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Age changes in the Ponzo and filled-space illusions*

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A generalization about age changes in assimilation and contrast illusions was proposed. A version of the Ponzo illusion, which apparently provided an exception to the generalization, was analyzed into the classical Ponzo and the filled-space illusions, and these were administered to children ranging in age from 5 to 17 years. Both of these illusions were found to decline with age, thus contradicting the results of earlier investigations.

The question of whether children perceived geometric illusions in a different fashion from adults was considered as early as 1895. Binet showed that young children exhibited a larger illusion on the Mueller-Lyer target than did adults, and this finding was verified subsequently by numerous investigators (Wohlwill, 1960).

The bulk of research and theory about developmental changes in geometric illusions has been carried out by Piaget and his associates (1961) and by Pollack and his colleagues (1969). Both groups of investigators have adopted a classification of geometric illusions into Type I (those that decline with age) and Type II (those that increase with age), and both groups have proposed rather elaborate mechanisms to account for the different developmental trends. It is not the purpose of this report to evaluate Piaget's or Pollack's theories, except to say that there is a simpler answer which is rooted in a broad theory of illusions (Pressey, 1971) and which has a potential for providing an avenue for systematic research into developmental changes in perception.

Any geometric illusion of size can be analyzed into two components. One consists of the stimulus to be judged which is called the "standard magnitude," and the second component consists of the stimuli within which the standard is embedded; these stimuli are called "contextual magnitudes." There are two ways in which the standard magnitude can be distorted by the contextual magnitudes. In one of these, the standard becomes more like the contextual magnitudes, so that the differences between the contextual and standard magnitudes are diminished. This process is called "assimilation." In the other case, the differences between the standard and the contextual magnitudes are accentuated, and this process is called "contrast." One example of an assimilation illusion is the Delboeuf illusion shown in Fig. 1A. The circle in the center of the figure appears smaller than the inner circle on the left. In the Titchener circles illusion, shown in Fig. 1B, the circle in the middle of the figure appears larger than the inner circle on the right.

Given the above classification of illusions, a simple generalization about age changes seems appropriate: Type I illusions are assimilative illusions which decrease with age, and Type II illusions are contrast illusions which increase with age.

The following evidence is offered in support of the generalization. First, the Mueller-Lyer, the parallel lines, the Sander parallelogram, the Poggendorff, and the Delboeuf illusions are all assimilative illusions (Pressey, 1971; Pressey & Sweeney, 1972) and they all decline with age (Wohlwill, 1960; Pressey & Sweeney, 1970; Weintraub & Cooper, 1972; Robinson, 1972). Second, the Titchener circles illusion, a temporally disparate Mueller-Lyer illusion, and a particular form of the Delboeuf illusion all display contrast effects; and, in every case, the contrast illusion increases with age (Wapner & Werner, 1957; Pollack, 1964; Santostefano, 1963). One major exception to this rule is the Ponzo illusion, which has been shown to involve assimilation (Pressey, Butchard, & Scrivner, 1971), yet has been reported to increase with age (Leibowitz & Heisel, 1958; Leibowitz & Judisch, 1967; Farquhar & Leibowitz, 1971).

Unfortunately, Leibowitz and his colleagues have used the version of the Ponzo illusion shown in Fig. 2A rather than the classical illusion shown in Fig. 2B. But the problem with Fig. 2A is that it is a *confounded* illusion. It is well known that if a standard line is interrupted by several hatchings, that line will appear elongated. Moreover, up to a certain point, the greater the number of hatchings, the greater the illusion (Spiegel, 1937). This phenomenon is known as the filled-space illusion. In Fig. 2A, the upper line is interrupted by nine hatchings and the lower line by only three. Thus, on an a priori basis, we would expect an illusion in which the upper line appears larger than the lower one. Therefore, Fig. 2A is probably a dual illusion consisting of the classical Ponzo illusion and the filled-space illusion. But Gaudreau, Lavoie, and Delorme (1963) have shown that the filled-space illusion increases with age and that the increase is very pronounced. Therefore, it is possible

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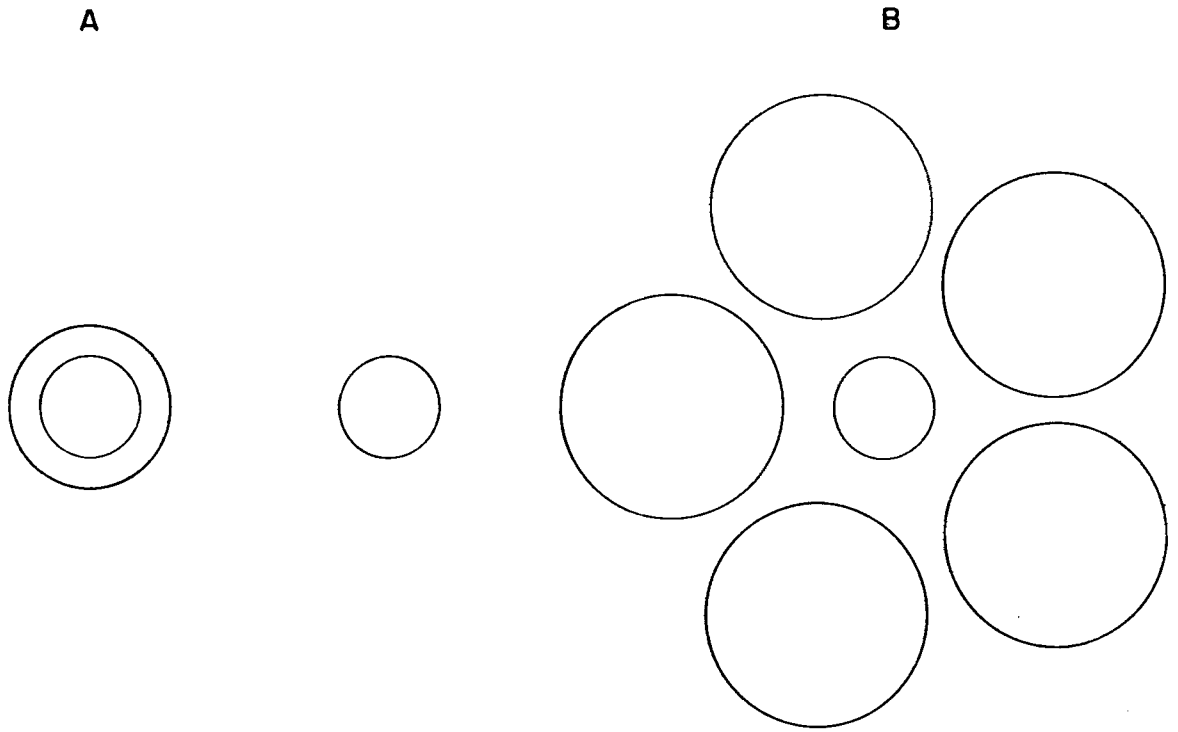

Fig. 1. The Delboeuf (A) and the Titchener circles (B) illusion.

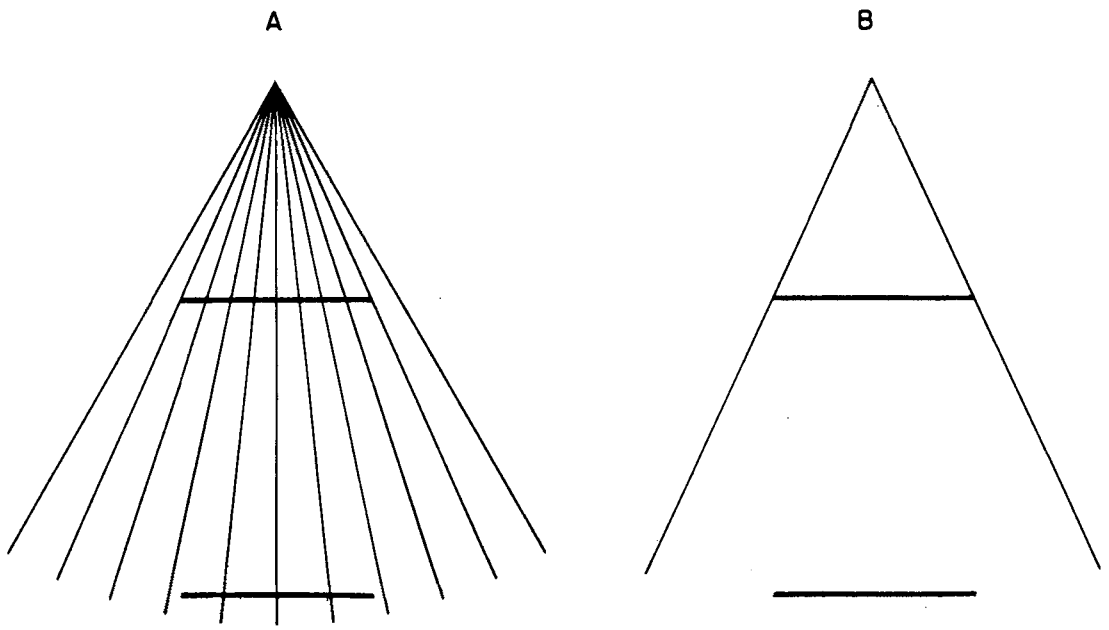

Fig. 2. A confounded version of the classical Ponzo illusion (A) and the classical Ponzo illusion (B).

that, in the target used by Leibowitz and his colleagues, the increase due to the filled-spaced illusion masked the effect due to the Ponzo illusion so that no unequivocal statement about age changes on the Ponzo illusion is possible.

The purpose of this study was to measure the Ponzo

illusion and the filled-space illusion separately in children and adolescents ranging in age from about 5 to 15 years. It was predicted that the Ponzo illusion would decrease with age and that the filled-space illusion would increase with age.

METHOD

Subjects

The Ss were 222 male and female students, ranging in age from 5 to 17 years. They were grouped into 11 age-grade groups with 20 Ss in each group, except in the 15-year-old group, in which only 17 Ss were tested. Five Ss, all from the 5-year-old group, were eliminated because of a failure to understand the task. The decision to replace Ss from this youngest group was made prior to analysis of data. None of the Ss had been tested on illusory targets prior to this study.

Apparatus

The apparatus consisted of a large translucent back-projection screen and a Kodak Carousel projector, both of which were located on a table. A chair was placed in front of the screen so that the targets were approximately 1.5 m away and roughly at eye level when S was seated.

Three sets of targets were photographed and converted into slides. The first set consisted of Ponzo figures in which the angle formed by the long oblique lines was 30 deg and the length of each oblique line was 80 mm. The oblique line was placed in such a fashion that 20 mm of that line was above the standard line and 60 mm was below the standard line. The standard line was 40 mm long and was located in a manner which yielded a gap of 1 mm on each side between the standard and the oblique lines. There were 13 slides in the Ponzo set, each differing only in the length of the comparison line. The lengths of the comparison lines varied from 36.8 to 56 mm in steps of 1.6 mm. All comparison lines were located 80 mm directly below the standard line.

The filled-space illusion also consisted of a series of 13 targets in which the comparison lines varied from 36.8 to 56 mm. The standard line was 40 mm long and was located 80 mm directly above the comparison lines. The standard line was interrupted by six vertical lines, each of which was 3 mm high and 1.5 mm wide.

The control targets were identical to the illusory targets except that the illusion-inducing contexts were eliminated.

Procedure

Ss were tested individually by two Es. A female E tested 50 Ss and a male E tested the remaining Ss.

Each S was seated in front of the screen and shown a sheet of paper on which a sample target from the control group was presented. He was asked to say whether the bottom horizontal line appeared shorter or longer than the top line. It was emphasized that an "equal" category could not be used. If the response indicated that the task was understood, E told S that he would have to make similar judgments of figures that would be shown on the screen. It was emphasized that his task was to say whether the bottom line appeared longer or shorter than the top line. Several of the 5-year-old children pointed to the longer line or reversed their comparisons. E simply converted their responses to the proper language on the protocol.

Each S was presented with the three sets of targets in a random order, and two trials were given for each set. The method of limits was employed in which E began presentation at one extreme and continued until S reversed his response. One ascending and one descending trial was given and the order was counterbalanced between Ss. The rate of presentation was S-paced in the sense that a new target was presented only after S responded.

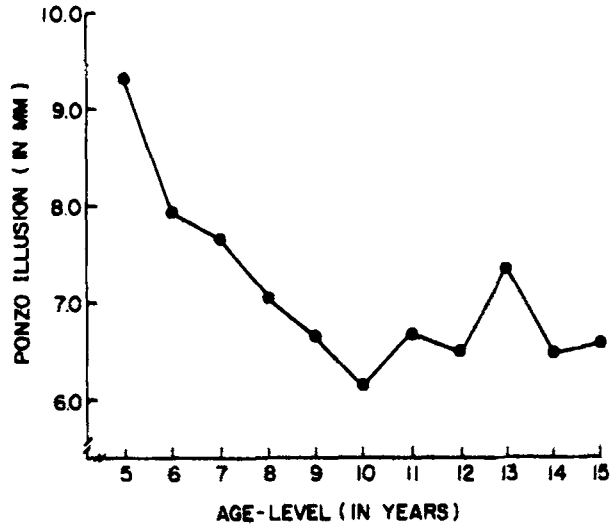

Fig. 3. Age changes in the Ponzo illusion.

RESULTS AND DISCUSSION

For each trial, the comparison line corresponding to the first reversal of response and the comparison line corresponding to the immediately prior response were averaged. The mean of the two trials was then calculated to obtain a score for each target. Finally, the score on the control line was subtracted from the score on the two illusory targets to obtain a measure of illusion.

Analysis of the data revealed that the trends did not vary as a function of E, and thus the data from the two Es were combined.

The mean Ponzo illusion as a function of age is shown in Fig. 3. Analysis of variance indicated that age had a significant effect on illusion ($F = 3.11$; $df = 10/206$; $p < .01$). The results contradict the findings of Leibowitz and his colleagues, who claim that the Ponzo illusion increases with age and are consistent with the generalization that assimilative illusions decline with increasing age. The results are also consistent with the findings of Quina and Pollack (1972), who measured the elongation (assimilation) effect and the shrinkage (contrast) effect separately in the Ponzo illusion as a function of age. The elongation illusion declined, and the shrinkage illusion increased with age in their study.[1]

Changes in the filled-space illusion with age are shown in Fig. 4. Analysis of variance indicated that the illusion declined with age ($F = 4.02$; $df = 10/206$; $p < .01$). These data, of course, contradict the report by Gaudreau et al, who claimed that the filled-space illusion increased with age. But they are consistent with a claim that the filled-space illusion is an assimilative illusion (Pressey, 1967). That is, that short distances are all overestimated and that these summate to yield a perception of a large filled space. This interpretation has been challenged by Robinson (1972), but it is interesting that, if it were true that the filled-space illusion was an assimilative illusion,

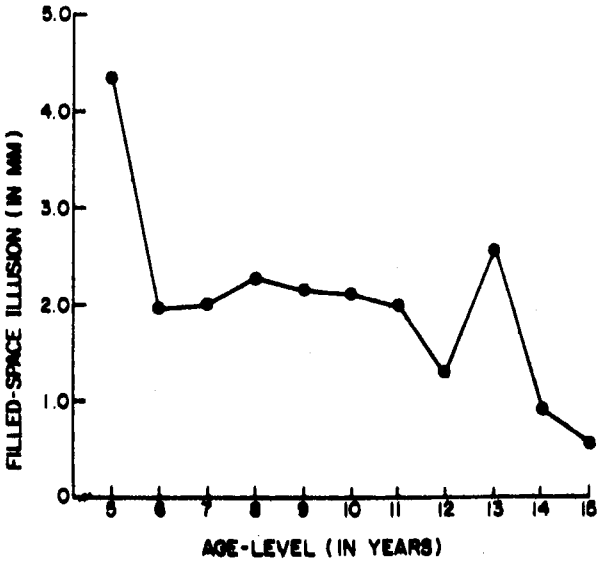

Fig. 4. Age changes in the filled-space illusion.

then the fact that it declines with age would be consistent with the hypothesis presented earlier in this report.

The most obvious question that is prompted by these results is why previous trends were not supported. It was argued that one possible explanation of the increasing trend with increasing age found in the Ponzo illusion by Leibowitz and his colleagues is that the target they used was confounded with the filled-space illusion. The data presented here indicate that this is not the proper explanation, because the filled-space illusion apparently decreases with age. However, there are at least two other possibilities for the contradictory results. First, Leibowitz used, as his comparison magnitude, the line that was nearest to the apex, whereas in the present study the line furthest from the apex was used. This difference in position of the comparison magnitude may be responsible for the different trends, although it is not clear through what specific mechanism the difference would be mediated. A second possibility is that the target used by Leibowitz and his colleagues was primarily a measure of contrast. As such, the increasing trend would be expected. But whatever the exact cause of the difference, it is clear that a systematic analysis of the target or methods used by Leibowitz and his colleagues is necessary before major effort is expanded on researching the role of organismic variables such as age or cross-cultural variations.

The failure to replicate the increase in the filled-space illusion found by Gaudreau et al is also puzzling, but at least two factors may be of importance. First, they used the method of adjustment which produces large "anticipatory" errors or hysteresis effects. Wohlwill (1960), Gerjuoy and Winters (1969), and Hill (1971) have questioned the validity of using the adjustment method with children, and trends found with one method do not necessarily hold up when another method is employed (Spitz, Goettler, & Diveley, 1970; Hill, 1971). A second factor which may account for the discrepancy is that Gaudreau et al had the E adjust the variable stimulus on the basis of signals from S. However, this is a situation that would allow E bias to operate freely (Rosenthal, 1966), and if the Es were aware of the hypothesis, inadvertently they may have influenced the results. In fact, they were testing Piaget's theory, which predicted an increase in illusion. This interpretation is given credence by Spitz et al, who presented a fascinating historical account of the presumed facts about age changes in the filled-space illusion. They wrote, "Piaget (1950, p. 80) originally reported that the Oppel illusion decreases with age. He held to this notion as late as 1958 (Piaget, Vinh-Bang, & Matalon, 1958) when he stated that, during unlimited exposure, the number of centrations to each element of the Oppel figure will tend to equalize the two elements (filled and unfilled). In other words, more complete coupling reduces the size of the illusion. Since older Ss should exhibit more complete coupling than younger Ss, the illusion should decrease with age and is, consequently, a primary illusion. However, Piaget later claimed that the illusion was not entirely a primary illusion, but involved features of a secondary illusion in which greater exploratory activity (couplings) strengthens instead of diminishes the illusion. Consequently, the Oppel illusion should increase with age and, according to Piaget, his co-workers have shown that it does (Piaget, 1961, p. 92)."

Thus, it seems thatthe researchers who have obtained an increasing trend in the filled-space illusion were those who were testing a theory which predicted an increasing trend. Piaget, before his theoretical revision (1950), Spitz et al (1970), and the present investigation all found that the filled-space illusion declines with age, and this is probably the correct fact about developmental changes in the filled-space illusion.

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NOTE

1. Ann McDevitt (personal communication, 1973) at St. Joseph's College in Philadelphia also has obtained data which seems to indicate that children have larger illusions than adults.

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