EXPERIMENTAL STUDIES OF A PERCEPTUAL ANOMALY

V. SOME FACTORS INFLUENCING THE APPEARANCE OF THE BLOCK DESIGN ROTATION EFFECT IN NORMAL SUBJECTS*

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Introduction

The present paper is a continuation of work previously carried out and is an attempt to define more accurately the conditions under which the rotation effect can be induced in normal subjects.

Outline of Previous Research

The block design rotation effect was first observed in some patients while they were doing the Goldstein Cube Test, in which the subject has to reproduce patterns with the aid of coloured cubes. Some patients, while completing the designs correctly, would leave the completed pattern in a rotated position. apparently without being aware of this (Shapiro, 1951). Such rotation might be as large as 45° (Fig. 1), but rarely exceeded this amount.

Subsequent research has resulted in two main findings:

(*i*) The rotation effect occurs to a significantly greater degree among brain-damaged psychiatric patients than among non-brain-damaged psychiatric patients—at least within the limits of the samples tested (Shapiro, 1952).

(*ii*) The rotation effect tends to appear according to definite laws.

The three main laws so far established are:

(*a*) When the line of symmetry of a design (the line of symmetry being defined as the line which divides the design into mirrored halves) is at an angle to the vertical axis of the total visual field, as in "C" and "D" of Figure 2, the tendency to rotation will be increased. When the line of symmetry is parallel to the vertical axis of the total visual field, as in "A" and "B" of Figure 2, then the tendency to rotation will be decreased.

(*b*) When the design is in a diamond orientation, as in "C" and "D" of Figure 2, the tendency to rotation will be increased; when the design is in a square orientation, as in "A" and "B" of Figure 2, the tendency to rotation will be decreased. Such orientation is referred to as the figure shape.

(*c*) When the ground (which is defined as the 6 inch by 6 inch white card on which the design is placed) is in a diamond orientation, as in "B" and "D" of Figure 2, the tendency to rotation will be increased; when the ground is in a square orientation, as in "A" and "C" of Figure 2, the tendency to rotation will be decreased.

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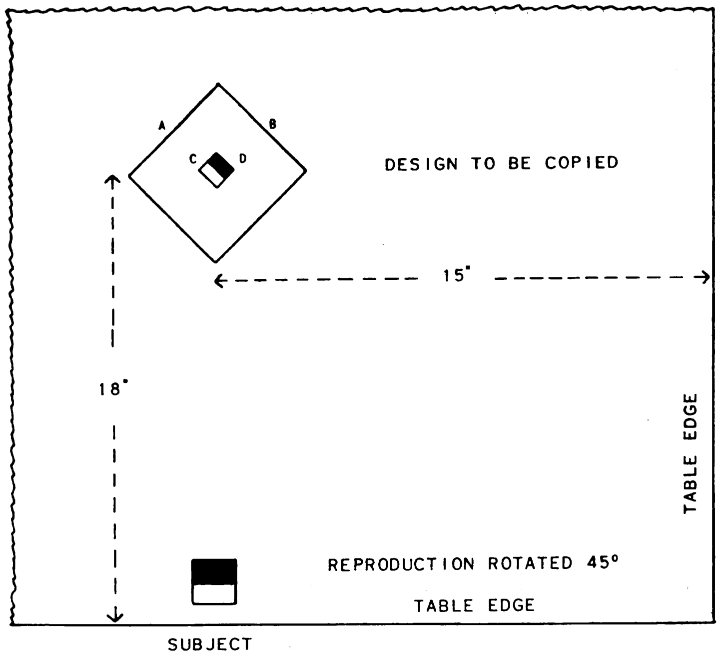

FIG. 1.—Example of a card from the Block Design Rotation Test with the reproduction rotated 45°.

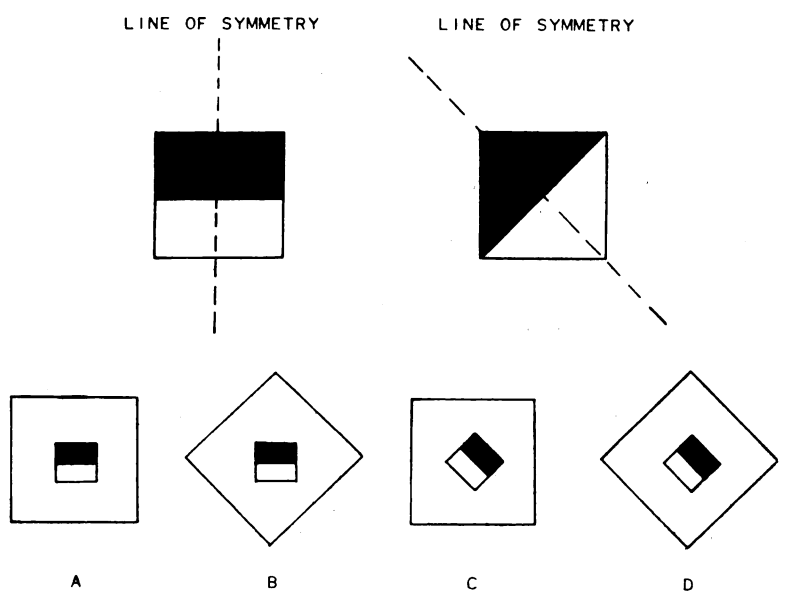

FIG. 2.—Combinations of figure shape, ground shape and angle of the line of symmetry.
Square oriented figure in cards a and b.
Diamond oriented figure in cards c and d.
Square oriented ground in cards a and c.
Diamond oriented ground in cards b and d.

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These laws have been validated only for a special form of the Block Design Rotation Test, which has been described by Shapiro (1952).

From certain considerations (Shapiro, 1953) it was deduced that brain-damaged patients rotated more than non-brain-damaged patients because the former were deprived of many of the visual cues which would counteract the rotation-inducing properties in the cards (described above). In order to test this theory, it was further deduced that normal subjects deprived of most of their visual cues would also rotate to the same extent as the brain-damaged patients and in accordance with the same laws.

Two experiments were carried out to test this deduction. In the first experiment, 20 subjects were tested under two conditions. In the first set of conditions, the subject wore a "field-reducer" consisting of two halves of a table-tennis ball set in felt so that each eye was covered. In one of the halves, a small hole, 6·5 mm. in diameter, was pierced so that the subject obtained only restricted vision. To complete the withdrawal of directional cues, the table surface was covered with plain black paper. In this situation it was predicted that the normal subject would rotate the blocks. In the second set of conditions, the subject did not have to wear the special mask; but for administrative convenience the black paper was left on the table. In this set of conditions it was thought that the directional cues provided by the whole room would be sufficient to prevent the rotation effect from appearing. The outcome was not in accordance with expectation. In both situations the subjects rotated as much as brain-damaged subjects and according to the same laws.

As reported in the previous paper (Shapiro, 1953), it was then decided to carry out a second experiment on normal subjects, this time reproducing as exactly as possible the two original conditions for brain-damaged and non-brain-damaged subjects. Two samples of 20 subjects each were drawn. One was tested under completely normal conditions, the other worked throughout the testing session under cue-reduced conditions, with masks on and black felt on the table. The latter was called the "pseudo-brain-damaged" group. This time, clear results, in accordance with expectations were obtained. The pseudo-brain-damaged group rotated significantly more than the control and as much as the genuinely brain-damaged subjects. They also did so in accordance with the same laws. These results did not, however, explain why it was, in the first experiment, subjects produced the rotation effect with only black paper on the table and without wearing the field-reducer. It was desirable to set up explanations of this finding and to test them experimentally.

Design of the Experiment

(i) Factors Involved and Hypotheses to be Tested

Four possible explanations, arising from the conditions of the two previous experiments were considered. None of them, of course, were mutually exclusive.

(a) *Felt v. No Felt*

It was possible that the black surface on the table alone was sufficient to produce the rotation effect and that the artificial cue-reduction obtained by means of the field-reducer was unnecessary. It will be remembered that, in both the experiments discussed above the pseudo-brain-damaged group had worked on felt while doing the test, whereas the normal control group had worked on black paper when it rotated and on the grained surface of the table when it did not.

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This graining, however, was so distributed as to produce a definite pattern, possibly providing visual cues which would help to counteract the rotation effect—since the pattern arranged itself in a horizontal manner. It was possible, therefore, that it was the presence of these cues immediately surrounding the test object which prevented rotation in the normal group, and the absence of these cues for the group working on black paper which facilitated rotation. If this were so, then it would follow that the perceptual cues farther out in space, such as the vertical walls, table edges, etc. (the influence of which Shapiro was trying to exclude by means of the field-reducer), would play very little role in the production of the phenomenon.

The first hypothesis was, therefore, that the use of felt would by itself (in the absence of cue-reduction by other means, e.g. the field-reducer) induce rotation to a significant degree.

(b) *Small Room v. Large Room*

In previous experiments, the size of the room used had varied, although within any one experiment, the size of the room had been kept constant. Now, Asch and Witkin (1948) had shown clearly that errors in the perception of the vertical varied systematically as the amount of information to be derived from the surrounding room was varied. In one of their experiments, for instance, judgments of the uprightness of a rod were obtained under three different conditions of the visual field: (*i*) the subject, standing at a distance from the tilted field, viewed it through a tube which restricted his view to the interior of the scene; (*ii*) the subject stood directly in front of the scene without a tube; (*iii*) the subject stood at a distance from the scene, without the tube, so that he saw not only the tilted scene, but the outer upright room as well. Under all three conditions, the perceived vertical and horizontal were displaced significantly in the direction of the visual scene. However, when an outer upright visual field was present, the effect of the tilted scene upon the perceived upright diminished. In fact, the mean deviation from the upright dropped from about 15° with the tunnel to about 7° without the tunnel and with the cues from the room available. While Asch and Witkin did not actually vary the size of the room they used, it seemed a logical inference from their work that the closer to the subject the various indications of the horizontal and vertical were, the more use he would be able to make of them in counteracting the rotation-inducing tendencies of the cards. Such indications would be closer in a small room than in a large one. It was therefore predicted that if the size of the room were increased, a significant increase in rotation would result.

(c) *Distance of the Card from the Edge of the Table*

In his experiments, Shapiro had at different times placed the cards so that their centre was 12 inches or 18 inches from the edge of the table and the possible effect of this factor had not been investigated. With the card at a distance of only 12 inches, the subject might obtain at least some peripheral vision of the cards while constructing the pattern with the blocks. This would then become an important variable, since it was stated explicitly (Shapiro, 1953) that the card and the area where the patterns were constructed could not be viewed simultaneously.

It was therefore predicted that significantly more rotation would be produced when the cards were at a distance of 18 inches than when they were at a distance of 12 inches.

(d) *Experience v. Lack of Experience*

In all the previous experiments, except one, the subjects had been given the Wechsler Block Design test, in order to familiarize them with the material before the administration of the Rotation Test—the one instance in which this procedure was not followed produced the ambiguous results already discussed above. There was therefore the possibility that lack of experience might lead to increased rotation, since unfamiliarity with the situation might result in over-dependence on the most striking visual cues, i.e. the patterns.

The prediction was therefore made that subjects who had not been given the Wechsler Block Design test the day prior to the Block Design Rotation Test would produce significantly more rotation than those subjects who were experienced.

One further factor, not directly arising out of the earlier experiments was also included in the experimental design.

(e) *Intelligent v. Dull Subjects*

In his experiments, Shapiro had obtained a measure of control over intelligence by omitting those subjects who obtained a Wechsler Vocabulary weighted score of 6 and below. It happened that in most of the earlier experiments, the subjects were reasonably well matched for intelligence (e.g. Yates, 1954). In two pilot experiments, however, involving subjects of average and superior intelligence the results obtained were equivocal and it was considered that there was a need to control this variable also as it might prove to be a source of significant variation.

The prediction was made that persons of high intelligence would rotate significantly less than persons of low intelligence.

To summarize, it was predicted that rotation would be significantly increased by:

(*a*) Felt on the table;
(*b*) Increasing the size of the room;
(*c*) Increasing the distance of the stimulus-card from the edge of the table;
(*d*) Lack of experience with the blocks;
(*e*) Low intelligence on the part of the subject.

(*ii*) Design of the Experiment

The 2^n factorial design for experiments was used, each factor being varied in only two ways. In the resulting analysis of variance, there were thus five main actions—Felt (F), Room (R), Distance (D), Experience (E) and Intelligence (I)—ten first-order interactions, ten second-order interactions, five third-order interactions and one fourth-order interaction, with a total of 31 degrees of freedom.

The following is a brief description of the various conditions under which the experiment was carried out. These conditions are, of course, derived from the hypotheses discussed above.

(a) *Felt*

For half the subjects, the table was completely covered in black felt, which offered no spatial indications at all to the naked eye. The other half worked on the grained surface which has already been fully described (Shapiro, 1953).

(b) *Room*

Two sizes of room were used:

(i) *Small Room.* This room was about 12 feet by 6 feet, and was relatively full of objects, e.g. a large chest of drawers, three chairs, etc., so that there were no empty spaces against the walls.

(ii) *Large Room.* This room was more than twice the size of the small room, being approximately 20 feet by 20 feet in size. Besides the table and chairs used for the experiment, the only other objects in the room were a built-in cupboard and a wash-basin.

(c) *Distance*

The subjects were equally divided between the two distances, which have already been fully described.

(d) *Experience*

Half the subjects were tested in two separate sessions. In the first session, these subjects were given the three Wechsler sub-tests used to estimate intelligence-level (Vocabulary, Similarities and Block Design—the latter test also serving as a practice or familiarizing test with the blocks) and in the second session the rotation test under the appropriate conditions. These are called the Experienced subjects. The remaining half of the subjects were given all the tests on the same day and at the same session, the Rotation Test being administered after the Similarities and Vocabulary tests, but before the Block Design test. These are called the Inexperienced subjects. The order of testing for the two groups was therefore as follows:

Experienced Subjects	*Inexperienced Subjects*	
1. Vocabulary	1. Vocabulary	same day
2. Similarities	2. Similarities	
3. Block Design	3. Rotation Test	
One-day Interval		
4. Rotation Test	4. Block Design	

(e) *Intelligence*

The subjects used in this experiment were placed in one of two groups according to whether they were of "high" or "low" intelligence. These terms are, of course, relative ones in this context, since the group as a whole was probably significantly above average in intelligence compared with the general population (the mean I.Q. for the whole group was 113·50). It did not prove possible to test the group as a whole for intelligence prior to the main experiment. In order, therefore, to split them into high and low intelligence groups with the least amount of wastage, the following procedure was adopted. It was known that the subjects came from an environment closely similar to that of subjects previously used as controls, i.e. the subjects were all nurses in study block at the time of testing and came from similar social and cultural backgrounds; nor did they differ in age, education, etc., from previously tested groups. The intelligence scores of these previously tested subjects were therefore used, the median point being calculated for the sum of the raw scores on the Vocabulary and Similarities sub-tests (this was 39·5 raw score points). For the present group, therefore, any subject obtaining a score above this point was arbitrarily called "intelligent", while any subject scoring below it was called "dull". That this procedure was successful is shown by the fact that the wastage of subjects was small (i.e. it did not prove difficult to obtain equal numbers of subjects above and below the cut-off point) and the fact that the method succeeded in obtaining two groups equal in numbers and significantly differentiated from each other in terms of intelligence. The Wechsler Block Design Test was not used in the determination of intelligence since, in the case of the Inexperienced subjects, this sub-test could not be given until the subject had taken the Rotation Test and had therefore already been allocated to a cell.

(*iii*) Allocation of Subjects to the Cells

As far as possible, subjects were allocated to cells randomly. Although this was not possible entirely (due to difficulties associated with the number of different possible conditions) it is not considered likely that any systematic bias was present.

(*iv*) Subjects

For the experiment 32 female subjects were used. A number of other subjects had to be rejected because they could not be fitted into appropriate categories.

Results

In an analysis of variance experiment without replication, the usual procedure is to pool the higher-order interactions along with their associated degrees of freedom in order to obtain an estimate of the degree of experimental error. The mean square arrived at in this way is used in the manner in which the mean square based upon the variation within groups is used in experiments with replication, that is, as an estimate of the uncontrolled variation against which to test the significance of the other mean squares. This procedure is, of course, based on the assumption (which, without replication and a proper test of significance cannot be proved) that the variance obtained by pooling the higher-order interactions with the error variance would not differ significantly from the variance obtained with replication—in other words that the higher-order interactions are not significant. There is no reason to think that these assumptions are being violated in the present experiment, since the subjects used were very similar to those of previous control groups, about whom a great deal was known. the various groups having proved very similar with respect to intelligence, education, socio-economic status, etc.

In the analysis of variance, the first step was to pool the third-order interactions with the fourth-order interactions. This resulted in a mean square of 36·33, with 3 degrees of freedom. When the second and first-order interactions were tested for significance, using this mean square as an estimate of error, none of the interactions reached the 5 per cent. level of significance. Having established this, it was now legitimate to combine all the interaction sums of squares with their respective degrees of freedom and use the resulting mean square to test the significance of the main actions. The results obtained are shown in Table I. It will be seen that the mean square now being used as an estimate of the error variance is 27·42 with 26 degrees of freedom. In this way, a more sensitive test of the significance of the main actions is obtainable, using 1 and 26 degrees of freedom. However, the only main action which shows a significant F ratio is Felt *v.* No Felt, with an F ratio equal to 12·83 (significant beyond the ·1 per cent. level of confidence). None of the other main actions reached the 5 per cent. level of significance. Table II shows the means and standard deviations for each of the main variables considered in this experiment.

TABLE I

Results of Analysis of Variance After Pooling of Higher-order Interactions

Variable	df	Mean Square	F ratio	P
Room	1	67·46	2·460	NS
Felt	1	351·92	12·834	·005
Distance	1	0·19	—	NS
Experience	1	73·08	2·665	NS
Intelligence	1	18·12	—	NS
Error	26	27·42		
Total	31			

TABLE II

Means and Standard Deviations for Main Variables

Variable	Mean	S.D.
Felt	9·98	7·41
No Felt	3·35	1·79
Large Room	8·11	7·26
Small Room	5·21	4·93
12 inches	6·74	7·24
18 inches	6·59	5·36
Experienced	8·17	5·50
Inexperienced	5·15	6·51
Intelligent	5·91	4·96
Dull	7·41	7·47

The principal results obtained with respect to the hypotheses put forward in this experiment may be summarized as follows:

(a) *Felt v. No Felt*

The hypothesis is strongly supported. Reduction of visual cues by means of felt is sufficient to induce the rotation effect to a highly significant degree. It is not necessary to introduce artificial reduction of the visual field by means of a field-reducer to obtain the rotation effect. Consideration of the results obtained here and of those obtained in the experiments carried out by Shapiro suggest the conclusion that the decisive factor in inducing rotation in normal subjects must be the presence or absence of visual directional cues *immediately surrounding the stimulus figure*. The cue which most subjects utilize under the usual test conditions would seem to lie in the graining of the table, which, as already pointed out, seems to offer clear horizontal indications. For fully satisfactory proof of this conclusion, however, it must be pointed out that two further experiments would be necessary. In the first place it would be necessary to demonstrate that normal subjects would rotate if the table top were of *any* uniform kind, i.e. that the graining really is being used as a visual cue and that no quality of the felt other than its uniformity is important in inducing rotation.

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In the second place, it would be necessary to show that subjects wearing the field-reducer would not rotate when working on the graining provided, of course, that they were able to perceive the graining while wearing the field-reducer.

(b) *Large v. Small Room*

The size of the room made no significant difference to the rotation effect in the present experiment, although the difference in the means was in the predicted direction. It may be noted that everything was in favour of the appearance of a significant difference. For example, the small room had at one time been a bathroom and the walls were tiled half-way up to the ceiling, so that clear visual vertical and horizontal cues (and their precise relationship to each other) were directly opposite to the subject at a distance of only about 2½ feet directly in front of him. In the large room, on the other hand, the walls were entirely distempered and hence relatively unstructured with respect to visual cues. It may be pointed out, however, that the analysis of variance shows a tendency close to significance on the part of the room variable to interact with the felt variable in the predicted direction; this interaction had the highest mean square of all the interactions. It is possible that the use of an even larger room would have produced a significant interaction and possibly even a significant main action for Room.

(c) *Distance*

That this variable did not prove significant is not surprising in view of the failure of the room size to affect the rotation phenomenon.

(d) *Experience v. Inexperience*

The hypothesis concerning the influence of experience on the rotation effect was not confirmed and the mean values were actually in the opposite direction. It seems safe to conclude that for samples of subjects similar in nature to this one, experience or non-experience of the Goldstein blocks prior to being given the Rotation Test will not influence performance on the latter.

(e) *Intelligent v. Dull Subjects*

The 32 subjects were successfully separated out into "intelligent" and "dull" by the method previously described. The mean combined raw score for the "intelligent" group was 43·75; while that for the "dull" group was 33·53. Analysis of variance between the two groups yielded an F ratio of 56·91 (1 and 30 degrees of freedom). Since the numerator of F has only 1 degree of freedom, this is equivalent to a t of 7·55, which is significant at the 1 per cent. level of confidence. The prediction that these groups would differ significantly in the amount they would rotate was not, however, confirmed.*

Discussion

In the first place, it seems that the results obtained in the first experiment by Shapiro discussed in the introduction can be arrived at without recourse to the field-reducer. All that is necessary is a homogeneous black surface on

* It may be added that analysis of variance carried out separately on the rotation scores of the two groups (16 on Felt; 16 on Graining) showed that the factors influencing the rotation effect (Figure shape, Ground shape, Angle of the Line of Symmetry, etc.) exercised the same relative influence as in previous studies on similar groups by Shapiro (1952, 1953).

the table. Thus, it would seem that the negative induction effects presumed to be operating in brain-damaged subjects do not need to be quite as drastic as was first envisaged in order to produce the rotation effect. Furthermore, it would seem that, in so far as our visual perception of objects is influenced by the surrounding visual field, the decisive factors which help to determine the nature of such perceptions may sometimes at least be restricted to those which immediately surround the object of perception. Thus, visual perceptions may be radically changed, not by controlling the complete range of visual perceptions available to the subject, but simply by concentrating the subject's attention by means of a suitable task and varying only a limited aspect of his environment. Hence, in the present experiment, it was necessary only to remove the horizontal indications immediately surrounding the test object for the subject to be significantly influenced by the special properties of the test object. It did not prove necessary to remove visual vertical and horizontal indications even a few feet away from the subject. In this connection, it is interesting to recall the experiment of Holway and Boring (1941), who used similar but rather elaborate methods of cue reduction to eliminate the constancy phenomenon. They showed that, the more thoroughly visual cues were removed, the closer objects approached their retinal size. However, they went from full or monocular vision to field-reducer or even more restricted ("tunnel") vision, without exploring simpler methods of cue-reduction. It is possible that their effects could have been produced by the method used here.

The results of the present experiment may also be compared with those obtained by Witkin and Asch (1948). After experimenting with elaborate visual set-ups, specially constructed rooms, etc., they found that equally if not more striking results could be obtained simply by placing the subject in a dark-room. As one example of their work, we may quote the experiment in which they showed their subjects a diamond-oriented square and asked them which side was the top. Most subjects, of course, correctly chose the top-right or left-hand side of the diamond; a few subjects, however, made gross errors and said that the bottom sides were the top. Apparently, when deprived of their normal visual cues, they were unable to distinguish top from bottom in the usual way—nor did they seem able to make use of other cues not normally dominant, such as kinaesthetic cues.

The present results may also have some implications for the treatment of brain-damaged patients. If, in fact, the pseudo-brain-damaged subjects in this experiment were behaving like brain-damaged patients, then it would seem to follow that some brain-damaged patients are unable to utilize cues in their immediate environment, i.e. they are grossly stimulus-bound. The problems involved in teaching such patients would clearly be very great. The present experiment, however, seems to provide a starting-point for such therapeutic experiments, such as the removal of the rotation effect in normal and abnormal subjects. It might be possible in some cases to remove the rotation effect where it exists by simple repetition (i.e. practice, the brain-damaged patient who rotates differing from the normal person who does not merely in taking longer to make use of rotation-counteracting cues). On the other hand, other subjects may require their error simply to be pointed out to them for them to stop rotating. In yet other cases, specific visual aids might be necessary before the rotation effect could be dispersed. The present results are also useful in so far as they enable a definition to be given of the simplest conditions under which the rotation effect may be induced in normal subjects.

Finally, it must be stressed that the results obtained in the present experiment should not be generalized beyond the group on which they have been established. It may well be that such factors as intelligence, experience with the blocks, size of the room and distance of the stimulus-card would prove to be of importance in determining the amount of rotation produced by brain-damaged or other patients; as well as the interaction of these variables.

Summary

Previous experiments on the block design rotation effect had left several problems unsolved. The present experiment was designed to investigate the influence of a number of factors on the induction of the rotation effect in normal subjects. Five factors were systematically varied—Felt, Size of Room, Distance of stimulus-card, Experience with blocks, and Intelligence level. The major factor influencing rotation in normal subjects is shown to be the presence or absence of felt on the table, no other factor playing a significant role. The implications of these findings are discussed.

References

Asch, S. E., and Witkin, H. A., "Studies in space orientation. II. Perception of the upright with displaced visual fields and with body tilted", 1948, *J. Expt. Psychol.*, **38**, 455–477.

Holway, A. H., and Boring, E. G., "Determinants of apparent visual size with distance variant", *Amer. J. Psychol.*, 1941, **54**, 21–37.

Shapiro, M. B., "Experimental studies of a perceptual anomaly. I. Initial experiments", *J. Ment. Sci.*, 1951, **97**, 90–110.

Idem, "Experimental studies of a perceptual anomaly. II. Confirmatory and explanatory experiments", *J. Ment. Sci.*, 1952, **98**, 605–617.

Idem, "Experimental studies of a perceptual anomaly. III. The testing of an explanatory theory", *J. Ment. Sci.*, 1953, **99**, 394–409.

Witkin, H. A., and Asch, S. E., "Studies in space orientation. IV. Further experiments on perception of the upright with displaced visual fields", *J. Expt. Psychol.*, 1948, **38**, 762–782.

Yates, A. J., "Experimental studies of a perceptual anomaly. IV. The effect of monocular vision on rotation", *J. Ment. Sci.*, 1954, **100**, 975–979.