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The Predictability of Behavior: a Methodological Study.

Lester Douglas Hornsby Jr

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in

The Department of Psychology

by

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August, 1966
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ABSTRACT

Handedness is a very ancient concept which has been systematically incorporated in cultural ideologies. The concept has also been long useful in science, particularly in the development of the study of the brain. Recently there has been increasing research interest in handedness, defined as preference and called laterality herein, and its relation to the brain but the various results are most often at odds with one another. Several related factors are felt to be the basis of some of the lack of consistency; these include (1) specific hereditary factors in left handedness, (2) cultural emphasis on right handedness, (3) failure to consider degrees of handedness, (4) failure to consider eyedness. An approach which considers perception in relation to mirrored images and the symmetry of the stimulus is discussed. This approach was modified in Experiment I to include controls for the four factors mentioned. In the first experiment it was found that the right dominant Ss showed a left to right directional orientation whereas mixed dominant Ss were variable. The discussion considered
the two-sided nature of the stimuli and the effects of
cultural influences on the two groups. It was concluded
that further interpretation of the results was desirable
but difficult due to inability to fully assess symmetry
characteristics of the stimuli and due to the failure to
differentiate between mixed dominant Ss.

The second experiment was designed to avoid these
two difficulties. Evidence was reviewed which suggested
that the symmetry dimension is not a stimulus characteris­
tic only but is partially a function of response to the
stimulus. It was postulated that in order to define groups
in terms of laterality characteristics it is necessary to
include specification of responses in terms of laterality
characteristics AND the stimulus.

It was found that right handed Ss responded so as
to produce an AS. It was suggested that this tendency may
reflect the fact that responses with the preferred hand
lead to different consequences with different stimulus con­
ditions. There were no differences between dextral right­
eyed and dextral left-eyed Ss in response to the same
stimulus. It was suggested that in order to show that
there are differences due to mixed hand and eye preference
it is necessary to consider as a different form of dominance Ss who responded with reversed motor patterns. This was done and it was found that there were effects in a right dominant group which were correlated with the left to right orientation found in Experiment I, but this orientation does not affect all forms of response equally. When reversal of response was considered there were differences within the right dominant group and between right and mixed dominant groups. The results are discussed in terms of individual differences in motor responses as these are related to bilaterality of the body. It is felt that variation in directional orientation as demonstrated in these studies is a finding of sufficient importance to propose further research in this area.
INTRODUCTION

Handedness has long been a matter of interest to civilized man. There are references to handedness in the Old Testament. Dennis (1958) has recently reported that as long ago as 2500 B.C. the Egyptians clearly depicted handedness in their artifacts. Hulse (1963) states that all cultures throughout the world systematically distinguish between the preferred, "good" hand and the non-preferred hand. Hulse further states that the preferred hand is the right and that, behaviorally, 85% to 95% of the members of any given culture are right-handed. Similarly, Dennis (1958) feels that the evidence indicates that the ancient Egyptians were predominantly right-handed or dextral. Early scientific interest in handedness appears in the writings of John Hughlings Jackson, the British neurologist of the nineteenth century, who noted the association between the faculty of speech and symbolic processes and the left hemisphere of the brain. Jackson was thus aware that the handedness of the asphasic patient was an important consideration in localizing the lesion. Jackson's
work was more appreciated in the early years of this century than in his own time and he has had considerable influence in the development of the study of the brain. Particularly his influence is notable in the study of brain-behavior relations since he repeatedly stressed the necessity of observing the function or meaning of symptoms as related to the total capacity of the human organism. Recent work continues to support many of Jackson's concepts (Mountcastle, 1962) and an interest in handedness has developed into a differentiated research area. Palmer has recently reviewed and discussed the issue (1964) and finds much evidence of differences in functional anatomy between right and left handed individuals. Piercy (1964) and Riklan and Levita (1964) review in more detail evidence which supports the conclusion that the brain is organized differently in persons of differing handedness. These authors note frequent instances of conflicting results and suggest that continued research activity is desirable. One difficulty is the fact that although much of the reviewed work considers hereditary factors in handedness, it does not adequately deal with possible differences in modes of inheritance in right versus left-handedness. There is evidence according
to Fuller (1960) that left handedness is inherited in a particular way. That there are factors other than purely genetic ones in right handedness is suggested by the reports of Hulse and Dennis cited above. It seems apparent from the antiquity and prevalence of dextrality that there are cultural factors involved in the incidence of right and left handedness. How these cultural factors are involved in MIXED handedness, i.e., in a less than complete degree of dextrality or sinistrality seems to have been entirely ignored.

These problems are partially due to the fact that in any given study, whether of the cultural, genetic, or behavioral antecedents of handedness, no distinction is made between degrees of handedness. That it is in fact possible to assess degrees of handedness is indicated in the work of Benton who found a continuous distribution of handedness scores (1962). Most studies, however, employ a single measure of hand preference. It seems likely that this lack of interest in the degree of preference is due to the fact that EYEDNESS has not always been recognized as a measure related to handedness. Harris (1958) suggests that a measure of eye preference and of foot preference is
necessary to fully assess hand preference. This suggestion stems from investigations of cerebral dominance which has to do with the importance of a single hemisphere in mediating a general behavior pattern (Mountcastle, 1962). Hand performance and foot performance are fully lateralized, cortical events mediating the movements of a single limb can be observed in a single hemisphere. The situation is more complicated in the case of eye preference since each eye projects to both hemispheres. Harris, however, finds a high correlation between hand, foot and eye preference. Perhaps the finding by Hubel (1963) that the nasal retina may be dominant is related to behavioral eye dominance.

One approach to the problems of the incidence of handedness and its relation to degrees of handedness has been in clinical studies of the brain-injured person. Thus in such lengthy works as those of Critchley (1953) and Mountcastle (1962) much evidence has been gathered to shed light on the relation of handedness to general functions such as perception. There are a number of limitations in the use of clinical data which are recognized by these workers and which, perhaps, it is possible to avoid.

Another approach to the problem of perception and handedness
is exemplified by the report of Gaffron (Zener and Gaffron, 1962, pp. 562-608). Gaffron points out that perceptual experience of a given example of graphic art differs profoundly as a function of its formal arrangement. Then she goes on to show that the perceptual experience can be totally changed by a mirror reversal of the picture so that the portion which, in gross analysis, originally occupied the upper right quadrant, now becomes the upper left and vice versa. A similar result has been obtained experimentally by Adair and Bartley (1958). Their results indicate that the left and right sides of a scene are changed by reversal. When a particular scene is presented first one way and then in a mirror image, objects in the left half appear nearer. Both Gaffron and Adair and Bartley suggest that these changes in formal arrangement would be experienced differently by persons of differing handedness and eyedness on the assumption that the perceptual system itself produces or reorganizes mirror images in terms of the eyedness or handedness of the subject. Neither study included any left handers or mixed handers among the subjects, however.
EXPERIMENT I

It seems that an investigation of perceptual processes in persons of differing laterality characteristics might reveal differences in perceptual experience of the same scene. In order to measure laterality it seems necessary to assess eye and foot preference as well as hand preference. Once this is done it is further necessary to distinguish between laterality on all three measures in order to account for the cultural emphasis on dextrality or right-handedness. In short the cultural process has no specific means of affecting eye and foot dominance since these are not ordinarily observable by the layman as is handedness. But Harris suggests that the three are correlated. Therefore, it is postulated that in affecting handedness the cultural process also affects eyedness and footedness so that persons who are right dominant on hand, eye and foot will as a group (Group R) be different from a group (Group M) composed of all other varieties of laterality characteristics.

In order to demonstrate that there is a difference
in perceptual processes between these two groups it is necessary to employ a measure which will be relevant to lateral preference. As noted above Gaffron (1962) and Adair and Bartley (1958) suggest that mirror images are pertinent. It is here suggested that the relevant element in the ordinary environment which corresponds to a mirror image is the dimension of symmetry. An asymmetrical stimulus (AS) has a mirror image which is asymmetrical in the opposite direction, e.g. the mirror image of an arrow pointing left to right is an arrow pointing right to left. A bilaterally symmetrical stimulus (BS), on the other hand, is by definition a stimulus whose mirror image is the same as the original. For example, an arrow pointing either up or down does not change when mirrored vertically. The situation is different with a symmetrical stimulus mirrored in other than the vertical plane but this investigation will be confined to the BS since the vertical is the plane of the organism. Bilateral symmetry is a distinguishing feature of vertebrate anatomy (Weichart, 1958).

(1) It is hypothesized that differences in perceptual processes between the two groups defined above will be observable in terms of the asymmetry and bilateral symmetry
of the stimulus.

(2) It is further hypothesized that the differences will not be the same on an AS as on a BS.

Method

Subjects

Ss were 40 undergraduate students from introductory psychology courses who volunteered for the study. There were 18 males and 22 females. It is of some consequence to note that Ss were unselected and had no knowledge that the investigation was concerned with handedness and eyedness.

Materials

Materials included three background scenes from the Make a Picture Story (MAPS) projective personality test (Shneidman, 1947). The scenes were a CAVE, a STREET, and a STAGE. The cave scene depicted a cavern with the entrance to the left foreground and the passage leading off to the right. The STREET scene depicted a street corner in the right foreground with the street leading off to the left. Both these scenes should elicit a general right or left directional tendency but S has to begin at opposite sides of the scene in order to go in the same direction.
Figure 1 is a schematic illustration of the scenes. With these two scenes were included 8 solid-black cut-out figures approximately 5 1/2 inches high, two each of males, females, boys, and girls. Of the two one appeared to be walking facing toward S and the other facing away from S. The figures were depicted in clear walking direction so that directional movement rather than circular movement or standing would be elicited.

The STAGE scene was chosen because it is bilaterally symmetrical. With this scene there were presented 18 dummy figures, four each of males, females, boys, and girls and one each of a dog and a snake. These were outline figures on white cardboard approximately 1 1/4 inches by 6 inches. The figures were different from those used in the first two scenes so as not to suggest directional aspects to S. With these dummy figures the Examiner Identification card from the MAPS test material was presented which depicts in miniature and by number all 67 of the figures normally employed in the projective use of the MAPS test. These figures were used in order to encourage S to arrange something other than simple walking movement as he might have done on the basis of his memory of the first two scenes.
Figure 1
Illustrations of Scenes

Cave

Street

Stage
The second test was the Harris Tests of Lateral Dominance (HTLD) as described by Harris (1958).

Procedure

Ss were tested individually. They were each seated before the eight solid black figures arranged randomly, handed the CAVE scene and told, "you have some people and you have a place. Arrange one or more of the figures you see there in the place so as to tell a little story. Then tell me the story." The stories were recorded; the position, sex and direction of the figures recorded; and the figures returned to a random order before $S$. Then the STREET scene was given to $S$ and he was told, "now use the same figures from which to select one or more and arrange them in this place." Recording was done as before, then the black figures were removed and $S$ permitted to see the dummy figures arranged in piles of four in the order males, females, boys, girls, from left to right. $S$ was then given the STAGE scene and the identification card and told, "Here you have (on the identification card) a number of different people. Here (indicating dummies) you have dummy males, females, boys and girls. As before you are to select some
figures, this time from the card, with which to make a story. When you have selected one or more give me the number printed below it on the card, take the appropriate dummy and arrange the story on the stage." The number of the figure selected, the position (s) of the dummy figure (s) and the story were recorded.

The HTLD was administered and scored according to the standard directions (Harris, 1958). The protocols were assigned a number so that E did subsequent classifications "blind."

The final aspect of procedure was classification of the responses by E in terms of the direction of walking motion on the Cave and Street scenes. The responses from the Stage scene were classified in terms of the direction of dynamic action defined as action of an emotional or verbal kind which initiated at a primary figure and proceeded in the direction of a secondary figure. In most cases this was obvious, as for example, in parent-child interaction the parent was the primary figure. Other examples, with the primary figure indicated first, are policeman - culprit, angry person - subject of anger, employer - employee.
Results

On the basis of performance on the HTLD there were two groups. Group R (right) included the 17 Ss who were right on all three measures; Group M (mixed) included the 23 Ss who departed from right dominance on any of the three measures. Table I shows the laterality characteristics of Group M.

**TABLE I**

Laterality Characteristics of Mixed Dominant Group (N = 23)

<table>
<thead>
<tr>
<th>N</th>
<th>Hand</th>
<th>Eye</th>
<th>Foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>R*</td>
<td>L*</td>
<td>R</td>
</tr>
<tr>
<td>4</td>
<td>R</td>
<td>R</td>
<td>M*</td>
</tr>
<tr>
<td>6</td>
<td>R</td>
<td>M</td>
<td>R</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>M</td>
<td>R</td>
</tr>
<tr>
<td>1</td>
<td>L</td>
<td>M</td>
<td>M</td>
</tr>
</tbody>
</table>

*(R = Right; L = Left; M = Mixed)*
In responses on the CAVE scene the majority of Ss depicted walking motion in a left to right direction. There was a difference in the two groups on this category of response. Group M included a greater number of Ss who did not depict the figures in walking motion or who depicted figures going in both directions. These latter forms are classified as Other in Table II.

**TABLE II**

Direction of Motion On CAVE
In Right and Mixed Groups (N = 40)

<table>
<thead>
<tr>
<th></th>
<th>Group R</th>
<th>Group M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left to right</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>11</td>
</tr>
</tbody>
</table>

A chi square calculated on the basis of Table II was significant (chi square = 4.267; df = 1; p < .05). Most Ss of the right dominant group depicted motion in a left to right direction. The mixed group was more variable, about half of them depicted motion in both directions or no motion.
In response to the STREET scene there was a more complex form of response. The majority of Ss depicted more than one movement direction. There was no difference in the two groups in the direction of movement. Inspection of the data suggested that there was a difference between the groups in presence or absence of motion. Table III shows these data.

**TABLE III**

Presence or Absence of Motion On STREET In Right and Mixed Groups (N = 40)

<table>
<thead>
<tr>
<th></th>
<th>Group R</th>
<th>Group M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right or left motion</td>
<td>16</td>
<td>10</td>
</tr>
<tr>
<td>No motion</td>
<td>1</td>
<td>13</td>
</tr>
</tbody>
</table>

A chi square calculated on the basis of Table III was also significant (chi square = 8.905; df = 1; p < .01). Almost all Ss of the right dominant group depicted directional movement. The mixed group was again more variable, over half of them depicted no motion.
Responses to the STAGE scene are shown in Table IV. The Other category refers to cases where the dynamic action was such that it was not readily possible to determine a directional tendency, in which there was a single figure, or in which the action was obviously circular.

**TABLE IV**

Direction of Dynamic Action in Responses of All Ss in the Two Groups to Stage (N = 40)

<table>
<thead>
<tr>
<th></th>
<th>Group R</th>
<th>Group M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Left</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>Other</td>
<td>5</td>
<td>12</td>
</tr>
</tbody>
</table>

For statistical purposes the data of Table IV were placed in the form shown in Table V. Here the two groups are compared in terms of the tendency to relate dynamic action in the direction of left to right.
TABLE V

Right and Mixed Groups Compared in the Tendency
To Relate Dynamic Action in a Left to
Right Direction on Stage
(N = 40)

<table>
<thead>
<tr>
<th></th>
<th>Group R</th>
<th>Group M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left to right</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>5</td>
<td>23</td>
</tr>
</tbody>
</table>

A chi square calculated on the basis of Table V was significant (chi square = 19.18; df = 1; p < .001). Group R tended to relate dynamic action which began at the left and proceeded to the right. In Group M no Ss related stories in which the dynamic action clearly proceeded from left to right, while as can be seen from Table IV, about half of them exhibited the reverse tendency and related action proceeding in a right to left direction.

Discussion

Both hypotheses were supported. There were differences in the two laterality groups in response to all three scenes. There was also a response specific to the
bilaterally symmetrical scene which seems distinguishable from response to the asymmetrical scene. That is, response to BS was in the opposite direction in the two groups but such was not the case on the two AS. Instead there was a tendency for Ss of group M to show mixed directional orientation or no directional orientation on an AS. In summary there was a general tendency in Group M to greater variability on all three scenes.

In interpreting these results it is important to note that there are only two sides to any scene observed visually, the left and the right. Therefore it seems likely that some process will insure that neither side is neglected. It is not surprising that this process is observable on a BS since there is, so to speak, no directional "pull" and endogenous differences are allowed free operation. The AS, on the other hand, has a definite "pull" and it seems that cultural processes are involved in the differing reactions. That is, in the present results the group assumed to be most affected by culture, Group R, responded with a clear left to right directional orientation. This is an interesting finding in itself and should be further investigated. Why this was left to right rather than vice versa is suggested
only by the speculation that left to right reading habits affect perception in general. That some aspects of perception are affected has been established by Mishkin and Forgays (1952). They found that verbal stimuli presented in a visual half-field were more readily perceived in the left field by Ss who read only English which proceeds from left to right. Contrarily, persons who read Hebrew which proceeds from right to left perceived the same stimuli more readily in the right visual field. That this lowered threshold for verbal stimuli may have general effects was investigated by Jensen (1952). Jensen observed the direction of figure drawing in three different cultures, two whose writing proceeds from left to right and one whose writing proceeds from right to left. Sixty-five per cent of all Ss drew a figure facing left. Jensen's results are therefore inconclusive. The present results would support the speculation that the left to right orientation of English affects perception except for the finding that such is the case only in clearly right dominant persons. For it is clear that perception in mixed dominant persons is different. That this is not due to reading habits is clear also since all Ss were native born English speakers.
Perhaps there is a genetic factor which is not apparent from these results.

There are two chief difficulties in interpreting these results further. One difficulty is that it is not possible to state conclusively that Ss were in fact responding to the asymmetry or bilateral symmetry of the stimuli only. Since the scenes were actual pictures the results may be due to elements other than the symmetry dimension. The "clinical" judgements employed by E to categorize the data are not likely to be an acceptable way of clarifying the issue.

The other principle factor which makes these data difficult to interpret is that the mixed group was composed of a variety of different dominance categories. If it were demonstrable that mixed eyed Ss were different from Ss who were not mixed eyed an interpretation in terms of the interaction of handedness and eyedness would be more feasible.

Further investigation in which the symmetry dimension is precisely definable and which investigates in greater detail the differences within the laterality groups is desirable.
EXPERIMENT II

It was suggested that the results of the first study can be made more meaningful by the use of a stimulus which can be more precisely specified. The only dimension specified on the three scenes was a gross division into asymmetrical or bilaterally symmetrical. It has been found that behavioral distinctions can be made between an AS and a BS but the explanation of the difference has been undertaken in terms of information theory (Michels and Zusne, 1965). These authors state that a BS, being the same on both sides, contains only half as much information as an AS with an equal number of dimensions. Such an interpretation fails to account for individual differences which have been observed. In particular no mention is made of handedness or eyedness as the basis for differences in response. One reason that the laterality dimension has been overlooked in this respect is that the typical study in the area reviewed by Michels and Zusne did not require a motor response from S. There is evidence, however, that the motor system must be considered in an analysis of
visual perception. In particular the work of C. S. Harris reviews this evidence.

Harris has recently (1965) reviewed evidence from which he concludes that the visual system is largely innate in organization as distinguished from the proprioceptive system of feedback consequent upon motor performance. The first experiment of the present study failed to make such a distinction but it was suggested that an analysis of the interaction of hand and eye is the next logical step. If the assertions of Harris can be meaningfully included in the methodology of this second experiment perhaps the analysis will be possible.

One reason that the data reviewed by Harris was overlooked is that no mention is made of handedness. A second related lack in that data was that the investigations failed to take into account the asymmetrical nature of response in a bilaterally symmetrical organism. Consider that a response with a given hand which begins in one visual field and proceeds to the other is not the same as a response with the same hand which proceeds in the opposite direction. For in the one case the hand moves toward the midline of the body but in the other the hand moves away
from the midline toward the environment. For example if a person is asked to reproduce a line, A---B, beginning with his right hand at A, then his hand moves outward. If he is instructed to begin at B his hand moves inward. The same is true of a slanting line but there are other factors involved. Mello has reported recently (1966) that pigeons can be taught to discriminate during monocular training between a slanted line (S+) and a mirror image (S-) of that line (a mirror image slants in the opposite direction). If they are tested with the other eye they respond maximally to the mirror image. The motor behavior involved was a pecking response. It is suggested that the basis of Mello's results is that the beak is a midline organ and the pigeon therefore has no feedback from inward or outward motor patterns as is the case with an organism which responds with a lateral organ. This suggestion places some strain on the evidence because the pecking response was simply a respondent which was not specific to the stimulus. It is further suggested, however, that even if the pigeon were required to trace the line it would still have much difficulty in discriminating monocularly between lines of opposite slant. Further if this discrimination is made it is
based on processes different from those in higher organisms since the optic system in the pigeon involves complete crossing at the chiasma. It can be said with some feasibility, however, that there is an interaction of proprioception with visual perception so that the visual environment is altered with changes in proprioception. The chief problem for investigation at this point is to consider distinctions made as a function of the proprioceptive system between movements which are anisotropic, i.e. with the right versus the left hand.

Accordingly it would seem that differences in eye preference are related to differences in proprioception rather than to the visual system alone and therefore to differential handedness. In order to investigate this contention it is necessary to include a stimulus definable on several aspects of symmetry and, in addition, to require a motor response specific to the form of the stimulus. It has been shown, however, that there are endogenous motor patterns in the form of handedness and that these patterns are correlated with preferences in the use of the eye. The method, therefore, must specify a motor response which can be defined in advance but which can be altered once a
response has been made. In short although the response is to some degree endogenous in the population, in the individual S the nature of response alters as soon as it has been performed. Ultimately the distinction between endogenous processes and stimulus effects cannot be made except in a group of Ss. Therefore it is proposed to define groups on three variables (1) handedness and eyedness, (2) nature of the stimulus and (3) nature of the response. Accordingly only the first two can be defined in advance. Therefore it is hypothesized that:

(1) groups of different laterality will differ in the stimulus they prefer;

(2) that Ss of different eye preference will respond differently to the same stimulus;

(3) and that once a motor response occurs additional difference will be observed within as well as between groups.

Method

Subjects

Ss were 18 student nurses aged 19-21 and one aged 25.
Materials

A stimulus which is bilaterally symmetrical but which has asymmetrical aspects is provided by a square with the corners oriented to the vertical and horizontal. The slanting lines as noted previously are asymmetrical in themselves but the total configuration is bilaterally symmetrical. If such a square is divided into triangles with a vertical line two AS are produced. If divided with a horizontal line 2 BS are produced. The stimulus used was a black line drawing of a square on a white card.

A means of eliciting motor response to the stimulus which allows habitual motor patterns to operate must prevent S from seeing his response and perhaps altering it in accord with visual information. An apparatus designed for such a means is described and pictured by Held (1958, 1965). The apparatus interposes a mirror at a 45 degree angle between a vertical stimulus and a horizontal writing surface. S is given a monocular view of the stimulus through an aperture looking down into the mirror. S can see the stimulus in the mirror and it appears to him as though it were lying on the horizontal writing surface. He can mark on this surface but cannot see his hand due to
the interposed mirror. Figure 2 is a schematic illustration of the apparatus.

**Procedure**

S stood before the apparatus, was given a black lead marking pencil and told: "Look through the hole you see there and you will see a square like this (E showed a duplicate of the stimulus): take the pencil and draw a line dividing the square into two triangles." With this procedure S added either a vertical or horizontal line depending on his preference. This feature of the stimulus is in terms of proprioception only, S could not see the line in relation to the square, he could only feel his movements in making it. As S responded E recorded the preferred eye and hand and the direction of marking. The instructions continued: "Choose one of the triangles you have drawn and mark the three corners with a single dot at each corner. When you have finished stand up." E recorded the preferred eye and hand and the place of initiation and direction, clockwise or counterclockwise.

On the second trial S was given a different color pencil and instructed: "Now use the other eye and mark
Figure 2

Virtual Image Apparatus

[Diagram of a virtual image apparatus with labels: aperture, mirror, stimulus card, pencil]
the same triangle again with three dots. When you have finished return the pencil." E recorded as on trial 2.

The inclusion of the second trial has two functions (1) to rule out chance as a determinant of response and (2) to make observable individual differences. Pilot data had indicated that the performance with the two eyes resulted in a lateral displacement between the two productions of the triangle. This seems due to the fact that to view the stimulus monocularly S shifts his body to the right or left, to the right with the left eye and vice versa. The pilot data further indicated that some Ss reversed the direction of displacement thus suggesting a means of categorizing individual differences. Figure 3 provides two schematic protocols illustrating the response that is expected and the response which is reversed.

Results

The laterality characteristics of Ss are shown in Table VI. These four categories include all possible forms of dominance of hand and eye and in approximately the percentages found in the general population.

Also in Table VI is indicated preference for AS or
Figure 3

Schematic Protocols Illustrating Lateral Displacement Due to Monocular Viewing

Regardless of preferred eye the lateral displacement should be as shown above. $O$ is with right eye; $\odot$ is with left eye. Magnitude of displacement is schematic. An example of reversed displacement is shown below.

$\odot\quad O$

$\odot\quad O$

$\odot\quad O$
BS. Two out of three sinistral Ss chose to draw the line horizontally to produce a BS; 15 of 16 dextral Ss chose to draw vertically producing an AS.

**TABLE VI**

<table>
<thead>
<tr>
<th>N</th>
<th>Hand</th>
<th>Eye</th>
<th>AS</th>
<th>BS</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>R</td>
<td>R</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>R</td>
<td>L</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>L</td>
<td>L</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>L</td>
<td>R</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

In Table VII the two groups of persons who were dextral but who differed on eye preference are compared. The Fisher test of exact probability (Seigel, 1956) revealed no significant differences between the groups on any of the response categories shown in Table VII (critical values of D .05).
TABLE VII

Responses of Subjects of Right and Mixed Laterality
(N = 16)

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Hand-Eye</th>
<th>Triangle*</th>
<th>Direction**</th>
<th>Predicted Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>11</td>
<td>R</td>
<td>7</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>M</td>
<td>5</td>
<td>R</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
<td></td>
<td>15***</td>
<td>12</td>
<td>5</td>
</tr>
</tbody>
</table>

* R = Right; L = Left.

** C = Clockwise; CC = Counterclockwise

*** Subtotals differ from N because not all Ss of either group could be scored on all categories.

Table VIII compares those right dominant Ss who showed a directional displacement as predicted (Group Ra) with right dominant Ss who did not perform as predicted (Group Rb). The response categories are clockwise or counterclockwise direction in moving from the dot placed first to the second and third dots. The other category is placement of both sets of dots to the right of the virtual stimulus. Group Rb was variable on this category,
some Ss placed one set to the right and some placed both sets to the left. Table VIII also shows the performance of Group M on these same measures.

**TABLE VIII**

Comparison Between Groups Who Differed on Displacement (N = 11)

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Direction</th>
<th>Placement</th>
<th>Number of Reversals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ra</td>
<td>4</td>
<td>C 3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CC</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Rb</td>
<td>7</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>M*</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

* The responses of Group M are shown in this additional row of the table (N = 5).

The Fisher test of exact probability indicated a significant difference between groups Ra and Rb on direction (D 0.05). Group Ra tended to execute movements in a clockwise direction and Group Rb the opposite. The same test also indicates a significant difference in placement relative to virtual stimulus (D 0.025). Group Ra tended
to place the two productions to the right but none of Group Rb did so.

In further comparisons of the data in Table VIII, there is no significant difference between either Group Ra or Group Rb and Group M on either of the two response categories (Critical Values of $D \cdot 05$). There is a significant difference between Group Ra and Group M on reversed displacement; Group Ra did not reverse as did Group M ($D \cdot 05$). Comparing Groups Rb and M on the same dimension revealed an insignificant difference ($D \cdot 05$); both Group Rb and Group M reversed displacement.

Discussion

The laterality characteristics of the Ss shown in Table VI include all possible forms of dominance of hand and eye and in approximately the percentages found in the general population. Therefore, although the numbers are small it is felt that conclusions drawn are more reliable than is sometimes the case with small numbers.

With respect to the hypothesis that groups of differing laterality will prefer different stimuli there are several lines of evidence. First 16 of 19 Ss produced
an AS. Of those who produced a BS two were lefthanded or
two-thirds of the lefthanded group. This is suggestive
evidence that there is some difference in laterality
groups in preferred stimulation. In the study by Jensen
(1952) described above it was found that a group of left-
headed Ss were different from all other Ss in direction of
figure drawings. However, as was noted differences in
laterality groups based on differences in preferred hand
alone are somewhat misleading in studying the meaning of
handedness because there is apparently a specific genetic
factor in sinistrality. For this reason the present
result derived from sinistral Ss is not directly comparable
to results from other laterality groups. There is, how­
ever, a second line of evidence in that right handed per­
sons considered alone do in fact structure the environment
in a particular way; 15 of 16 chose the AS and all of these
drew the line from top to bottom. This tends to support the
first hypothesis also. It suggests that visual perception
is affected by motor response. In interpreting this
result it may be noted that drawing the line vertically
is a more economical way than drawing it horizontally. For
to draw a vertical line only one decision is necessary --
up or down. Division horizontally requires a decision along several dimensions: (1) Toward or away from the midline; (2) toward or away from preferred side; (3) right to left or vice versa; (4) and the interaction of all these determinants. If the tendency of sinistrals to choose the horizontal aspect is a reliable finding then their choice is made in spite of many complicating obstructions and is, therefore, a very complex way of approaching reality. This approach is undoubtedly related to the differences in functional anatomy which have been noted between sinistrals and some forms of dextrality.

With respect to the second hypothesis it is necessary to examine several aspects of the response. Table VII presents these aspects but statistical tests indicate that there are no significant differences between the two laterality groups shown there. The second hypothesis is not supported. There seems not to be, on the basis of these data, any reason to distinguish between these groups in response to an AS. It is suggested that the difficulty with this hypothesis is that it does not allow distinctions within a given laterality group. In testing the third hypothesis this distinction will be made.
To test the hypothesis that the nature of motor response will point up differences it is necessary to further divide the groups in terms of the responses. It was suggested that the tendency to reverse the direction of displacement between performance with the preferred eye followed by performance with the non-preferred is the aspect of motor performance of interest. Therefore the Ss were divided in the data shown in Table VIII.

In discussing the findings it may be helpful to note certain things which characterize the task when a person uses one eye only:

(1) There is movement to the left or right to bring the eye into alignment with the line of sight, Movement 1.

(2) The preferred eye is used.

(3) If a motor response is also required the individual does so with the preferred hand and therefore crosses or does not cross the midline of the body in order to align the hand with one eye -- Movement 2.

It is suggested, then, that the tendency to reversal is associated with discrepancies between the proprioceptive
information from Movement 1 and Movement 2.

It is therefore apparent that a tendency to reversal in the mixed Ss, Group M, is not unexpected since the two movements are in opposite directions; Movement 1 is to right and Movement 2 is leftward and crosses the midline. In right dominant individuals (Group Rb), however, the two movements are in the same direction -- leftward --, and the midline is not crossed. This is true on trial 1. On trial 2 the situation is reversed. Movements 1 and 2 are in the same direction for Group M and opposite for Group R. Thus the situation where discrepancy is likely to result is trial 1 for Group M and trial 2 for Group Rb. Thus the discrepancy was experienced in the context of a different history in the different groups. In short, whether the discrepant information occurs early in a task or later is of importance. This postulate is not directly confirmed by the present method but inspection of the data reveals that the magnitude of displacement was much greater in mixed individuals than in those right dominant Ss who showed a reversal. Whether this is a reliable finding should be further investigated, but it can be stated that whatever the determinants of other aspects of the
reversal, the reversal itself always in the different
groups produces different environmental effects. A reversal
in the right dominant means a tendency to move from an
initial position to a leftward position. While reversal in
the mixed Ss entails a shift to the right.

One difficulty which might be raised with this inter­pretation is that not all right dominant Ss showed a rever­sal. It is suggested that discrepancies in proprioception
did not occur in these Ss (Group Ra) because they tended
not to cross the midline of the body at any time; as noted
their productions were all much to the right of the virtual
stimulus.

There are many things which these data do not clari­fy. The most obvious is the complexity of the exposition
required to even cursorily cover the variables. Perhaps
it can be noted that this investigation began with the
assumption that a broad spectrum of determinants are
involved in even the simplest manifestation of laterality.
Among these determinants there were noted cultural emphases,
cerebral anatomy and behavioral correlates. The chief con­clusion drawn is that these determinants produce different
environmental effects by way of altering the organism,
i.e. individual differences are created.

It is felt that the ultimate solutions to questions raised by this investigation will be wholly theoretical. At any rate, perhaps a point has been reached where something can be said about the reasons for this enormous range of individual difference on what is, after all, a simple task. We have been dealing here with the capacity of an individual to structure reality in a predictable fashion in terms of the stimulus and of movements relative to that stimulus. Obviously S does not possess this capacity, in that his movements are not fully determined by the stimulus but by events prior to stimulus onset. It seems reasonable to conclude that stimulation is meaningless until a response has been made. Therefore for each individual or type of individual there is a particular form of stimulation, insofar as there are differences in response due to the type. In order, then, that no aspect of the stimulus is left out in this process there must be some factor which produces systematic variation in individuals. A genetic factor would systematically produce a potential for adaptation but heredity in itself leads to greater and greater diversity. There are restrictions on the limits hereditary
diversity can attain which are imposed by the necessity for adaptation. In short there must be some factor or factors which impose order on the potential for diversity. It is suggested that the order is imposed by the necessity for maintaining adaptive mechanisms in an environment which, with respect to the two general modes of movement -- toward or away from the body -- is entirely arbitrary and devoid of cues as to the direction to be taken. In short there is no order in the environment except that which is specifiable in terms of the organism. Epigenesis produces lateral preferences and the consequences of acts performed with a directional orientation resulting from laterality are observed and integrated by the organism into lasting patterns which constitute reality. This is readily testable in juvenile individuals who have not yet developed lateral preferences. It is already known that young organisms are different from older ones in myriad ways due to incomplete maturation. What is not generally accepted is that the primary fact of bilaterality of the body is an important concept in tracing the developmental sequence.
SUMMARY

Handedness is a very ancient concept which has been systematically incorporated in cultural ideologies. The concept has also been long useful in science, particularly in the development of the study of the brain. Recently there has been increasing research interest in handedness, defined as preference and called laterality herein, and its relation to the brain but the various results are most often at odds with one another. Several related factors are felt to be the basis of some of the lack of consistency: these include (1) specific hereditary factors in left handedness, (2) cultural emphasis on right handedness, (3) failure to consider degrees of handedness, (4) failure to consider eyedness. An approach which considers perception in relation to mirrored images and the symmetry of the stimulus is discussed. This approach was modified in Experiment I to include controls for the four factors mentioned. In the first experiment it was found that right dominant Ss showed a left to right directional orientation whereas mixed dominant Ss were variable. The discussion
considered the two-sided nature of the stimuli and the
effects of cultural influences on the two groups. It was
concluded that further interpretation of the results was
desirable but difficult due to inability to fully assess
symmetry characteristics of the stimuli and due to the
failure to differentiate between mixed dominant Ss.

The second experiment was designed to avoid these
two difficulties. Evidence was reviewed which suggested
that the symmetry dimension is not a stimulus charac­
teristic only but is partially a function of response to
the stimulus. It was postulated that in order to define
groups in terms of laterality characteristics it is
necessary to include specification of responses in terms
of laterality characteristics AND the stimulus.

It was found that right handed Ss responded so as
to produce an AS. It was suggested that this tendency may
reflect the fact that responses with the preferred hand
lead to different consequences with different stimulus
conditions. There were no differences between dextral
right-eyed and dextral left-eyed Ss in response to the same
stimulus. It was suggested that in order to show that
there are differences due to mixed hand and eye preference
it is necessary to consider as a different form of dominance Ss who responded with reversed motor patterns. This was done and it was found that there were effects in a right dominant group which were correlated with the left to right orientation found in Experiment I, but this orientation does not affect all forms of response equally. When reversal of response was considered there were differences within the right dominant group and between right and mixed dominant groups. The results are discussed in terms of individual differences in motor responses as these are related to bilaterality of the body. It is felt that variation in directional orientation as demonstrated in these studies is a finding of sufficient importance to propose further research in this area.


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VITA

Lester D. Hornsby, Jr. was born August 20, 1934, in the town of Greensburg, Louisiana. His childhood and adolescence were spent in a rural home near Greensburg. He attended school there until graduation in 1952 and entered Louisiana State University in the fall of that year. The years from 1952 to 1962 were spent at Louisiana State University with the exception of two years in the United States Army during 1956 and 1957. The Bachelor of Arts degree was granted at Louisiana State University in 1959. A year internship at Central Louisiana State Hospital in Pineville, Louisiana was completed in June, 1963. The Master of Arts degree was granted at Louisiana State University in 1963. Since June, 1965 he has been employed as Clinical Psychologist at Southeast Louisiana Hospital, Mandeville, Louisiana.
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Major Field: Psychology

Title of Thesis: The Predictability of Behavior: A Methodological Study

Approved:

[Signatures]

Major Professor and Chairman

Dean of the Graduate School

EXAMINING COMMITTEE:

[Signatures]

Date of Examination:

27 June 1966