EXPERIMENTAL STUDIES OF A PERCEPTUAL ANOMALY

VII. A NEW EXPLANATION

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Previous Findings

Previous papers in this series (Shapiro, 2, 3, 4; Shapiro and Tizard, 6; Yates, 13 and 16) have been concerned with the investigation of an aspect of the reproduction of designs called the rotation effect. Rotation is the term used to describe the fact that subjects often, when copying a design, make their reproductions in an orientation which is different from that of the model (see Figure 1).

This investigation was carried out by means of a specially designed test called the Rotation Test. In this test the subject was presented, in succession,

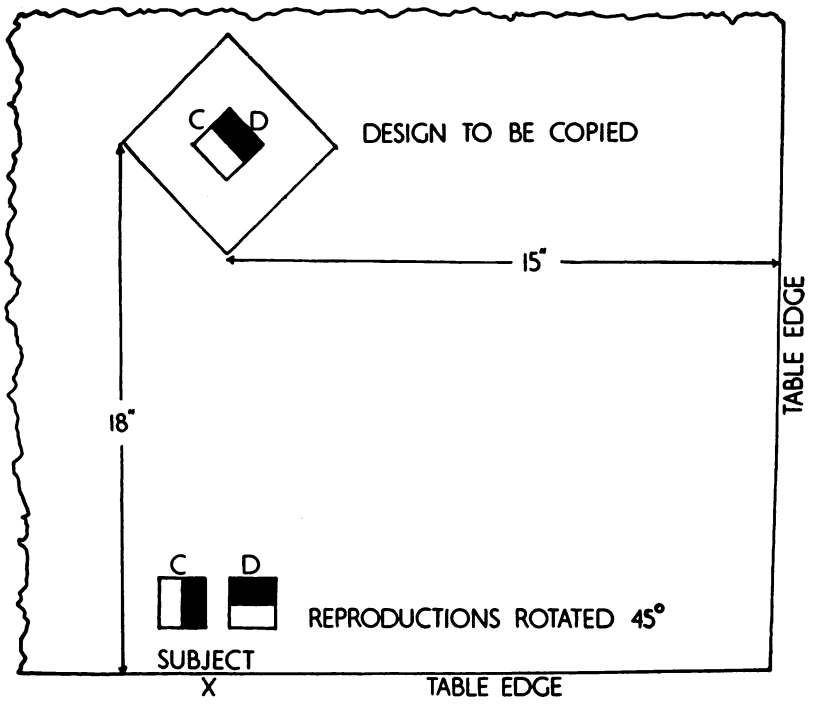


Fig. 1.

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with 40 abstract designs (see Figure 2), each being 1 inch by 1 inch square, coloured in yellow and blue, and placed in the centre of a white card 6 inches by 6 inches square. The 40 abstract designs in fact consisted of 10 different designs (see Figure 2), each design being presented four times, twice in a diamond orientation and twice in a square orientation. Each orientation of a design was presented once on a diamond oriented card and once on a square oriented card. The order of presentation of the cards had been arranged to minimize the systematic influences of fatigue and practice.

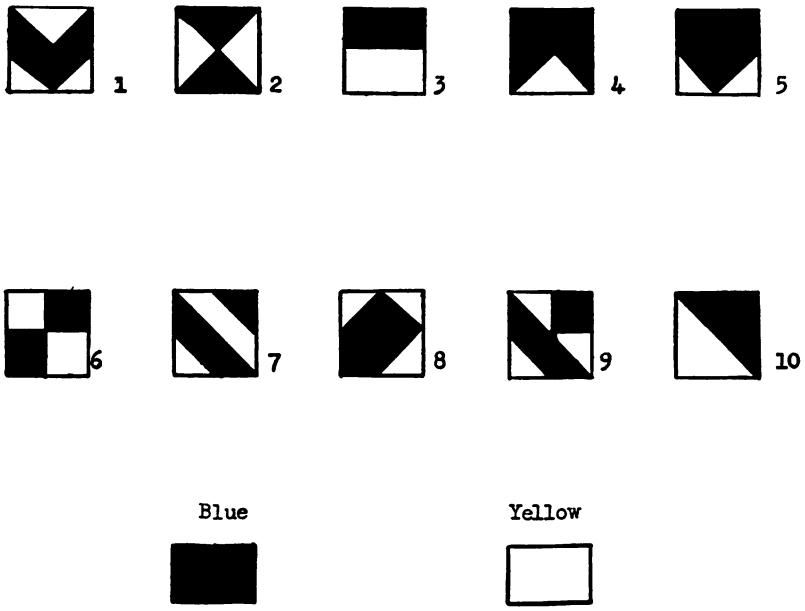


FIG. 2.

Two forms of reproduction were utilized. In one form, described in detail elsewhere (Shapiro, 3), the subject had to reproduce the design with multi-coloured one-inch cubes of the Koh's Test. Most of the experimental work was carried out with this form. In the second form, described in detail elsewhere (Yates, 15), the subject had to reproduce the design by drawing with a blue pencil on a pad, a new page being used for each drawing. In both forms each design was kept before the subject throughout each trial, and the subject was required to work at the table edge 18 inches below the design. Direction of rotation was not taken into account in the methods of measuring rotation. These methods are described in detail elsewhere (Shapiro, 3; Yates, 15). Two main findings have emerged from the work which has been so far done.

The first of these findings was that brain-damaged subjects rotated their reproductions more than non-brain-damaged subjects in both forms of the rotation test (Shapiro, 3; Williams, Lubin, Giesking and Rubenstein, 12; Yates, 15). The "brain-damaged" subjects were neuropsychiatric patients who, at the time of testing, had a history and/or symptomatology indicative of damage to the brain as a result of disease, trauma, or surgery. In a proportion of the cases there was, incidentally, additional damage to the spinal cord and peripheral nervous system.

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The second finding was that the amount of rotation varied in accordance with certain laws of organization of the material which had to be copied. These laws have been observed in a number of studies (3, 4, 12, 16) and were utilized by Shapiro in the development of an explanation of why brain-damaged patients rotated more than other patients (4).

The Explanation of These Findings

The first feature of this explanation was that the tendency to rotate was produced when there was a difference in directional properties of (*i*) the design and card, compared with (*ii*) the directional properties of situation in which the design had to be reproduced on the other. Figure 1 represents an extreme difference of this kind. The perceived "top" of the design would tend to be at "C" or "D". The degree to which this tendency actually affected perception would depend upon the degree to which the subject was able to integrate other sensory cues and relevant associations. When the subject was actually making his reproduction, 18 inches below the card, the directional properties of the situation which he perceived would now be differently organized. "Top" would now tend to lie in one position, and would be straight ahead of the subject. He would therefore tend to construct in this directional situation what he had perceived when he looked at the design, a square. He would thus tend to rotate his reproduction.

The second feature of the explanation was the hypothesis that inhibitory processes were intensified in brain-damaged subjects (Shapiro, 4, 5). It was thought that this intensification would affect the mechanisms of attention, one of the main features of which is the reciprocal inhibition of all simultaneous stimulation which is irrelevant to the formation of a correct percept. In adequately functioning perception there should, however, be sufficient input of correcting stimulation from all modalities, both without and within the body, to produce "correct" perception. Thus there would be a tendency to perceive the square design in Figure 1 as a *diamond* oriented design; i.e., the processes of reciprocal inhibition must be limited in normal attention.

In the case of the brain-damaged subject, the processes of reciprocal inhibition were presumed to be over-strong, resulting in what might be called "over-exclusion", thus depriving the subject of correcting stimulation. Thus there might be an increased tendency to perceive the square design in Figure 1 as *square* oriented. One way of describing this effect is to say that the percepts of a brain-damaged subject are similar to those of a normal person, in a dark room, for whom each object of regard is illuminated in turn. Experiments testing deductions from this kind of theorizing were carried out on normal and brain-damaged subjects (Shapiro, 4; Shapiro and Tizard, 6; Williams, Lubin, Giesking and Rubenstein, 12; Yates, 16). They have, on the whole, produced results consistent with expectation. The one outstanding exception will be discussed later. Suffice it to say here that it was found that normal subjects, when their visual fields were restricted, rotated as much as brain-damaged subjects, and according to the same laws.

Purpose of the Present Investigation

While these results supported the above explanation they also strongly suggested a simpler alternative. If the elimination of surrounding visual stimulation increased the tendency of normal subjects to rotate, then it could be argued that any interference with the visual mechanism, whether due to a minimal field defect or some paralysis or paresis of the intrinsic or extrinsic ocular

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muscles (this will henceforward be referred to as an "oculo-motor" defect), might lead to a restriction or distortion of the visual afferent stream, and hence increase the tendency to rotate. Such defects could be brought about by lesions, not only in the cerebral cortex, but in various sub-cortical centres and fibre pathways. It is important, therefore, to follow up J.B.'s original suggestion that we should obtain evidence of the relation of the rotation effect to defects of visual field and of oculo-motor co-ordination. This suggestion was made by J.B. on the ground that an investigation of this kind should always be made in the case of any defect associated with brain damage.

Subjects

It was decided to re-analyse the rotation data which had been used in previous investigations by Shapiro (3), Yates (15), Shapiro, Kessell and Maxwell (7) and Campbell (1).

Initially, there were three groups of subjects: normal, functionally disordered, and brain damaged. The normals consisted of 61 subjects who, in response to a specially devised set of questions, had denied a history consistent with the possibility of neuropsychiatric disorder of any kind. This group will be referred to henceforward as the "normal" group. The functionally disordered patients consisted of 58 psychiatric patients with neurotic, schizophrenic, and depressive disorders. For each of them the existence of brain damage, as defined above, had been ruled out as far as possible by the psychiatrist in charge. This group will henceforward be referred to as the "functional" group.

The brain-damaged subjects included in the present study consisted of 48 subjects. Some of these subjects had had a brain operation and they were tested either before, or at least six months after, operation. A number of patients had been eliminated before arriving at the final figure of 48 subjects. In the first place all of the brain-damaged subjects tested by Shapiro *et al.* (7) were excluded because their case notes were not easily available. They had been drawn from a variety of hospitals other than the Maudsley or Bethlem. In the second place, seven patients were excluded from the Maudsley/Bethlem group. Six of these seven were excluded by the second author, because his re-examination of the case notes made him doubt whether they were really brain damaged. The seventh was excluded because the exact date of testing was not known.

Tests

1. *Wechsler Vocabulary Test*

It was necessary to compare the cognitive ability of our samples. Advantage was therefore taken of the fact that results were available for all the subjects on the Wechsler Vocabulary Test. In this test the subject is required to give definitions of words of increasing difficulty.

2. *The Wechsler Block Design Test*

It was necessary, if possible, to determine the degree to which results obtained on the rotation test would generalize to other measures involving visuo-motor functions, which appear to be comparable with those involved in the Rotation test. Fortunately, all the subjects had been given the Wechsler Block Design Test. In this test, the subject has to copy abstract multi-coloured designs very similar in nature to those used in the rotation test, with Koh's cubes. Additional scores are given to the subject for the speed with which the reproduction is completed.

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3. *Rotation Tests*

The results from three forms of the rotation test were used in order to maximize the number of subjects included in the study. (Note that the numbers given here include the seven patients who were finally excluded). *Form 1* (to be called the "long block form") of the test was the original form, and consisted of 40 trials, as described at the beginning of this paper, the blocks being used as the form of reproduction. Data was available for 19 brain-damaged, 19 functionals and 20 normals (Shapiro, 3, 4). *Form 2* (to be called the "short block form") of the test was exactly the same as Form 1 with the exception of the omission of Designs 3, 7 and 10 (see Figure 2). There were thus 28 cards in all. This form of the test was given to 19 brain-damaged subjects (Yates, 14). *Form 3* (to be called the "drawing form") of the test employed 48 cards as did Form 1. The mode of reproduction was, however, by drawing. Data was available for 17 brain-damaged, 39 functionals and 41 normals (Yates, 15).

Comparability of Results from Different Forms of the Rotation Test

The original 19 brain-damaged subjects on the "long block form" produced a mean rotation score of 8·15°, with a standard deviation of 5·45°. The mean score of the second group of brain-damaged subjects on the "short block form" was 7·92°, with a standard deviation of 4·44°. A test of significance is not necessary here. On the "drawing form" Yates' 20 brain-damaged subjects produced a mean rotation score of 6·85°, with a standard deviation of 5·16°. For the purposes of a *t* test, H.R.B. combined the results for the "long block form" and the "short block form" and compared them with the results on the "drawing form". The *t* was 1·057 which is far from an acceptable level of significance. In view of these results, it seemed legitimate to combine the data of all three forms for the purpose of our investigation.

General Procedure

All the brain-damaged subjects accepted for investigation had been patients of the Maudsley-Bethlem Hospitals, or of the Guy's-Maudsley Neurosurgical Unit. On the basis of a re-examination of the case notes, J.B. divided the brain-damaged group into two groups. The first, consisting of 24 cases, had either one or both of the following features:

(*i*) any type or degree of visual field defect as established by the usual perimetric methods, and which could be anything from a minimal defect in a single quadrant to a complete homonymous hemianopia.

(*ii*) any type or degree of paralysis or inco-ordination of the extrinsic and/or intrinsic eye muscles. This group will henceforward be referred to as the "experimental" brain damaged group.

The remaining 24 cases will henceforward be referred to as the "control" brain damaged group. Table I gives the details concerning localization, type of defect, age, sex and rotation of the brain-damaged subjects. The case notes were independently examined by M.B.S. and the patients sorted into the two groups. There was disagreement on only two cases involving minimal field defects. The disagreements were resolved in discussion.

It was found, after all the statistical work had been completed, that one subject had been mistakenly tabulated in the experimental brain-damaged group when he should have been included in the control group. This was the second

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patient listed in the frontal group in Table I. As examination of the histograms will show, the main outcome of the statistical analysis will not be affected by this error. It should be remembered, therefore, that the statistical analysis was carried out with 25 subjects in the "experimental" brain damaged group, and 23 subjects in the "control" brain-damaged group.

TABLE I

Details concerning the Brain Damaged Groups

F = Field Defect D = Apparent Cognitive Impairment
M = "Oculo-Motor" Defect O = No Defect

Sex	Age	Lesion	Defect	Mean Rotation Score
Temporal (N=11)				
M	48	L. Temp. Lobect. for Glioma	F	10·07
F	51	R. Temp. Meningioma	O	10·35
M	46	L. Temp. Lobect. Gliosis	F	7·43
M	17	R. Temp. Art.-Ven. malformation	F M	13·43
M	26	L. Temp. Haemorrhage	F	4·73
F	51	R. Temp. Lobect. for Glioma	F	6·65
M	42	L. Antr. Lobect. for Glioma	O	1·98
M	38	L. Temp. Lobect. Gliosis	F	2·53
F	41	L. Temp. Lobect. Gliosis	F	4·16
F	25	L. Temp. Lobect. Atrophy	F	14·68
M	42	L. Temp. Lobect. Glioma	F	1·93
Frontal (N=10)				
M	41	L. Angioma. Vessels tied.	O	3·08
M	29	L. Trauma. Scar excised.	O D	11·24
M	30	L. Aneurysm. Haemorrhage	O	5·96
F	43	L. Front. Lobect. Glioma	O	4·28
F	26	L. Art.-Ven. Malformatn. Haemorrh.	O	3·53
M	29	R. Bullet track and scar	F	17·59
M	34	R. Front. Lobect. Glioma	O	2·93
F	43	L. + R. Leucotomy	O	2·66
F	28	L. + R. Leucotomy	O	3·94
M	45	L. + R. Leucotomy	O	3·23
Parieto-Occipital (N=4)				
F	13	R. Glioma	F M	11·71
F	30	L. Art.-Ven. Malformatn. Vessels tied	O	4·28
F	44	L. Porencephalic Cyst	F	5·79
M	38	L. Scar. No operation	O	1·65
Cerebellar (N=3)				
M	52	Cystic Midline Tumour	M	13·57
F	48	Midline Tumour	M	17·27
M	48	R. Tumour	M	11·74
Fronto-Temporal				
F	34	L. Glioma	O	2·82
Occipital+Parietal+Temporal				
M	43	R. Scar.	F M	18·55
Hemisphere				
M	55	L. Carotid Thrombosis	M	4·22
Frontal+Diencephalon				
M	48	R. Fr. Lobect.+Missile track into Thalamus	O	3·23
Diencephalon				
M	29	Third Ventricle Tumour	F	7·78

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Diffuse Lesions (N=15)

F	37	Otitic Hydrocephalus	F	10·23
M	27	Hydrocephalus	O	3·85
M	39	Huntington's Chorea	O	4·34
M	41	Huntington's Chorea	M	14·45
F	41	Tabes+Cerebral Syphylis	M	11·17
M	38	Meningitis	O	4·45
M	44	Post-encephalitic Parkinsonism ..	M	15·09
M	45	Post-encephalitic Parkinsonism ..	M	12·03
M	43	Post-encephalitic Parkinsonism ..	M	16·50
M	45	Punch-drunk Encephalopathy ..	O	8·05
F	26	Disseminated Sclerosis (No ocular sys.)	O	3·00
M	49	Presenile Dementia	O D	12·95
F	48	Concussion+Drug Intoxication ..	O D	16·65
F	35	Changes secondary to Epilepsy ..	C	5·88
M	51	Cerebral atrophy and Temp. L Epilepsy	O	6·50

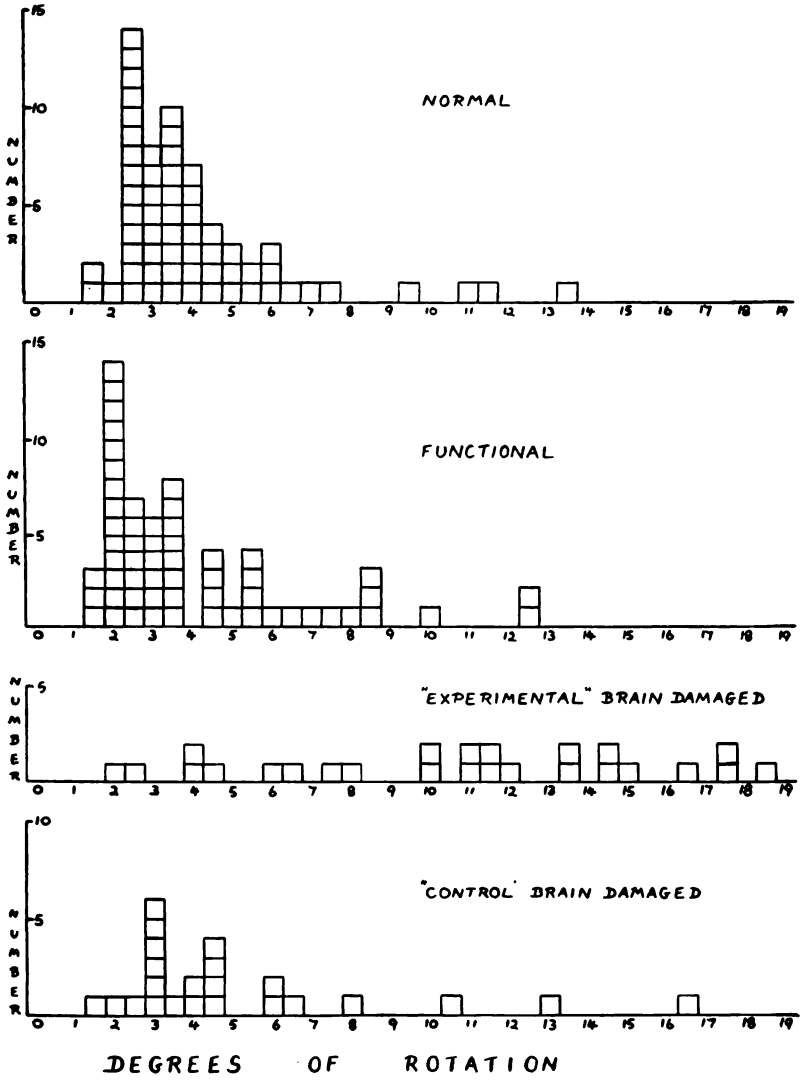


FIG. 3.

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Results

The raw rotation scores were subjected to a logarithmic transformation, because of their extreme negative skewness, in an attempt to normalize them for purposes of statistical analysis. Examination of Table II and the Histograms will show that the "experimental" brain-damaged group produces by far the highest mean score, which is 1·3 standard deviations higher than the next mean score, that of the "control" brain-damaged group. The analysis of variance involving all four groups produced a very high F ratio of 21·56 ($P<·001$). (Except where otherwise indicated, P.S. was responsible for all the statistical analyses). The difference between the mean score of the "control" brain-damaged group and that of the two non-brain-damaged groups is very small, being far less than half a standard deviation. The high F ratio would seem to be derived primarily from the high mean rotation of the "experimental" brain-damaged group compared with the other three groups.

Table II

Main Findings

Group	Age	Means for Vocabulary	Means for Block Design	Rotation
Normal	26·82	11·70	12·38	·5706
Functional	35·07	11·66	10·60	·5357
Experimental B.D. ..	37·68	9·24	8·48	·9607
Control B.D.	37·83	10·17	9·78	·6404
s.d. within groups ..	9·83	2·55	3·02	·2315
F	12·61	7·49	11·40	21·56

Further examination of Table II shows that each of the three variables, age, vocabulary and block design score, also differentiated between the four groups at high levels of statistical significance, the lowest F ratio being 7·49. We have, in addition, the facts (*i*) that each of these three variables was correlated at at least borderline levels of significance, with rotation (see Table III), and (*ii*) that they have a low correlation with each other. It is possible, therefore, that the large F ratio found for rotation was, to a large degree, the outcome of the fact that we had drawn each of our four samples from populations of different age, vocabulary and block design ability.

Table III

Correlations

	Vocabulary	Block Design	Rotation
Age	·1840	−·3374	·2144
Vocabulary		·2966	−·1649
Block Design			−·3321

A zero correlation with 163 degrees of freedom has a standard error of ±·0788. All the correlations reach an acceptable level of significance as the smallest of the correlations is more than twice this amount. The correlations were calculated from the variance and co-variances within groups.

Additional Statistical Investigation of the Results

The Independent Effect of Rotation

It was obviously necessary, in view of the findings discussed above, to determine whether rotation would still differentiate the "experimental" brain-damaged group from other groups, if they were all equated in terms of age, vocabulary and block design test score.

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The method of discriminant functions was used to achieve this purpose. This method enables one to determine the weights which should be given to each of a set of variables so that, when combined, they differentiate as powerfully as possible between the groups concerned. This procedure was carried out on each of the six pairs of groups in turn.

The procedure for each pair was as follows: the first step was to compute the weights for age, vocabulary and block design score which, when combined, would provide the maximum differentiation between the two groups. Such a combination would in effect produce a single *estimated* score for each subject. Column 1 of row 1 in Table IV gives the proportion of the actually *observed* variance, between the two brain-damaged groups, which is accounted for by the estimated variance between the two groups derived from the estimated combined scores. It will be seen that the estimated variance accounts for less than 2 per cent. of the observed variance, and does not approach an acceptable level of significance.

TABLE IV

Sums of Squares

	of the discriminant functions using				
	3 Variables only	All 4 variables			
for comparing	1. Variance between groups as % of total	2. Increment including Rotation	3. Residual error	4. F Ratio	5. P less than
Experimental with control B.D. cases	1·8555	11·0687	·5476	20·11	·001
Experimental B.D. with Normal cases	24·2591	7·6038	·4285	17·74	·001
Experimental B.D. with Functional cases	11·1806	17·7790	·4468	39·79	·001
Control B.D. with Normal cases	16·7880	·1914	·5221	·37	—
Control B.D. with Functional cases	4·7768	1·4543	·5897	2·47	—
Normal with Functional cases	12·8879	2·8045	·5302	5·29	·05

The second step was to compute the weight for rotation which, when combined with the weights for vocabulary and block design score, would maximize the differentiation between the two groups. The second column of row 1 in Table IV gives the increase in proportion of total variance thus accounted for. The increment was nearly 12 per cent. of the total variance. The remaining three columns of Table IV are concerned with the test of significance of that increment. The third column gives the error variance, the fourth gives its ratio to its error variance, and the fifth the probability corresponding to that ratio. It will be seen that the increment produced by the addition of rotation produced the very high F ratio of 20·21 which is significant at less than the ·001 level.

The same method of analysis was applied to the other five pairs of groups and their results are also reported in Table IV. In the first place, unlike the comparison between the two brain-damaged groups, significant results were

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produced by all the combinations based on weights derived from age, vocabulary and block design score. In terms of estimated combined scores, the two brain-damaged groups produced significantly lower estimated scores than the functional groups, who in turn produced lower scores than the normal group. The level of significance reached by these increments was at least at the ·05 level.

The significance of the increment due to rotation produced a very different picture. In the first place all the increments were very significant for the comparisons between the "experimental" brain-damaged groups and the other two groups, as reference to Table IV will show. However, the comparisons between the "control" brain-damaged group and the normal and functional groups produced small increments which did not reach an acceptable level of significance. Finally, the increment in the proportion of variance accounted for in the comparison between the functional and normal groups was significant at the ·05 level. The direction of this last increment was such as to make the functional subjects rotate *less* than the normals. This last finding would be of some interest if it were confirmed.

The Differentiating Power of the Wechsler Block Design Test

It was necessary to determine whether the block design test differentiated the "experimental" brain-damaged groups from the other groups relatively independently of age and vocabulary. A similar analysis to the one described above was carried out, except that in this case the first discriminant function was derived from age and vocabulary, and the increment calculated was that produced by the Block Design Test. The increments due to block design are given in Table V. The statistical significance of each can be calculated on the basis of the relevant residual errors in column 3 of Table IV. All the increments produced by the Block Design Test were small, and only that for the comparison between the "experimental" brain-damaged group and normals was at an acceptable level of significance, the ·05 level.

TABLE V

Additional Sums of Squares when Block Design is added to Age and Vocabulary

For comparing	Increment when including Block Design	F Ratio
Experimental with control B.D. ..	·8607	1·572
Experimental B.D. with normals ..	2·5289	5·901
Experimental B.D. with functional ..	·6713	1·502
Control B.D. with normals	·3123	·598
Control B.D. with functionals	·0405	·069
Normals with functionals	1·0656	2·010

Effect of the Extent of Brain Damage

All the brain-damaged groups, except those in the diffuse category, were rated on the basis of an inspection of the case notes by J.B. for the extent of cerebral pathology. Patients in the diffuse category were excluded because they could not be confidently rated in this respect. Patients of doubtful brain pathology, originally excluded from the control and experimental groups, were included in this study. Four degrees of extent of brain damage were used in the ratings: (*i*) doubtful (*ii*) slight (*iii*) moderate and (*iv*) extensive. The numbers assigned to each of these four degrees were, in the order stated, 6, 11, 8 and 13. Analysis of variance of the log scores produced an F ratio of 1·328, which does not approach an acceptable level of significance.

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Relation to Site of Damage and Type of Defect

This part of the investigation went through three phases. In the first phase we found that, when we compared the various localization groups for the amount of rotation, there appeared to be two main groups. One of them could be called the "cortical" group, which rotated relatively little, and consisted of patients whose lesions were localized in the frontal (N=10), temporal (N=11) and occipito-parietal (N=4) areas. (Any localization classification which only had one patient in it was excluded from this analysis). The mean rotation scores of these three localization groups were 0·6701, 0·7533 and 0·6735 respectively. It is important to note that these means are not materially different from the mean score of the control brain-damaged group which is 0·6575. (This mean is different from that given in Table II because the one incorrectly assigned subject has now been omitted).

The second group of subjects consisted of the relatively high rotaters, and were patients with lesions localized in the cerebellar (N±3) and diffuse (N±15) regions. The mean scores were, respectively, 1·464 and 0·9242. An analysis of variance produced an F ratio of 2·662 which is significant at the ·01 level.

The second phase of the investigation consisted of the extraction, from the experimental brain-damaged group, of all patients who had field defects but no "oculo-motor" defects (N=12), and all subjects who had "oculo-motor" but no field defects (N=9). Most of the former patients were to be found in the "cortical" groups, while all the latter patients were to be found in the cerebellar and diffuse groups.

There now appeared to be three distinct groups, the pure "oculo-motor" group with a mean log rotation score of 1·0831, the pure field group with a mean of 0·8131, and the control brain-damaged group with a mean of 0·6575. The F ratio was 9·24 which is significant at the ·001 level.

The third stage of the investigation consisted of an attempt to equate the two "defect" groups for the form of the rotation test used. Only one subject in the pure "oculo-motor" group had been tested with the drawing form, as against six of the pure field defect group. All the subjects who had been tested on the drawing form were, therefore, excluded. In addition all the subjects who had been tested on the "long form" blocks were rescored in such a way as to make their scores comparable with the "short form" blocks. This involved leaving out in the rescoring all the items which did not appear in the short form. We thus had three groups of patients, all of whom had scores based on the short block form of the rotation test; a pure field defect group (N=7); a pure "oculo-motor" group (N=8), and a control brain-damaged group (N=12). The mean of the log scores of these three groups were 0·9722 and 1·0678, and 0·5931 respectively. The F ratio was highly significant, being 27·44. We again appeared to have two main groups, but this time the field defect group is identical with the "oculo-motor" group, while the control group forms a separate group on its own.

The only firm conclusion we can draw is that both field and oculo-motor defects appear to be important in the generation of high rotation scores. Because of the small numbers involved, however, the exact role of each form of defect, and the way it interacts with type and length of rotation test, remains a matter for further investigation.

Discussion and Conclusions

One finding emerges clearly from this study. The tendency of brain-damaged subjects to rotate more than non-brain-damaged subjects appears to be un-

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equivocally, and almost solely, connected with the presence of field defects or defects of oculo-motor function in the brain-damaged subjects. Such defects are produced by lesions in definite parts of the brain, lesions whose sites might be included in a wide variety of conventional localization.

The immediate conclusion from this finding is that it was unnecessary for Shapiro, in trying to explain the relation of the rotation effect to brain damage, to invoke the idea that damage to the brain produced a strengthening of inhibitory effects in parts of the brain not directly affected by that damage. An alternative theory, which accounts for our results more satisfactorily, is that the restriction or disturbance of visual input, however caused, may alone be sufficient to produce an increased tendency to rotate.

The applicability of Shapiro's theory to other observations of the psychological effects of brain damage must also now be called into question Shapiro (4) (5) derived his generalization from a consideration of reports, primarily those of Bender and Teuber, of the effects of gunshot wounds involving the parieto-occipital lobes. Amongst the changes shown by these patients were (*i*) reduction in fusion threshold for flickering light, (*ii*) impairment of motion perception, (*iii*) distortion of shape and displacement of apparent position of objects. Shapiro was influenced by the fact that these defects were reported in parts of the visual field outside the defective areas indicated by perimetry, and that they appeared to be normalized by the reduction of the duration of stimulation and by the reduction of both the amount and intensity of other simultaneous stimulation (Teuber and Bender, 9). However, he failed to take into account that these observations were only reported in cases with visual field defects (Teuber, 8).

It is necessary to consider how far all disturbances of behaviour involving visuo-motor function might, in brain-damaged subjects, be ascribable to defects of sensory and motor function defects. For example, how far are the peculiarities found in patients with parieto-occipital lesions due primarily to the effects of reduced sensory input upon the sensitive psychological processes mediating perception? How far is the apparent "diagnostic" efficiency of tests of brain damage, such as the visual retention tests, due to similar causes?

An examination of the literature, and of our own findings, shows that the answers to such questions might turn out to be rather complicated. For example, Teuber and Weinstein (11) report that brain-damaged patients with field defects were *not* worse than other brain-damaged subjects on the Gottschaldt test, which requires subjects to discover hidden figures in complex patterns. They did find, however, that both brain-damaged groups were significantly less efficient in this test than non-brain-damaged controls, after the effects of intelligence test score had been partialled out statistically.

Different again is our own finding with the Wechsler Block design test, which was that there was no difference between the two types of brain-damaged subjects, functionals and normals, after the groups had been equated statistically for vocabulary score and age.

Finally we have the fact noted by J.B. that, in our study, the only subjects who were, on clinical grounds, noted by their doctors to be suffering from some form of intellectual impairment, though their Wechsler I.Q.'s were at least 90, were the three highest rotaters in our control brain-damaged group.

The sense of complication is maintained when we consider the studies reporting the effects of the imposition of artificial restrictions upon visual input in brain-damaged subjects. One would expect such impositions to place both brain-damaged and non-brain-damaged subjects under similar disadvantages, and that therefore there should be no differences between brain-damaged and

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non-brain-damaged subjects under such conditions. Three studies have produced results which are to some degree consistent with these expectations and to a considerable degree inconsistent with them.

Partially consistent with expectation are the results reported by Teuber and Mishkin (10) who made their subjects judge when a rotated line was exactly upright under two conditions: (*i*) complete darkness with the line consisting of a luminous rod and (*ii*) looking at a line consisting of a black thread against a background of tilted black and white stripes, the whole display being at the end of a tunnel which excluded all other visual cues. In both condition (*i*) and condition (*ii*) brain-damaged and non-brain-damaged subjects were not significantly differentiated from each other.

Teuber and Mishkin (10) obtained materially different results when they introduced a conflict of postural cues into condition (*i*). The subjects were seated in specially designed seats that could be tilted at an angle of 28 degrees to the right or left. Under these conditions the subjects with anterior lesions made errors in their judgments to a significantly greater degree than did the controls and patients with posterior lesions. The controls and the patients with posterior lesions were still not significantly differentiated. Field and motor defects appeared to have no relation to their findings.

Finally we have the findings of Williams *et al.* (12). They found, as did Shapiro (4), that normal subjects, wearing the special restricting mask, rotated more than normal subjects who did not wear it. However, they found that brain-damaged subjects wearing the mask rotated significantly *less* than the brain-damaged controls not wearing it. They do not give us sufficient information about their brain-damaged subjects to make it possible to evaluate their results. Another difficulty in the way of confident assessment is the fact that *all* the subjects worked on black felt, a condition which was reported by Yates (16) as alone being capable of increasing the tendency of normal subjects to rotate.

It is outside the scope of the present paper to carry out a comprehensive survey of the relevant literature. However, we do have, in the data which has been cited above, a sufficient diversity of findings, conditions of experimentation, and of psychological functions, to indicate the existence of fruitful lines of systematic research.

Summary

This paper reports an investigation of the relation of the rotation effect to visual field defects and to "oculo-motor" defects. The "rotation effect" refers to the tendency to reproduce abstract designs correctly but in a misoriented position. The subjects consisted of 61 normals, 58 non-brain-damaged functionally disordered patients, 24 patients with visual field and "oculo-motor" defects and 24 brain-damaged patients without such defects. The influences of differences in age, Wechsler vocabulary, and Wechsler Block Design ability were partialled out by means of discriminant function technique. The outstanding finding was that, after this was done, the brain-damaged group with visual field and "oculo-motor" defects rotated far more than the other three groups, which were only slightly differentiated from each other.

On consideration of further analyses of the data, it was concluded that it was reasonable to look upon visual field defects and "oculo-motor" defects as sufficient causes of rotation and that it was unnecessary, as Shapiro had previously done, to postulate a generalized increase in the strength of inhibitory processes in brain-damaged subjects. The general implications of these findings are discussed.

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BIBLIOGRAPHY

1. CAMPBELL, D. (1957). "A study of some sensory motor functions." Unpublished Ph.D. Thesis. University of London.
2. SHAPIRO, M. B. (1951). "Experimental studies of a perceptual anomaly. I. Initial experiments", *J. Ment. Sci.*, **97**, 406.
3. *Idem* (1952). "Experimental studies of a perceptual anomaly. II. Confirmatory and explanatory experiments", *J. Ment. Sci.*, **98**, 605-617.
4. *Idem* (1953). "Experimental studies of a perceptual anomaly. III. The testing of an explanatory theory", *J. Ment. Sci.*, **99**, 394-409.
5. *Idem* (1956). "An experimental investigation of an anomaly in the performance of the Block Design Test". Unpublished Ph.D. Thesis. University of London.
6. *Idem* and TIZARD, B. (1958). "Experimental studies of a perceptual anomaly. VI. The application of the "peephole" analogy to the perception of organic psychiatric patients", *J. Ment. Sci.*, **104**, 792-800.
7. *Idem*, KESSELL, R., and MAXWELL, A. E. (1960). "Speed and quality of psychomotor performance in psychiatric patients", *J. Clin. Psychol.* **16**, 266-271.
8. TEUBER, H. L. (1959). "Some alterations in behaviour after cerebral lesions in man. Evolution of nervous control", *Amer. Ass. Adv. Sc.*, 157-194.
9. *Idem* and BENDER, M. (1949). "Alterations in pattern vision following trauma in the occipital lobes in man", *J. Gen. Psychol.*, **40**, 36-57.
10. *Idem* and MISHKIN, M. (1954). "Judgment of visual and postural vertical after brain injury", *J. of Psych.*, **38**, 161-175.
11. *Idem* and WEINSTEIN, S. (1956). "Ability to discover hidden figures after cerebral lesions", *A.M.A. Arch. Neurol. Psychiat.*, **76**, 369-377.
12. WILLIAMS, N. L., LUBIN, A., GIESKING, C., and RUBENSTEIN, I. (1956). "An experimental study of block design rotation in brain injured and controls", *J. Consult. Psychol.*, **20**, 275-280.
13. YATES, A. J. (1954). "Experimental studies of a perceptual anomaly. IV. The effect of monocular vision on rotation", *J. Ment. Sci.*, **100**, 975-979.
14. *Idem* (1954). "An experimental study of the block design rotation test with special reference to brain damage." Unpublished Ph.D. Thesis. University of London.
15. *Idem* (1956). "The rotation of drawings by brain damaged patients", *J. Abn. and Soc. Psychol*, **53**, 175-181.
16. *Idem* (1956). "Experimental studies of a perceptual anomaly. V. Some factors influencing the appearance of the block design rotation effect in normal subjects", *J. Ment. Sci.*, **102**, 761-771.

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