Cognitive factors associated with the Ponzo illusion: A study using the co-twin method*

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Thirty-four pairs of 9- to 11-year-old MZ twins (13 male, 21 female) who were discordant on the magnitude of their susceptibility to the Ponzo illusion were studied for their differences on WISC subtests. The purpose of the study was to test Pollack's hypothesis that children more susceptible to the illusion would perform better on tasks involving numerical sequencing and analogical reasoning. The hypothesis was confirmed for females in that the female twins who had higher magnitudes of the illusion had significantly higher scores on digit span and similarities than did their co-twins. Male twins showed no differences.

In his summary and synthesis of the Geneva research on optico-geometric illusions, Piaget (1969) distinguished between two basic types of illusions and the perceptual mechanisms operative in them. The first type, the primary illusions as typified by the Mueller-Lyer illusion, is one which yields a systematic decrease in errors with age. The second type, the secondary illusions as typified by the Ponzo illusion, is one for which errors increase with age. According to Piaget, the primary illusions result from the use of fewer centration or comparisons among aspects of the illusory stimulus. Conversely, the secondary illusions result from decentrations or more comparisons among aspects of the stimulus. Paradoxically, because children increase perceptual decentration with increasing age, more advanced perceptual activity leads to a greater susceptibility to secondary illusions.

The Ponzo illusion is elicited by the drawing shown in Fig. 1. The illusion consists of perceiving that the two equal vertical lines appear to be unequal, with the length of the line nearest the apex being overestimated. Several studies using this illusion have shown that susceptibility to the illusion increases with age (Hanley & Zerbolo, 1965; Leibowitz & Judisch, 1967), and that variations in experiences related to real-life cues similar to those in the Ponzo figure were related to the degree of error (Leibowitz, Brislin, Perlmutter, & Hennessy, 1969). Further, Matheny (1971) found that while identical twins differed in the magnitude of

error on the Ponzo illusion, they were significantly more similar than were fraternal twin children.

Pollack (1969), in an attempt to integrate ontogenetic changes in perception with aspects of cognitive development, has suggested that the perceptual activity involved in secondary illusions is a form of intelligent behavior. By combining the notions of temporal integration (Hearnshaw, 1956), stimulus trace or short-term memory (Ellis, 1963), and decentrations or attention (Piaget, 1961), Pollack proposed that certain

tasks in intelligence tests would be related to the magnitude of secondary illusions. He presumed that such tasks would involve, at least in part, (1) temporal integration of stimuli to be remembered in sequence, as in a number series, and (2) two or more cognitive stimuli to be remembered as aspects of them are compared until a relationship is established, as in analogies.

The present study was designed to investigate Pollack's formulation regarding the link between children's cognitive skills and susceptibility to the Ponzo illusion. In order to control for some of the variables previously identified as influencing the individual's susceptibility to the Ponzo illusion, only identical twins within a restricted age range and reared together, but differing in the magnitude of the illusion, were used. Specifically, it was hypothesized that the twins with relatively larger magnitudes of the illusion would achieve higher scores than their co-twins on WISC Digit Span and Similarities subtests, which should demonstrate, respectively, temporal sequencing and analogical reasoning.

SUBJECTS

Thirty-four pairs of identical twins (13 male, 21 female), ranging in age from 9 to 11 years, were selected from

Fig. 1. Typical Ponzo figure. The two vertical lines are equal in length.

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Table 1
WISC Similarities and Digit Span Scaled Scores for Identical Twins with Larger and Smaller Magnitudes of the Ponzo Illusion

	Males (13 Pairs)		Females (21 Pairs)	
	Twins with Larger Magnitude	Twins with Smaller Magnitude	Twins with Larger Magnitude	Twins with Smaller Magnitude
Magnitude of Illusion				
Mean	.257 in.	.183 in.	.247 in.	.158 in.
SD	.03 in.	.04 in.	.08 in.	.08 in.
WISC Subtest Scores				
Similarities	11.69	11.85	13.19	11.24*
Digit Span	9.62	9.23	10.19	9.05*

*Within-pair comparisons, $p \leq .05$, two-tailed

a larger sample of twins participating in the Louisville Twin Study described by Wilson, Brown, & Matheny (1971). The pairs were selected from the larger sample on the bases of their being genotypically identical, as determined by serological tests, and each pair's being discordant on the magnitude of the Ponzo illusion.

PROCEDURE

Each child was presented with a series of 14 cards, each bearing a Ponzo figure. In the series, one vertical line, located 1 in. from the apex of the figure, varied in length from 0.5 to 1.3 in., in 0.06-in. steps. The other vertical line, located 3.75 in. from the apex of the figure, was constant in length at 1 in. As in the method of constant stimuli, the series was presented randomly, one card at a time, to the child. The cards were placed flat on a table, at a viewing distance of about 2 ft. Each card was arranged so that the apex of the Ponzo figure was always to the child's left and the vertical lines were perpendicular to the edge of the table. The task demanded that the child indicate whether the vertical line nearest the apex was longer or shorter than the other vertical line. To ensure that the child understood the task, two cards with obvious differences were first given to the child, and, if necessary, the child was shown that one line was longer than the other. Different examiners gave the series to each member of the twin pair, and neither examiner was aware of the method for determining the magnitude of the illusion. A third person calculated the magnitude of the illusion by interpolating the point at which the vertical lines were seen as equal in length and subtracting that value from the 1-in. standard.

For 10 pairs of twins, the complete series of the Ponzo figures were given twice, with an intervening task between the two series. The test-retest correlation for the magnitude of the illusion for the two series was 0.87. Within the 10 twin pairs, all twins with larger magnitudes of the illusion, as compared with their co-twins, retained their relative positions, even though

the absolute values of the magnitude of the illusion may have changed.

The Wechsler Intelligence Scale for Children (WISC) was also given to each member of the twin pair by different examiners. The specific subtests, Digit Span and Similarities, were examined to see if twins who manifested relatively higher magnitudes of the illusion also manifested higher scores on these subtests than did their co-twins. The other scores from the WISC were also examined to see if systematic differences appeared. The Wilcoxon matched-pair signed-ranks test (Siegel, 1956), two-tailed, was used to test the within-pair differences on each set of scores because it makes no assumptions regarding the shape of the distribution of difference scores and because of the small sample size resulting from treating males and females separately.

RESULTS

Table 1 presents the means of the WISC Similarities and Digit Span scaled scores for the twins who had relatively larger and smaller magnitudes of the Ponzo illusion. Among the females, the twins with larger magnitudes of the illusion scored significantly higher than their co-twins on the Digit Span and Similarities subtests. No other subtests showed significant differences. Among the males, the direction of difference on Digit Span was the same as for the females; however, this difference was not significant. Differences on all the other subtests were also nonsignificant. To see whether the lack of differences for the males was a function of their having smaller within-pair differences than the females in the magnitude of the Ponzo illusion and the two WISC subtests, Mann-Whitney U tests were made. The tests indicated that the within-pair differences for the males tended to be smaller ($p < .10$) on the Ponzo illusion and Digit Span subtest and significantly smaller ($p < .05$) on the Similarities subtest.

DISCUSSION

For females, at least, the findings in this paper support Pollack's (1969) hypothesis that the perceptual activity leading to greater susceptibility to the

Ponzo illusion would be related to cognitive abilities. Those abilities specifically would appear to involve temporal integration or sequencing and comparison of two (or more) cognitive stimuli. Following Hearnshaw (1956), Pollack sees perceptual activity as requiring two main activities: first, immediate or short-term memory, and second, a predisposition to arrange successive events in a coherent and ordered pattern. Ellis's (1963) construct, stimulus trace, fulfills the requirement for short-term memory, and it is the Digit Span subtest that loads highly on a factor believed to demonstrate this construct (Baumeister & Bartlett, 1962). However, other evidence (Osborne & Tillman, 1967; Matheny, 1968) suggests that adequacy on the Digit Span subtest can be explained in terms of an attentional factor isolated by Cohen (1959). In terms of the present study, whether Digit Span measures individual differences in short-term memory or attention—if the two can be separated—does not detract from Pollack's hypothesis, since the attentional component is also covered by the conceptual parallel between perceptual decentration and attention. The second requirement of temporal arrangement of successive events would be fulfilled, again, by Piaget's (see Flavell, 1963, p. 229) explanation that the perceptual activity of decentration necessarily involves temporal or spatial "transports" (e.g., eye movements), which could lead to successive "coupling" or comparisons of visual elements. From this explanation, it seems likely that children who are more capable in making successive comparisons of perceptual stimuli would be more capable in making successive comparisons of cognitive stimuli. This explanation is, of course, what Pollack implies in his hypothesis.

That individual differences within female twin pairs, but not within male twin pairs, support the hypothesis is not explicable at present. Piaget has paid little attention to sex differences in perception; however, he has reported (1969) some of his associates' work that indicates that sex differences should be considered. In the present study, the individual differences of the males were quite small for the cognitive measures and the illusion itself. In other samples for which individual differences of cognitive measures for males would be greater, the effect found for females might appear for males as well.

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