Age differences in perceptual learning on the Müller-Lyer illusion¹

J. RICHARD BARCLAY² and PETER E. COMALLI, JR.,³ Temple University, Philadelphia, Pa. 19122

Reduction in the illusion effect of a black Müller-Lyer figure following stimulus differentiation treatments was compared among children, adults, and the aged. Practice with a differentially colored Müller-Lyer pattern resulted in a greater pre- to posttest reduction than did practice with a black figure, while part-perceiving instructions delivered between pre- and posttest produced no greater reduction than did a brief rest period. Adults under all treatments demonstrated greater illusion reduction than children and the aged, who themselves did not differ. These results, interpreted within Gibson and Gibson's theory of perceptual learning, demonstrate that the facilitation of distinctive-feature abstraction enhances perceptual learning.

The reduced effectiveness of the Müller-Lyer illusion following repeated or prolonged exposure (Eysenck & Slater, 1958; Kohler & Fishback, 1950; Moed, 1950; Mountjoy, 1958; Noelting, 1960; Selkin & Wertheimer, 1957) is predictable from Gibson & Gibson's (1955) specificity theory of perceptual learning. Specificity theory suggests that repeated or prolonged exposure of the Müller-Lyer allows the S to more effectively abstract the pertinent stimulus attributes and thereby increase the veridicality of his judgment.

Other experimental manipulations which produce lowered Müller-Lyer illusion effects include (1) instructions to adopt a part-perceiving attitude (Benussi, 1904) and (2) using a multicolored Müller-Lyer pattern (Mukerji, 1957; Segal, Campbell, & Herskovitz, 1966). Both of these conditions may be viewed as procedures that facilitate the process of stimulus differentiation, proposed by Gibson and Gibson to occur naturally over the course of repeated or prolonged exposure. On this basis, it was hypothesized that training which involves either part-perceiving instructions or practice with a differentially colored Müller-Lyer figure would result in greater perceptual learning than would corresponding amounts of repeated exposure. Perceptual learning here is inferred from a reduction in illusion effect following specific kinds of practice or training.

Closely intertwined with perceptual learning phenomena are those of

perceptual development. The roughly U-shaped developmental curve for Müller-Lyer illusion magnitude depicts similarly high susceptibility in childhood and old age, with lowered susceptibility during adulthood (e.g., Wapner, Werner, & Comalli, 1960). Within Werner's developmental framework (1948), this age trend is interpreted as resulting from the relative inability of children and the aged to isolate the parts of the figure from the whole. This interpretation suggests that developmental level may affect the extent of perceptual learning expected to result from differentiation training with the Müller-Lyer illusion. Since the part-whole isolation is presumed to be initially weakest in children and the aged, stimulus differentiation training might be expected to produce the greatest changes (relative to pretest performance) in these two groups. However, children and the aged were found to demonstrate less perceptual learning than adults on a figure-ground task by Santos & Farrow (1965). If the age-dependent levels of perceptual flexibility implied by Santos and Farrow's results are indicative of general capacities for perceptual learning, adults would be expected to show the greatest pre- to posttest decreases in the present study. While insufficient relevant literature exists at present for strongly favoring either developmental hypothesis over the other, both hypotheses predict that both children and the aged would differ from adults in the same direction.

The present study examined the effects of stimulus differentiation treatments on perceptual learning with the Müller-Lyer illusion at three developmental levels. It was hypothesized that these treatments would produce greater reductions in this illusion's magnitude than would repeated exposure of the figure. Similar performance was expected from children and the aged, relative to adults.

SUBJECTS

The sample consisted of 20 males and 20 females from each of three age groups: children (elementary school students, 8 to 10 years old, mean age 9.0), adults (Temple University undergraduates, 19 to 21 years old, mean age 19.6), and aged (Jewish Home for the Aged residents, 65 to 84 years old, mean age 76.2). The 40 Ss in each group were randomly assigned to the four treatments, placing 10 Ss (5 males and 5 females) in each cell of the 3 by 4 (Age by Treatment) factorial design.

APPARATUS

The Müller-Lyer figures were each presented on a 5 x 8 in. white card, which was mounted on 11 x 12 in. white posterboard. All line segments were composed of pressure-sensitive tape 1/32-in. wide. Three experimental conditions employed flat-black figures exclusively, while a fourth also used figures with flat-black obliques and flat-red horizontals. The standard (left) horizontal was 60 mm long, and the variable (right) horizontal ranged from 40 to 64 mm, in 2-mm steps. The obliques, 20 mm long, departed from the horizontals at a 30-deg angle. All line segments were spaced 2 mm apart at the usual points of intersection to permit the S's clear determination of the end points of the horizontals (see Fig. 1). The stimulus figures were presented at the rear of a 1 x 1 x 2 ft flat-black viewing box and were illuminated by a tensor lamp mounted beneath the S's viewing slit.

PROCEDURE

For each S, one of four treatments was interpolated between pretest and posttest measurements of illusion magnitude with the black Müller-Lyer figures. In both pre- and posttests, each of the 13 figures covering the range of stimuli was presented twice in random order. Upon each presentation, the S stated whether the variable horizontal appeared longer than, shorter than, or equal to the standard. Illusion magnitude was indicated by the S's constant error (CE), computed by subtracting the standard (in millimeters) from the mean of his "equal" judgments.

The four interpolated treatments are described below. In the colored figure and black figure treatments, each of which consumed approximately 10 min, the S's task was identical to that of the pretest. The instruction and rest treatments, each of which consumed approximately 2 min, presented no opportunity for response.

Colored Figure

This treatment consisted of 52 presentations (each of 13 stimulus patterns appearing four times in random order) of figures that differed from the pre- and posttest patterns only by having red, rather than black, horizontals.

Black Figure

Fifty-two presentations of the pretest figures served as a control for the effects of repeated exposure per se.

Instruction

The Ss in this treatment group were

Fig. 1. Example of the Müller-Lyer pattern used in the experiment.

Table 1
Adjusted Posttest Mean CEs (in mm) on the Müller-Lyer Illusion

Age Group	Black	Colored	Instruction	Rest	Mean
Children	11.0	10.3	11.1	11.0	10.9
Adults	10.4	9.0	9.3	10.6	9.8
Aged	10.8	10.2	11.6	12.1	11.2
Mean	10.7	9.8	10.7	11.2	

instructed to attend very closely to the horizontals alone on the subsequent (posttest) presentations. A three-dimensional model of the figure, with movable parts, was used to show the S how the figures would look if he could perceptually ignore the obliques. The model's horizontals were made exaggeratedly discrepant, so the removal of its obliques would not provide the S with clues as to how much his previous impressions of relative length had been in error.

Rest

A 2-min rest period served as a control for the instruction treatment.

At no time during the procedure did the E inform the S of the accuracy of his judgments.

RESULTS

Pretest

While sample size limitations precluded the use of sex as a variable in the analysis of perceptual learning data, it was possible to investigate age and sex differences on pretest illusion magnitude. A 3 by 2 (age by sex) analysis of variance was performed on the pretest CEs, collapsed across treatments.

Tests on the simple main effects of age and sex were performed to analyze the significant Age by Sex interaction ($F = 9.28$, $df = 2/114$, $p < .01$). Sex differences were significant only for the aged, among whom females were more susceptible to the illusion than were the males ($F = 20.30$, $df = 1/114$, $p < .01$). Age differences were significant only for females ($F = 22.60$, $df = 2/114$, $p < .01$). The Newman-Keuls test revealed that among females, the aged were most susceptible to the illusion, while the children and adults did not differ.

For the three age groups, the effects of stimulus differentiation treatments were evaluated by examining pre- to posttest changes in illusion magnitude. A 3 by 4 (age by treatment) independent groups analysis of covariance was used which controls for individual pretest differences. Criterion and covariate measures were the posttest CEs and pretest CEs, respectively. The mean posttest CEs, adjusted for the effect of the covariate, are presented in Table 1.

Treatment Effects

In probing the significant treatment main effect ($F = 2.97$, $df = 3/107$, $p < .05$), planned comparisons (Winer, 1962) revealed a significantly greater pre- to posttest illusion reduction for the colored figure group than for the black figure group, as expected ($F = 4.23$, $df = 1/107$, $p < .05$). The difference between instruction and rest treatments failed to reach significance, contrary to expectation ($F = 2.61$, $df = 1/107$, $p > .10$).

Age Differences in Pre- to Posttest Illusion Reduction

Planned comparisons indicated that the adjusted mean posttest CE of the adults was significantly lower than those of both the children ($F = 6.62$, $df = 1/107$, $p < .01$) and the aged ($F = 11.37$, $df = 1/107$, $p < .01$), producing a significant age main effect ($F = 5.65$, $df = 2/107$, $p < .01$). The children and the aged did not differ ($F < 1.00$). Despite a strong tendency for adults alone to profit more from instructions than from a rest period, the Age by Treatment interaction was not significant (see Fig. 2).

DISCUSSION

In the present study, significant age differences on the pretest were demonstrated only by the females, among whom children and adults were equally less susceptible to the illusion than were the aged. The disparity between the pretest results of the present study and previously reported U-shaped developmental curves for the Müller-Lyer illusion (e.g., Wapner, Werner, & Comalli, 1960) may have stemmed from the differences in stimuli and measurement techniques. Whereas the present study employed a separated or broken Müller-Lyer pattern and the constant stimuli method, previous research has commonly used a connected pattern and the method of limits or adjustment. On the basis of our findings, sex appears to be a variable worthy of consideration in developmentally oriented investigations involving geometrical illusions, especially in studies using elderly Ss.

Interpolated practice with a colored Müller-Lyer figure significantly reduced the illusion effects of the black figure from pre- to posttest. An equal amount of practice with the black figure resulted in significantly less reduction, as expected. Within Gibson and Gibson's perceptual learning framework, these results may be interpreted as follows: Coloring the figure facilitated the S's abstraction of the crucial stimulus attributes (the relative lengths of the horizontals) and thus increased perceptual veridicality from pre- to posttest; repeated exposure, which occurred in both treatments, also permits

Fig. 2. Adjusted posttest illusion magnitude.

abstraction; the difference between the two treatments resulted from facilitating abstraction in one and not in the other. That these findings provide evidence for Gibson and Gibson's theory is strengthened by the absence of differential reinforcement throughout the experiment.

Despite a strong tendency for instructions to be effective for adults, instruction and rest treatments did not significantly differ. The finding that adopting a part-perceiving set did not facilitate perceptual learning is based on the tenuous assumption that all Ss understood and adopted the instructions. Several Ss, most notably in the aged group, expressed the feeling that instructions to focus their attention on the horizontals added nothing new to their task.

Adults demonstrated more perceptual learning than did either children or the aged, who themselves did not differ in this respect. Since repeated exposure occurred in all treatments to some degree, the nonsignificant Age by Treatment interaction makes it difficult to infer whether the age differences were due to differential effects of repeated exposure, the treatments, or both. Noelting (1960) found that adults showed a greater decrease in Müller-Lyer illusion magnitude than did children over a series of 20 trials. Thus, repeated exposure effects may have been sufficient to produce the age trend in the present study. In any case, the type of perceptual learning capacity demonstrated with the present method appears to be less as one approaches either end of the ontogenetic span.

One should not infer that the same factors necessarily underlie the similar performances of the children and the aged in this experiment. While limitations imposed by maturation and experience contribute to the perceptual responses characteristic of the child, evidence

suggests that central physiological impairment produces forms of perceptual regression in the aged (cf. Birren, 1959; Rajalakshmi & Jeeves, 1963; Welford & Birren, 1965).

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NOTES

1. This experiment was performed in partial fulfillment of the requirements for the Master's degree, Temple University.
2. Now at the Institute of Child Development, University of Minnesota.
3. The investigators gratefully acknowledge the following persons for their assistance in obtaining subjects: the Superintendent of Schools and the principals of the West Marshall Street and the Burnside schools, Norristown, Pennsylvania, and the staff of the Jewish Home for the Aged, Philadelphia, Pennsylvania.

Words functioning simultaneously as positive operant reinforcers and unconditioned stimuli

ANDREW T. ABELL, *Southeastern Louisiana College, Hammond, La. 70401*

Data that would allow a partial analysis of the results of several earlier studies were gathered from 64 undergraduates in an experiment of identical-Ss design. A recently introduced conditioning device (reinforcer form) permitted the presentation of pleasant and neutral words to be contingent upon motor responses to CVCs. As predicted, Ss tended to respond to the CVC followed by pleasant words rather than to the one followed by neutral words, and they subsequently tended to

rate the CVC preceding pleasant words as more pleasant than the other one.

In an experiment that introduced a group verbal-conditioning device (reinforcer form), Abell (1969b) demonstrated that words can function concurrently as operant and respondent reinforcers. However, that preliminary study allowed for gross comparisons only, i.e., for determination of the effects of a "package" of variables, but not for the effects of individual ones alone.

As Abell suggested, an analysis of his findings is needed. For example, his results indicating that words functioned as

operant reinforcers may have reflected the operation of positive reinforcement or punishment or both. Similarly, his results showing the conditioning of evaluative meaning to consonant-vowel-consonant (CVC) trigrams do not permit an analysis that would indicate whether one of the CVCs acquired positive value, or the other one, negative value, or some combination of the two.

The present study was designed to initiate such analyses. The hypotheses were the following: (1) The tendency to respond to CVCs followed by pleasant words is greater than that to CVCs followed by neutral words; (2) CVCs preceding pleasant words are rated as more pleasant than those preceding neutral words.

SUBJECTS

A total of 64 students (25 males and 39 females) in two introductory psychology classes served as Ss during regular class periods. They were given no information about the experiment before serving in it.

MATERIALS

Four-page reinforcer forms, similar to those used before (Abell, 1969a), were constructed to present CVCs and eight evaluative words in an identical-Ss design. The CVCs, XIB and ZUJ, have the same scaled meaningfulness (m'), which is .73 (Noble, 1961). The eight evaluative words, four pleasant and four neutral, were chosen from words rated for pleasantness by students in general psychology classes. The words were rated on a 7-point scale ranging from *very pleasant* (7) through *neither pleasant nor unpleasant* (4) to *very unpleasant* (1).

From a preliminary rating by 41 students (18 males and 23 females) of the 71 neutral words used by Staats & Staats (1958), the 16 most nearly neutral ones (median ratings nearest 4.000) were determined. These neutral words, together with the 16 most pleasant words (highest medians) and the 16 most unpleasant ones (lowest medians) from earlier ratings (Abell, 1969b), were evaluated by another group of students (30 males and 52 females).¹ From this last set of ratings, the four most pleasant words and the four most nearly neutral ones were selected for use in the present study. These words, together with their medians, are the following: *love*, 6.914; *happy*, 6.839; *success*, 6.589; *mother*, 6.589; and *of*, 4.019; *those*, 4.013; *cord*, 4.000; *it*, 4.000.

A comparison of the format of a page or the form used in the present study (Fig. 1) with that of one used earlier (Abell, 1969a) will reveal only minor differences. For example, the overall dimensions of each undersheet of the present form are 7 x 14 in. rather than 8½ x 14 in. (The right and left margins that will not