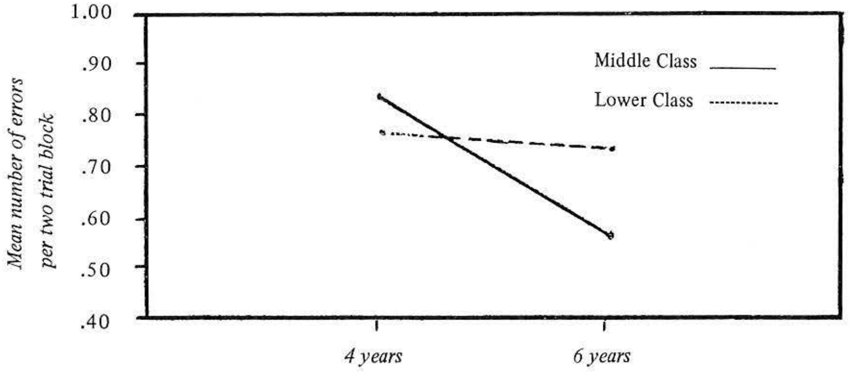
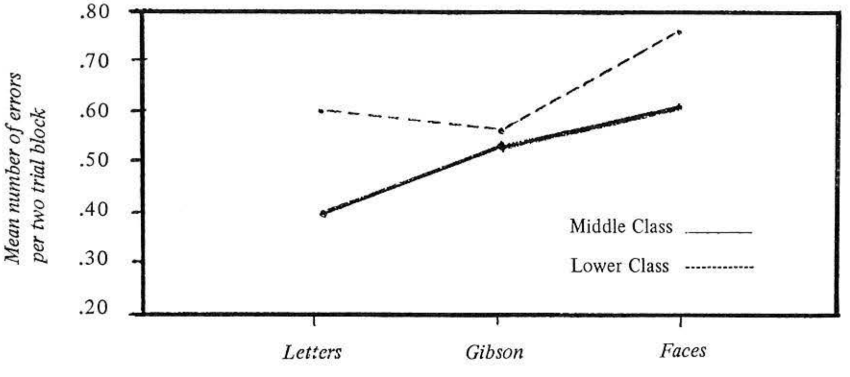


Figure 3. Mean number of errors of lower-class and middle-class 6-year-old children on three sets of high confusability stimuli.



The overall significant difference on the stimulus factor revealed that the children made fewer discrimination errors with English letters than they did with Gibson letter-like forms or faces. It may be argued that even prior to formal reading instruction, some degree of exposure to English letters is taking place which leads to better discrimination of these stimuli.

The results of this study indicate that social class differences at the age of four years are not significantly related to the discrimination of letters, letter-like forms, or line drawings of faces. At the 6-year age level, middle-class children made fewer errors on high confusability single element letters. However, social class differences were not found to be significantly related to the discrimination of high confusability single element letter-like forms or line drawings of faces at either age level. Finally, no social class differences appeared at either age level on the discrimination of triple element trials.

In relating these findings to the hypotheses of this study, it appears that the social class status of 6-year-olds is related to discrimination performance on letters at the single element matching task level. Why wasn't this superiority generalized to triple element replacement trials since these contained stimulus elements identical to those in the single element matching of letters? One possible explanation may be the effect created by the variant stimulis difficulty of these two task levels. The increased stimulus complexity of triple element trials may have been great enough to mask any effects due to social class differences on the discrimination of these elements as isolated stimuli.

The nonsignificant social class differences on the discrimination of line drawings of faces could also be interpreted in terms of differences in stimulus complexity. Even though the basic feature differences of the faces were the imbedded letters, discrimination performance could have been influenced by the increased item complexity of these stimuli relative to letters in isolation. A second argument could be that the inclusion of certain letters within the facial context inadvertently produced total stimulus complexes with emotive qualities. If the subjects responded to the items on the basis of this added dimension, the nonsignificant social class difference could have been due to this confounding effect.

A more interesting finding was the nonsignificant social class difference on high confusability single element letter-like forms at the age of 6 years. Since the letters and letter-like forms were of equal item difficulty and since they contained identical types of transformation, it was expected that the confusion errors made by middle-class subjects would be significantly less than those made by lower-class children on both sets of these stimuli. That middle-class superiority was not significantly demonstrated on letter-like forms suggests that comparative discrimination performance of middle-class and lower-class children at the 6-year age level is dependent upon the types of graphic stimuli employed.

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