

The Clinical Usefulness of the Archimedes Spiral in the Diagnosis of Organic Brain Damage^{1, 2}

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In reporting their promising results using the spiral aftereffect to differentiate groups of patients with cortical involvement from non-organic control groups, Price and Deabler concluded that "... the results are such as to justify present clinical use of this technique in diagnosis of organicity" (4, p. 302). They found almost no overlap in the performance of their groups: fewer than 8% of normals or functional psychiatric patients were misclassified as organic and only 2% of their organic group was incorrectly classified. While they reported no data on such variables as age, which might have contributed to their results, the description of the syndromes included in the organic group suggest that this group was considerably older than the normals or psychiatric patients. However, later studies by Gallese (2) and Page *et al.* (3) showed no significant age-score relationship, and offered some additional evidence for Price and Deabler's original assumption. Gallese, however, noted that the spiral test was relatively insensitive with certain types of organic patients, notably those with convulsive disorders or brain syndromes associated with alcoholism. The performance of twelve lobotomized schizophrenics also was

indistinguishable from that of nonlobotomized schizophrenics and normals. Page *et al.* supported Price and Deabler's theoretical assumptions but their study provided "... less evidence that the aftereffect may serve as an effective diagnostic device" (4, p. 91). These investigators also noted unimpaired performance on the part of some lobotomized schizophrenics. They did not report separate data for patients with convulsive disorders. A study by Standlee (5) of psychiatric patients tested before and after electric shock treatment (which generally produces some temporary organic dysfunction) was inconclusive because the effect of prior experience with the spiral was not controlled.

During the course of their clinical practice at the Veterans Administration Hospital, Ann Arbor, Michigan, the present writers utilized the Archimedes spiral as a part of their test battery in examining patients referred for psychological evaluation. The present paper reports on findings over a period of one year.

Method

Apparatus. The instrument used in this study was a 78 rpm phonograph turntable, vertically mounted on an 8 × 14 inch black box which housed the motor. One clockwise and one counterclockwise Archimedes (or Plateau) spirals, each 2½ circuits (920 degrees) about the center, were painted in black on 10-inch white cardboard discs, which could be affixed to the turntable. This instrument differed slightly from that of

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Table 1
Diagnostic Classification of Subjects

Subject group	Diagnosis	N
Normal	No pathology	30
Psychiatric	Schizophrenia	4
	Psychoneurosis	8
	Psychophysilogic reaction	5
Post-EST	Schizophrenia	10
	Psychoneurosis	1
Organic	Cerebral thrombosis	7
	Arteriosclerosis	5
	Convulsive disorder	5
	Cerebral neoplasm	3
	Encephalomyelitis	2
	CNS lues	1
	Paralysis agitans	1

previous investigators both in speed of rotation and diameter of the spiral. Others (1, 2, 3, 4) have reported using spirals varying from 3½ inches to 8 inches in diameter and at speeds varying from 78 to 100 rpm.

Procedure. The following procedure was standard for all subjects (Ss): S was seated approximately 8 feet from the instrument in an office with good illumination. The spirals were presented in ABBA order, with the interval between successive trials varying with the duration of reported after-image. Each trial was for 30-seconds' duration. Instructions given to Ss were essentially the same as those used by Price and Deabler: "This is a special eye test. Look at the center (pointing) and don't take your eyes away until I tell you to." Approximately ten seconds after rotation was begun, S was asked, "What does the line appear to be doing?" After the spiral had been braked to a stop, the last instruction was repeated and S's response was recorded.

Subjects. The population from which Ss were selected included both staff and patients from the psychiatric and neurological wards of the Ann Arbor VA Hospital (Table 1). Patients classified as organics were those with mild to grossly limiting cortical dysfunction, confirmed by independent neurological diagnosis. Patients with questionable or mar-

ginal organic dysfunction were not included in the present analysis, except for a group of eleven psychiatric patients who were seen one to seven days following a course of four or more electro-shock treatments (EST). These were presumed to show a possible temporary organic deficit due to the effects of EST. The remaining psychiatric patients were untreated by EST and were seen during the acute fulminating stage of their illness, shortly after admission to the hospital. The normal control group included ward physicians, psychiatrists, psychologists, nurses, secretaries, and students employed at the hospital.

Scoring. Responses from all Ss were recorded verbatim and scored according to the criteria of Price and Deabler and also those proposed by Gallese. The latter method, which gave equal credit for a description of the aftereffect either as a change in apparent size or direction of movement, was judged the most applicable for the present analysis, since a large proportion of responses was phrased as some combination of these terms. Working independently from a sample of 38 verbatim protocols, the authors agreed perfectly in this manner of scoring for 35 Ss. Since four partial scores contributed to the total score for each S, this represented a total of 152 sets of independent judgments for which the scorers agreed 146 times (96%).

Results

Table 2 summarizes the findings for all groups. The normal Ss were superior to all others, attaining, without exception, perfect scores. Because of the absence of within-

Table 2
Spiral Aftereffect Scores

Subject group	Mean age	Mean score	Mean score adjusted for age
Normal	29.3	4.00	—
Psychiatric	35.7	2.94	2.72
Post-EST	38.5	2.55	2.45
Organic	45.0	2.17	2.37

Table 3

Distribution of Aftereffect Scores
(after Price and Deabler)

Subject group	Score				
	0	1	2	3	4
Normal	0%	0%	0%	0%	100%
Psychiatric	11%	6%	18%	6%	59%
Post-EST	18%	0%	27%	18%	37%
Organic	33%	4%	13%	13%	37%

group variability for the normal Ss, usual parametric tests of significance were inappropriate. Accordingly, a chi-square value was obtained for the difference between normals and the combined patient groups. When this was found to be significantly large ($\chi^2 = 23.50$, $p < .001$), the normals were excluded from subsequent statistical tests. An analysis of covariance for spiral scores of the remaining groups, adjusted for age, was not statistically significant ($F < 1$). Examination of the adjusted mean scores, presented in Table 2, shows that the organics nevertheless maintained the low order position among the groups.

The Pearson product-moment correlation between age and spiral score was $-.39$. For 32 patients for whom IQ measures were available, the correlation between intelligence and spiral score was small and not significant ($r = .11$).

Because these findings seemed so incompatible with the results of previous studies, the data were arranged according to the procedures followed by earlier investigators and new comparisons made. Table 3 shows the distribution of scores following Price and Deabler's original presentation. The patients were then split into those whose scores were 2 or under and those whose scores exceeded 2, after Gallese. Table 4 summarizes this analysis and shows the percentage of patients who were correctly classified as "organic" or "normal" by this method. Table 4 also shows the results of this breakdown for patients classed as *convulsive disorder* or "other types" of organic dysfunction. The present figures contrast sharply with those reported by Price and Deabler and Gallese.

Discussion

These findings cast considerable doubt as to the utility of the spiral aftereffect for differential diagnosis of organicity. Although Price and Deabler's results appeared so promising, later work (2, 3) made their findings look more conditional. The present findings add an even more compelling note of caution to the use of the instrument as a method of diagnosis. This seems especially important since all the published studies used clear-cut cases of cortical dysfunction, while in clinical practice, neurological involvement is often marginal or partial and thus the diagnostic problem might be expected to be even more difficult.

The organics used in the present study were all drawn from a group of recent admissions to a general medical and surgical hospital, and one might hypothesize that such patients tend more likely to show acute rather than chronic deteriorative effects of cortical destruction. Patients exhibiting chronic symptoms are more typically found in the VA neuropsychiatric hospitals and state institutions where the earlier studies were conducted. This might be one reason why the present data differs from previous findings. For the same reason, however, the present psychiatric groups did not include chronic, deteriorated schizophrenics, and it is difficult to understand how so large a proportion of these relatively intact patients failed to attain perfect scores. Our instructions and scoring procedures were identical to those of earlier investigations although some differences may have arisen from the manner in which

Table 4

Classification of Subjects According to
Gallese Criteria

Subject group	Organic score (2 or under)	Normal score (3 or over)	Correctly classified
Normal	0	30	100%
Psychiatric	6	11	65%
Post-EST	5	6	—
Organic	12	12	50%
Convulsive disorder	2	3	40%
Other types	10	9	53%

inquiries were conducted. Gallese noted that many schizophrenics would have been scored "organic" had not a detailed, direct inquiry been performed, and Page *et al.* reported a need for an objective nonverbal response measure for use with the spiral. Perhaps a multiple choice response situation such as that offered by Freeman and Josey (1) would insure more uniform results.

Many patients, both organic and psychiatric, suffered from disturbances in their ability to communicate effectively. Thus, although the spiral as originally presented appeared to be a neat, objective evaluative technique, in actual practice a large degree of clinical acumen may be necessary to determine an S's exact perception. The less contact the patient has with reality (whether functional or organic in origin) the less is the likelihood that correct inferences regarding his perception can be made. Caution must be observed in interpreting the remarks of negativistic patients, as well as overly defensive persons who wish to deny any experience which they perceive as a malfunction. Some patients expressed fear that reporting the aftereffect was tantamount to admitting a delusion, and one was concerned lest he be hypnotized unknowingly. Other patients, despite repeated instructions, responded to the spiral as a kind of projective technique, reporting such phenomena as "it looks like a coiled snake, ready to strike," and "it is a ram's horn, all curled up." The present authors do not imply that these cautions are in any way unique to the spiral technique but, rather, that this test shares with many other diagnostic instruments the difficulties encountered in evaluating verbal report.

It would appear also that variables such as the rate of rotation and size of the spiral, level of illumination, and other test conditions might well have some influence on results. For example, it was noted in preliminary work that the perception of movement toward or away from S was in part a function of the distance between the exact center of the turntable and the placement of the spiral upon it. When the spiral was positioned so that it turned about its *exact* center, then much less perception of changing distance occurred. Whether such variables

have a differential effect on different populations is unknown.

The one variable in this study which did seem related to ability to perceive the effect was *age*. Moreover, Freeman and Josey found marked differences in ability to see the aftereffect in a population of psychotic patients, and although they related this deficiency to memory impairment, their data would indicate that age may have been a factor. In both the Price and Deabler and Gallese studies, the organic groups appeared substantially older than their nonorganic controls.

There is a discrepancy between the present results and those of Standlee in regard to post-EST patients. Standlee reported that 23 out of 25 patients perceived the aftereffect on a retest 8 hours after one EST. In the present post-EST groups, scores ranged from 0 to 4 and were little correlated with clinical impression of "organicity." As has been suggested elsewhere (4), practice effects may have contaminated Standlee's results; moreover, the discrepancy between the two studies was probably even more heightened by the fact that all Standlee's Ss had considerably fewer shock treatments than the present ones. On the other hand, in the present study there was no apparent correlation between aftereffect score and number of EST or length of time since the last treatment.

One of the paramount problems in all studies utilizing the spiral has been the difficulty in establishing a satisfactory set of criteria of organic brain damage. In most studies, an implicit assumption is made that localization, chronicity, and degree of neurological destruction are irrelevant variables, as well as such factors as the optical efficiency of the S and the pharmacological effect of the drugs he has been administered. The fact that such a viewpoint is basically unsound has already been suggested (6). To date most studies, including the present one, confound these crucial variables and thus they cannot be effectively compared.

Summary

This study is an evaluation of the Archimedes spiral as a clinical technique for the diagnosis of organic brain damage. Over a pe-

riod of a year's work with the instrument the authors noted that normal Ss report perceiving the aftereffect of both expanding and contracting spirals without a single instance of failure. Psychiatric, post-EST, and organic patients—in respective order—performed with decreasing efficiency on the same task. When the scores for the groups were adjusted for age, however, the differences between the latter three groups became statistically indistinguishable. The correlation between age and spiral score was $-.39$.

In spite of early enthusiasm for the spiral, the present results warn against its indiscriminate use for differential diagnosis.

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