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ABSTRACT

Several studies have indicated that children have difficulty differentiating mirror-image stimuli. In the present study adults were required to classify pairs of horseshoe stimuli as same or different. Response times were compared for stimulus pairs that varied in orientation (left-right vs up-down) and spatial plane of the pair (horizontal vs. vertical). Stimulus pairs in which the orientation matched the spatial plane of the pair (i.e., horizontal and left-right or vertical and up-down) took longer to classify than stimulus pairs in which these two variables were crossed. These results are interpreted as reflecting the necessity of synthesizing two sources of information in order to compare the former pair types--temporally encoded visual information and directional information from the motor scanning process. Implication for the source of children's difficulty with mirror-image stimuli of this type are discussed. (Author)

MIRROR-IMAGE CONFUSABILITY IN ADULTS

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MIRROR-IMAGE CONFUSABILITY IN ADULTS

By Peter Wolff

Report from the Project on the
Role of Stimulus-Correlated
Motor Behavior in Children's Perception

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Statement of Focus

The Wisconsin Research and Development Center for Cognitive Learning focuses on contributing to a better understanding of cognitive learning by children and youth and to the improvement of related educational practices. The strategy for research and development is comprehensive. It includes basic research to generate new knowledge about the conditions and processes of learning and about the processes of instruction, and the subsequent development of research-based instructional materials, many of which are designed for use by teachers and others for use by students. These materials are tested and refined in school settings. Throughout these operations behavioral scientists, curriculum experts, academic scholars, and school people interact, insuring that the results of Center activities are based soundly on knowledge of subject matter and cognitive learning and that they are applied to the improvement of educational practice.

This Technical Report is from the Project on Variables and Processes in Cognitive Learning in Program 1, Conditions and Processes of Learning. General objectives of the Program are to generate knowledge and develop general taxonomies, models, or theories of cognitive learning, and to utilize the knowledge in the development of curriculum materials and procedures. Contributing to these Program objectives, this project has these objectives: to ascertain the important variables in cognitive learning and to apply relevant knowledge to the development of instructional materials and to the programming of instruction for individual students; to clarify the basic processes and abilities involved in concept learning; and to develop a system of individually guided motivation for use in the elementary school.

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Abstract

Several studies have indicated that children have difficulty differentiating mirror-image stimuli. In the present study adults were required to classify pairs of horseshoe stimuli as same or different. Response times were compared for stimulus pairs that varied in orientation (left-right vs. up-down) and spatial plane of the pair (horizontal vs. vertical). Stimulus pairs in which the orientation matched the spatial plane of the pair (i.e., horizontal and left-right or vertical and up-down) took longer to classify than stimulus pairs in which these two variables were crossed. These results are interpreted as reflecting the necessity of synthesizing two sources of information in order to compare the former pair types--temporally encoded visual information and directional information from the motor scanning process. Implications for the source of children's difficulty with mirror-image stimuli of this type are discussed.

I
Introduction

The discrimination of mirror-image stimuli is known to be uniquely difficult for children (Huttenlocher, 1967a, 1967b; Rudel & Teuber, 1963; Sekuler & Rosenblith, 1964), as well as many species of lower animals (Sutherland, 1957; Mackintosh & Sutherland, 1963; Riopelle, Itoigawa, Rahm, & Draper, 1964). Using three-sided horseshoe-shaped stimuli in a horizontal plane, Rudel and Teuber (1963) found that children confused left-right oriented horseshoes (i.e., ⊏ ⊐), but not up-down oriented ones (i.e., ⊓⊔). While these findings led investigators to believe that the phenomenon of mirror-image confusability was specific to left-right oriented stimuli, subsequent research demonstrated that the relative position of the pair of mirror-image stimuli is important in determining their discriminability. When the stimuli were in the horizontal plane, left-right oriented horseshoes were confused more often than up-down pairs, as previous studies had shown. However, when the pairs were in the vertical plane (i.e., ⊔ over ⊓ or ⊐ over ⊏) the reverse was true--confusability was greater for up-down than left-right oriented stimuli (Huttenlocher, 1967a, 1967b; Sekuler & Rosenblith, 1964).

Huttenlocher (1967b) suggested that the important factor in mirror-image confusability is the orientation of the stimulus pair in relation to their axis of separation. In her study nursery school children were required to match the orientation of a standard horseshoe. Each child's horseshoe was to be placed either beside or below the standard. She found that children made errors in their placement only when rotation of a covertly placed test horseshoe around the axis separating the pair would change its orientation relative to the standard. In other words, errors were made on this type of configuration, ⊏ ¦ x , but not on this, ⊓ ¦ x , where "x" denotes the position of the test horseshoe and the dotted line represents the axis of separation of the pair. She called the former pair-type "mirror-image," and the latter pair-type "aligned." Her data also indicate that more errors were made on left-right than up-down oriented stimuli, and among mirror-image stimuli, there were more errors on pairs in the horizontal plane than in the vertical plane.

While the existence of mirror-image confusability in children and animals is unquestioned, there is little agreement about a suitable explanation for the phenomenon. Caldwell and Hall (1969, 1970) have recently claimed that the child's difficulty with mirror-image stimulus pairs in a matching-to-sample task results from the child's inadequate definition of the concepts "same" and "different" as applied to mirror images. Since prereading children have always regarded mirror images of an object as the same object, this habit is carried over to the judgment of mirror-image letter pairs. These authors demonstrated significant improvement in discrimination of these pairs after a training task which they felt defined mirror-image stimuli as different. Gibson, Gibson, Pick, and Osser (1962) offer a similar explanation for the tendency of children in their study to confuse mirror-image letter-like pairs.

Corballis and Beale (1970), on the other hand, have proposed that mirror-image confusion arises from the bilaterally symmetrical organization of the organism's nervous system. They demonstrate that a perfectly bilaterally symmetrical system would be unable to distinguish left from right, and hypothesize that left-right confusability disappears in the child when handedness or consistent left-right scanning habits, made possible by the developing asymmetry of the brain, become established.

While Caldwell and Hall's (1969) explanation has the advantage of simplicity, it violates the fact that adults are known to confuse mirror-image stimuli, as, for example, in writing d for b or d for g, and direction, as in the case of a driver who signals a left turn and then turns right. There is, however, almost no empirical evidence concerning the discrimination of mirror-image stimuli for adults.

The present study examined the relative difficulty of mirror-image and aligned-stimulus pairs, using adult Ss but following as closely as possible the stimulus material and procedures used by Huttenlocher (1967b) with children. Time to respond "same" or "different" to a pair of horseshoe stimuli was used as a measure of difficulty since performance by adults in Huttenlocher's task presumably would be error free. Applying Huttenlocher's terminology, a mirror-image pair is one for which the rotation of one of the horseshoes around the axis of separation of the pair changes the identity status of the pair from either same to different (i.e., ⊏⊏) or different to same (i.e., ⊏⊐). An aligned pair is one for which this rotation does not change the identity status of the pair (i.e., ⊔⊔ or ⊔⊓).

If, as Caldwell and Hall (1969) propose, children's mirror-image confusions simply reflect a definitional problem arising from the tendency of the child to call different orientations of a figure the same figure, then adults who thoroughly understand the requirements of the task should compare mirror-image stimulus pairs as quickly as aligned pairs.

If the bilateral symmetry explanation of Corballis and Beale (1970) is a sufficient explanation of the phenomenon, any superiority of aligned over mirror-image pairs should be restricted to pairs located in the horizontal plane, since the human organism does not possess symmetry around the horizontal median plane.

II
Method

Subjects

Twenty-four undergraduates with normal or corrected-to-normal vision served individually as subjects.

Materials and Apparatus

Stimuli were 16 pairs of horseshoe-shaped figures. The horizontal set consisted of the following pairs: ⊏⊐, ⊐⊏, ⊓⊔, ⊏⊏, ⊐⊐, ⊔⊔, ⊓⊓, and ⊔⊓.

Pairs one, two, six, and seven are mirror-image pairs. The remaining pairs are aligned. The vertical set consisted of 90° rotations of each of these pairs. The horseshoe pairs were drawn with black India ink and the final stimuli were duplicated from these drawings by photo offset onto heavy white stock. Each of the three sides of the horseshoes was 3.2 cm. long (subtending 4.2° of visual angle) and 1.2 mm. wide (.30° of visual angle). The two horseshoes making up a stimulus pair were separated by 1.3 cm. (1.7° of visual angle).

Stimuli were presented in a Polymetric 2-channel tachistoscope (Model V-0959) with a blank fixation field. The tachistoscope was wired with a Hunter "Klockcounter" and a response panel containing two buttons, one for a "same" response and the other for a "different" response. Exposure of a stimulus started the clock, and depression of one of the response buttons stopped the clock and turned off the stimulus.

Procedure

Before responding in the reaction time (RT) task, S was shown each of the stimulus pairs and required to say whether their orientation was the same or different. He was told that when a stimulus pair appeared in the tachistoscope he was to respond "same" or "different" by pressing the appropriate response button. Subjects were instructed to respond as quickly as possible but to avoid making errors.

Each session was divided into two parts, separated by a 5-min. rest period, with the horizontal pairs presented in one part and the vertical pairs in the other. Subjects responded to 11 replications of each series of 8 stimuli. The first presentation of each stimulus served as a practice or warm-up trial and was not included in the analysis. Each replication was presented in a different random order. Presentation of each stimulus was preceded approximately 1 sec. by a "ready" signal. Half the Ss received the horizontal pairs in the first part, while the remaining half received the vertical pairs. For half of each order group the "same" response was made with the preferred hand, while the remaining half used the nonpreferred hand. The correctness and latency of each response were recorded.

III
Results

Mean RTs for the various pair types are shown in Table 1. Aligned stimulus pairs were responded to 57 msec. faster than mirror-image pairs: F (1, 20) = 49.23, $p < .001$. This difference is less pronounced for same pairs (39 msec.) than for different pairs (75 msec.): F (1, 20) = 15.21, $p < .001$, but is highly significant for both (F = 29.39 and 43.68, respectively, $p < .001$).

For stimuli in the horizontal plane, aligned pairs were responded to 51 msec. faster than mirror-image pairs. For vertically aligned pairs this difference was 62 msec. Separate analyses showed each of these differences to be highly significant: $t(23) = 5.45$ and 5.27, respectively, $p < .001$. The difference between these two values, which is equivalent in this stimulus set to the difference between up-down and left-right orientation, does not approach significance ($F < 1$).[1] While there was no difference in RT to up-down and left-right orientation, up-down stimuli were responded to slightly faster than left-right stimuli when the stimuli were the same. For different pairs, the reverse was true. This interaction is significant: F (1, 20) = 7.21, $p < .01$.

[1]Within the constraints of this stimulus set, the alignment factor (mirror-image vs. aligned) is actually the interaction of relative placement of the pair (horizontal vs. vertical) and orientation of the stimuli (up-down vs. left-right). Its "main effect" status is thus theoretical and not statistical.

Table 1. Mean RT in Msec. (and Total Errors) for Aligned and Mirror-Image Stimulus Pairs in the Horizontal and Vertical Plane

		Aligned	Mirror-Image
	Same	554 (18)	598 (22)
Horizontal	Different	573 (16)	631 (22)
	Mean	564 (17)	615 (22)
	Same	583 (14)	615 (15)
Vertical	Different	577 (16)	668 (19)
	Mean	580 (15)	642 (17)

Responses to same pairs were 25 msec. faster than those to different pairs: $F(1, 20) = 17.85$, $p < .001$, although this effect must be evaluated with the significant interaction between response and pair type reported above. For mirror-image pairs, same responses were made 42 msec. faster than different responses. For aligned pairs, this difference was only 7 msec.

A significant interaction between the plane of the stimulus pair and the order of presentation of the two planes was found: $F(1, 20) = 27.14$, $p < .001$, reflecting the fact that RT decreased from the first to the second half of the session.

While the error rate was only 3.7%, and the differences among conditions small, more errors were made on mirror-image than on aligned pairs and more on horizontal than on vertical pairs (see Table 1).

IV
Discussion

The results of this study demonstrate conclusively that adults have difficulty comparing mirror-image stimulus pairs when "mirror-image" is defined in terms of the axis of separation of the pair. Furthermore this difficulty is found equally for pairs in the vertical and horizontal planes.

One study with adult Ss using a same-different RT task and stimuli of this type has been reported by Sekuler and Houlihan (1968). Translating their results into the language of this paper, the differences between mirror-image and aligned stimuli were significant for horizontal but not for vertical pairs. These results must be interpreted with caution, however, since these differences were numerically almost identical, 42 and 38 msec. for horizontal and vertical pairs, respectively. Their failure to find significant differences between mirror-image and aligned pairs in the vertical plane is probably due to several factors contributing to instability in their data. Ss were uncertain as to the plane in which the pairs would appear since presentation of horizontal and vertical pairs was intermixed. In addition, Ss responded by moving a toggle switch to the right or left. A directional response of this type may be incompatible with a task requiring comparison of stimulus directionality. These factors, as well as their use of median values of only six responses to each stimulus, may explain the fact that their median RTs were almost 200 msec. longer than the mean RTs found in the present study.

The fact that adult response times are longer for mirror-image stimuli argues against the claim by Caldwell and Hall (1969, 1970) that children's errors are caused merely by their misunderstanding of the definition of identity applied to mirror-image pairs. In the present study Ss clearly understood the relevant distinction to be made before starting in the RT task. Also, since mirror-image difficulty was no greater for horizontal than for vertical pairs, and RT was the same for up-down and left-right stimuli, the bilaterally symmetrical nervous system of human adults cannot explain their performance on this task.

A plausible explanation of these findings, based on a suggestion by Deutsch (1955), depends on the fact that for mirror-image pairs the orientation of the individual stimuli (right-left or up-down) always matches the plane of the pair (horizontal or vertical). For aligned pairs the opposite is true--up-down stimuli are in the horizontal plane, while left-right stimuli are in the vertical plane. If it is assumed that the subject either explicitly or implicitly scans the pair of stimuli, either from the center outward in each direction or starting at one end of the array, then in order for S to determine the orientation of a mirror-image stimulus he must integrate temporally-organized sensory information with motor information about the direction of his scan. This point is most clearly seen in the example of a pair of horizontal mirror-image horseshoes, ⊏ x ⊐ , with "x" representing the subject's initial point of fixation. A scan to either the left or the right would result in exactly the same pattern of stimulation over time. This temporal equivalence is suggested by Deutsch (1955) as a possible explanation for the confusability of mirror-image stimulus pairs. In order for the two horseshoes to be distinguished spatially, additional information, provided by the S's knowledge of his direction of scan, would have to be integrated with this temporally-organized stimulation. This analysis applies in the same way to mirror-image pairs in the vertical plane. For aligned pairs, however, no integration of motor scan knowledge is necessary since the directionality of these stimuli remains the same regardless of direction of scan.[2] If it is assumed that this integration of information from more than one source requires time, comparison of both horizontal and vertical mirror-image pairs should take longer than comparison of aligned pairs as found in the present study.

The difficulty young children have with mirror-image stimuli may be due in part to the requirement of integrating these sources of information. In addition, the fact that kindergarten children have unusual difficulty with horizontal compared with vertical mirror-image pairs and with left-right stimuli compared with up-down stimuli (Huttenlocher, 1967b) suggests that at this age they cannot derive the necessary directional information from their movements in the horizontal plane. This lack of left-right response differentiation may well be, as Corballis and Beale (1970) have suggested, a function of the bilaterally symmetrical organization of the child's nervous system.

Gesell and Ames (1947) report that handedness does not become definitely established in the child until the age of five. The success of Caldwell and Hall's (1969) training procedures in decreasing confusion between mirror-image letter pairs possibly is explained by the fact that their kindergarten Ss have just reached the age where directional differences, especially left-right discriminations, can be successfully processed when a training task relevant to these differences is used.

[2]The integration of visual with motor scan information has also been used by Ghent (1961) to explain children's choices of "right side up" and "upside down" stimuli, and by von Holst (1954) to account for the fact that the environment remains stationary during a voluntary eye movement.

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References

Caldwell, E. C., & Hall, V. C. The influence of concept training on letter discrimination. Child Development, 1969, 40, 63-71.

Caldwell, E. C., & Hall, V. C. Distinctive-features versus prototype learning reexamined. Journal of Experimental Psychology, 1970, 83, 7-12.

Corballis, M. C., & Beale, I. L. Bilateral symmetry and behavior. Psychological Review, 1970, 77, 451-464.

Deutsch, J. A. A theory of shape recognition. British Journal of Psychology, 1955, 46, 30-37.

Gesell, A., & Ames, L. B. The development of handedness. Journal of Genetic Psychology, 1947, 70, 155-175.

Ghent, L. Form and its orientation: A child's eye view. American Journal of Psychology, 1961, 74, 177-190.

Gibson, E. J., Gibson, J. J., Pick, A. D., & Osser, J. A developmental study of the discrimination of letter-like forms. Journal of Comparative & Physiological Psychology, 1962, 56, 892-898.

Huttenlocher, J. Discrimination of figure orientation: Effects of relative position. Journal of Comparative & Physiological Psychology, 1967, 63, 359-361. (a)

Huttenlocher, J. Children's ability to order and orient objects. Child Development, 1967, 38, 1169-1176. (b)

Mackintosh, J., & Sutherland, N. S. Visual discrimination by the goldfish: The orientation of rectangles. Animal Behavior, 1963, 11, 135-141.

Riopelle, A. J., Itoigawa, H., Rahm, V., & Draper, W. A. Discrimination of mirror-image patterns by rhesus monkeys. Perceptual & Motor Skills, 1964, 19, 383-389.

Rudel, R. G., & Teuber, H. Discrimination of direction of line in children. Journal of Comparative & Physiological Psychology, 1963, 56, 892-898.

Sekuler, R. W., & Houlihan, K. Discrimination of mirror-images: Choice time analysis of human adult performance. Quarterly Journal of Experimental Psychology, 1968, 20, 204-207.

Sekuler, R. W., & Rosenblith, J. F. Discrimination of direction of line and the effect of stimulus alignment. Psychonomic Science, 1964, 1, 143-144.

Sutherland, N. S. Visual discrimination of orientation and shape by octopus. Nature, 1957, 179, 11-13.

von Holst, E. Relations between the central nervous system and the peripheral organs. British Journal of Animal Behavior, 1954, 2, 89-94.

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