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Psychological Deficit: an Approach Through Problem Solving Processes

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PSYCHOLOGICAL DEFICIT: AN APPROACH THROUGH PROBLEM SOLVING PROCESSES

by

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LIFE

Michael Anthony Partipilo was born in Bari, Italy, February 3, 1936.

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CHAPTER I

STATEMENT OF THE PROBLEM

In the last quarter of a century many attempts have been made to adopt psychological tests for the evaluation of brain injury. A survey of the significant reviews which cover this span indicate an emphasis on performance or "mental products" (Armitage, 1946; Klebanoff et al., 1945, 1954; Yates, 1954). This emphasis has not yielded testing devices that have increased diagnostic proficiency, especially in neuropathology. Results continue to be conflicting, equivocal and unsatisfactory (Meyer, 1961; Reitan, 1962; Haynes & Sells, 1963).

The difficulty appears to be that behavioral variables which have been related to neuropathology can also be related to other states such as neurosis and psychosis. It has been held, for example, that rotational error, perseveration, distortion in the relative size of figures and in their spatial relations, fragmentation of figures and reduplicated reproductions all point to disturbances of cerebral pathology. Certain motor-executive aspects of performance, e.g., tremulousness, sketchiness, difficulty in drawing acute angles and inability to reproduce overlapping figures have also been considered as distinctive of organic characteristics. Inabilities to synthesize, to shift and learn, to plan ahead, to anticipate, to persevere and recall have all been attributed to organic involvements. But, these behavioral characteristics can also be a function

of lack of adequate effort on the part of hostile, asocial or paranoid patients; inability of severely depressed patients to complete reproductions, particularly of the more complex designs; autistic preoccupations on the part of schizophrenic patients leading to irrelevant reproductions; defective graphomotor skill and poor task adjustment because of lack of education and relevant social experiences (Busse et al., 1956; Hill & Watterson, 1942; Williams, 1941).

In one recent study where Piotrowski's signs for organicity were considered, it was found that the differential diagnosis varied from state to state. A patient would receive a functional diagnosis in North Carolina and an organic diagnosis in New Jersey; if he was north of the 37 degree latitude it would tend to be organic, if he were south of it, it would be functional (Eckhardt, 1961). Other studies (Frank, Corrie & Fogel, 1955; Wittenborn, 1952) support Eckhardt's views.

Investigators (Goldstein & Scheerer, 1941; Rapaport, 1951; Bloom & Broder, 1950; Rimoldi, 1956, 1960, 1961; Mayman & Gardner, 1960) have criticized "output testing" strategy and demonstrated that the same "mental product" may be the outcome of different mental processes. Goldstein & Scheerer (1941) state in their classic monograph that:

> ....The usual scoring method based on a scale of difficulty which has been standardized on a statistical basis offers no adequate instrument for determining the nature or degree of impairment in a patient, unless one takes into account the entire procedure, the specific reasons for the difficulty the patient encounters, one cannot simply read off from a score which task represents a greater difficulty and which a lesser (p. 19). ....Therefore in testing pathological cases; a mere plus or minus does not betray the capacity

> under consideration as long as one fails to determine the way in which the result has been attained (p. 20).

These views are further strengthened by Schafer (1958) who indicates:

> ....That the responses to various test items of the battery we use are, almost entirely, verbalized end-products of thought processes initiated by these items. A test response is not a score; scores, where applicable, are abstractions designed to facilitate intra-individual and inter-individual comparisons ....However, to reason-or do research- only in terms of scores and score-patterns is to do violence to the nature of the raw material (p. 17).

These considerations indicate the preoccupations with "thought products" or responses may conceal modes of solution (underlying thought processes) which might be related to cerebral impairment. For, as the previous discussion has suggested, it is possible for pathological processes to yield correct solutions. With this as a point of departure another method of analysis could be adopted for the detection of neuropathology which proceeds to investigate thinking processes as well as responses.

Rimoldi (1955, 1956, 1960, 1961, 1962, 1963) has developed a technique for the study of thinking processes. It is based on the assumption that an important aspect of mental processes can be experimentally characterized by the sequence of questions a subject asks when solving a problem. It is a method which proceeds by evaluating the questions asked by a subject as he proceeds to solve a problem, the order of his selections and finally the solution itself. In summary, the main objectives of this research will be to relate the Rimoldi Technique to the study of brain

damage. Problem solving processes will be interpreted for both brain damage and non-brain damage medical patients at the individual and group levels.

CHAPTER II

REVIEW OF THE LITERATURE

A cursory purusal of the literature classified under the heading "Psychological Deficit" makes one immediately aware that the range of content subsumed under the term includes nearly every area of Psychology (Eysenck, 1961 and Reitan, 1962). This is particularly true for the domains of Cognition (Payne, 1961 and Meyer, 1961) and Abnormal Psychology (Rapaport, 1951). For this reason, it is important that the critera employed in selecting the studies for this review be clearly stated. First, a special effort will be made to consider work in journals which are specifically relevant to this investigation. Second, objective-experimental psychological test-findings on human material will be mainly considered with special emphasis on cognitive deficit as measured by General Intelligence Tests. Third, studies employing tests appraising specific disabilities (memory, abstraction, retention, etc.) will also be reviewed. Despite these criteria for inclusion, the following reports are presented to provide a representational picture of this area of research.

The references will be arranged and organized according to the following plan: 1) the effects of brain injury on General Intelligence Tests, 2) the effects of brain damage on certain specific abilities,

especially on those tests designed to assess these changes, 3) the detection of brain injury by various deterioration indices, 4) a critical evaluation of the experimental designs and methodology, and 5) an overview of the related experimental literature dealing with thinking processes in problem solving.

The Effects of Brain Injury on General Intelligence Tests

Rylander (1947) was one of the first to address himself to the question whether general intelligence is decreased after psychosurgical operations. He concluded that there is a consistent drop in intelligence as measured by the Terman and Merrill revision of the Binet Scales. Malmo (1948) reported significant drops in Wechsler-Bellevue and Stanford-Binet vocabulary scores for eight patients, subjected to leucotomies and seven undergoing gyrectomies. Koskoff et al., (1948) reported the testing of some of ten patients subjected to a psychosurgical procedure for the alleviation of pain and found a significant decline on Wechsler-Bellevue scores. Tow (1955) found a significant drop in scores on Raven's Matrices and the Vocabulary test from Terman's 1961 battery. Yacorzynski et al., (1948) administered a large battery of tests to a single patient and reported a drop of eighteen points on the Wechsler-Bellevue Scale.

Weinstein and Teuber (1957) using the AGCT compared Scores obtained from patients with penetrating brain injuries, approximately ten years after they had been wounded, with corresponding scores achieved before the injury. The results indicate that for patients with focal gunshot wounds there was a striking initial decrease in intelligence with little

evidence of deficit ten years after injury.

Williams, Lubin and Gieseking's (1959) brain injury group consisted of 64 male patients. These investigators defined brain injury as intrinsic damage above the tentorium cerebelli. Employing the Army Classification Battery (ACB) which includes reading and vocabulary, arithmetical reasoning, pattern analysis, mechanical aptitude, and clerical speed, data was reported that traumatic brain injury results in a general deficit with little differential deficit. Reading and vocabulary, arithmetical reasoning, and clerical speed decline slightly more than the spatial tests, pattern analysis and mechanical aptitude.

Ross (1955) administered the CVS Individual Intelligence Scale to each of his 20 subjects who had undergone brain surgery. The CVS consists of the Comprehension and Similarities items of the Wechsler-Bellevue and a Vocabulary scale based on the Stanford-Binet. The post-injury scores were reported as being significantly lower than the pre-injury scores ($P. < .01$). He cautions, however, that these results, though statistically significant, provide only presumptive indication that intelligence test performance deteriorates as the result of certain forms of brain injury.

These positive findings, however, are in a miniority and the more usual report is of no decrement in general intelligence as measured by orthodox means. None of the large-scale studies of the Columbia Greystone of New York Associates or those from the Boston Psychopathic Hospital contain mention of permanent deficits indicated by alterations in either Wechsler-Bellevue or Stanford-Binet scores. Likewise, the investigations of Robinson (1946), Frank (1946), Carscallen et al., (1951, Crown (1952),

Markwell et al., (1953), Struckett (1953), Medina et al., (1954), Hirose (1954), Wideman (in Miller, 1954) and Newman (1955) were more or less negative in respect to this class of change.

A number of writers have tried to analyze putative deficits by subtests. In general, these efforts have produced no consistent findings, but a direct attack on the problem has been made by McCullough (1959). He administered Form I of the Wechsler-Bellevue Scales to twenty-one patients undergoing psychosurgery, testing on three separate occasions. McCullough reported that the most prominent changes were seen in Digit Span, Picture Arrangement and Block Design subtests while no change occurred in Vocabulary, Information and Similarities. Medina et al., (1954) in the study mentioned above have reported a specific deficit on the Picture Arrangement subtest. Although Wideman (In Miller, 1954) also quoted above, was unable to demonstrate any deficit following operation, he reported, on analyzing his subtest scores, that clinical improvement seems to be associated with a higher Performance than Verbal Score, a small degree of Performance "scatter," and relatively high scores on Picture Arrangement, Picture Completion and Similarities.

Various attempts to cross-validate Wechsler's subtest patterning for organicity have also been unsuccessful (Everett,1956; Fisher, 1958; Ladd, 1959; Love, 1955; and Reitan, 1959). The main reason why brain-damaged cases are frequently unimpaired on such I.Q. tests as the Wechsler is that though the test is composed of subtests involving a wide variety of specific abilities, the test was designed for the measurement

of general intelligence and, in accordance with this aim, the subtests were selected as valid measures of this ability and, as such, intercorrelate highly.

Effects of Brain Damage on Certain Specific Abilities

The psychologists' diagnostic approach has long employed the supposition that the organic patient is incapable of forming abstractions. King (in Mettler, 1949) made an important contribution towards testing this notion in the field of psychosurgery when he administered seven different tests, purporting to measure abstract reasoning ability, to seventeen operated cases and thirteen controls. He carried out a factor analysis of the subjects' scores on these tests and on tests of general intelligence. His conclusion was that the tests of "abstract reasoning" were highly saturated with a factor of general intelligence and that no significant differences between the operated cases and the controls, could be demonstrated. Vidor (1951) also reported a high correlation between performance on sorting tests and tests of general intelligence. Sheer and Shuttleworth (in Mettler, 1952) reported a temporary deficit on the Weigl Sorting Test and on a revised Homograph test for his group of Ss of the second Columbia Greystone project, while Sheer (in Lewis et al., (1956) confirmed the finding of a deficit but once more stressed its temporary nature.

Neither of the two reports from the Boston Psychopathic Hospital made any material contribution towards this problem. Atwell in the first report (Greenblatt et al., 1950) administered Goldstein's Block Design

and Color Sorting tests, the Weigl Color-Form Sorting Test and the Shipley Test of Abstraction. He decided that none of the tests were suitable for proper quantification and was content to make a qualitative judgment about the post-operative changes. Upon the basis of these judgments he reported a slight decrement in performance on these tests. In the second report (Greenblatt and Solomon, 1953), Levinson et al., administered a number of tests of Abstract-Reasoning and of "Coherence of Association" and reported on "improvement" in their subjects, particularly in the "emotional forms of the abstraction tests" (proverbs and similarities). Supporting this claim they point out that the most clinically improved patients seen by them showed the most improvement on the test of abstraction. Insofar as the interpretation of these results can be accepted, they are somewhat contrary to others in the field.

Certain other investigations have utilized various tests of Abstraction. Kisker (1944) was able to demonstrate no consistent impairment on a modified version of Koh's Blocks, the Weigl and Scheerer Sorting Test and the Goldstein Color-Form Test. Likewise Robinson (1946) reported no decrement after operation on the Shipley-Hartford Retreat Scales. Neither Berg and Grant (1948), using a Weigl type sorting test and the Weigl Color-Form Test, nor Vidor (1951, using various tests of abstract thinking, was able to demonstrate any decrement after psychosurgery. Tow (1955) administered a sorting test to his subjects and, contrary to the aforementioned reports, noted a large decrement after operation, significant at the one per cent level of confidence. Tow described the

behavior of his Ss on this test as follows:

> ....After operation the subject is more foolish, naive and clumsy in his approach. He does not easily grasp the nature of the problem. If there is any plan or reason at all in his method, it is more rigid and stereotyped. The subject looks blank at the examiner's questions and he is more quickly moved to despair and abandonment of further trial. His whole performance is less directed and less purposeful. It is obvious that his ability to sort is greatly reduced. (P. 162).

Considering, then, tests of general intelligence and abstraction together, it would appear that some deficits may be expected after the more radical operations. The evidence is not clear, however, where pre-operative performance has been clouded by the gross defects of psychoses. The data does seem to suggest there are no gross deficits following such operations.

The evidence also most strongly suggests that the tests of abstraction are very closely related to tests of general intelligence and it is evident that where deficits are found in the latter, some impairment may be expected to be evident in the scores of the former.

Many investigators have administered tests of memory and retention. Stauffer in the first report of the Columbia Greystone project (Mettler, 1949) compared the performance of nineteen operated cases with thirteen controls on learning and retention of three forms of verbal material; (a) semi-meaningful paired associates, (b) meaningful paired associates and (c) verbal directions. She reported no significant impairment. In the second report of these associates (Mettler, 1952), North et al., examined memory, learning, mental set and perceptual tasks, largely by means of verbal tests. They reported no impairment of memory or learning.

It is interesting to note that these workers attempted to duplicate the delayed-response type of tasks used in comparative work but found that no deficits were evident with their human subjects. This discrepancy is not surprising, of course, when one considers the relatively greater damage done to the primates' cortices. These workers finally suggested that "forced" tempo learning was less affected than "free."

Kral and Durost (1953) have analyzed the amnestic syndrome in a variety of different categories of brain-damaged patients, including leucotomized patients. Their findings, contrary to those listed above, are that impairment of recent memory and recall are common to all. Their conclusions have rarely been paralleled. Hirose (1954) reported no drop in memory functions in a group of ten psychopaths and five neurotic patients subjected to leucotomies-nor previous to this study did Malmo (1948) nor did Markwell, et al., (1953) nor Medina, et al., (1954) using the Wechsler Memory Scales and the Benton Test of Visual Retention. Contrarily again, however, Newman (1955) has reported a significant drop on Wechsler Memory Scales for his group.

Halstead (1947), using factorial analysis and various systems of weighting, developed a battery of tests which discriminated at a high level of confidence between normals and patients with lesions of the frontal lobes. The ten tests having the highest "t" value were selected as the basis of an impairment index. In this arrangement, an individual whose scores fell below the criterion scores on all ten of the key tests had an impairment index of 0.0; while, on a simple proportion basis, an individual who satisfied the criterion score on three of ten key tests

had an impairment index of 0.3; or on all of the key tests, an index of 1.0. Using a cutting score of three, he was able to identify all 27 cases of frontal lobe injury and 29 out of 30 normals. The impairment index did not discriminate between normals and other cases of brain damage.

Of the ten tests, the Halstead Category Test, involving the ability of the subject to "abstract" various organizing principles such as "size," "shape," "color," etc. from a series of 336 stimulus figures presented visually and serially by means of a multiple-choice projection apparatus, proved particularly successful. Using a cutting score of .70, he correctly identified 27 out of 29 normals and 10 out of 11 cases of frontal lobe injuries.

When, therefore, the patient is known on other grounds to be neither psychotic nor neurotic, this battery of tests offers a very accurate indication of whether or not the lesion is situated in the frontal lobes. The impairment index was validated on a group different from the standardization group and was repeated on an independent group. The only obvious objection to the index is the inadequate representation of groups other than normals or brain damage.

In later studies Reitan (1955) reports highly significant intergroup differences between unequivocal brain damage and appropriated controls. The results also indicate that the Halstead Impairment Index is relatively uninfluenced by age when brain damage is clearly present. Age may be a pertinent variable in the group without neurologic evidence of brain damage, particularly in the range of 45-65. In a further study, Reitan (1955) reports a high degree of sensitivity of the Halstead Impairment

Index in neurological patients against matched controls. Shure and Halstead (1958) report on a further validation study of the Impairment Index in neurosurgical patients. This work again indicates that the Impairment Index is sensitive at least at the .001 level of confidence in detecting the presence of brain damage in verified cases.

Detection of Brain Injury by Various Deterioration Indices

Most of the investigations regarding the diagnostic usefulness of General Intelligence Tests have employed the Wechsler test as a point of departure. Thus Gutman (1950), using 30 organics and 30 controls, found that the Wechsler DI correctly identified only 43 per cent of organics, the Reynell index (1944), which makes use only of the verbal subtests, 50 per cent, and the Hewson ratios (1949) 60 per cent; whereas the DI misclassified 33 per cent of the normal group, the Reynell index 30 per cent, and the Hewson ratios 17 per cent. The three measures agreed in the diagnosis of brain damage in only 33 per cent of the cases. Five cases of clinically verified brain damage did not fall in the organic range of any of the tests. Allen (1949), using as his criterion of deficit a loss greater than 20 per cent, found that the Wechsler DI definitely screened out only 54 per cent of the total study group of 50 patients. Rogers (1950) evaluated the DI for seven groups (349 Ss) and found that, using a cutting score of 10 per cent, 75 per cent of subjects will be correctly identified, provided that only the brain-damaged and normal groups are used but that, when other clinical groups are included, the results are no better than chance. Andersen (1950), using 55 male soldiers with definite clinical

evidence of brain damage, showed that, when a cutting score of 10 per cent was used, nearly one-third of the total sample fell outside the organic range; yet when a cutting score of 20 per cent was used, nearly two-thirds of the patients fell inside the normal range. He divided his group of patients into those suffering predominantly from injury to the dominant hemisphere and those suffering from injury to the non-dominant hemisphere. This did not materially improve the results. Kass (1949) gave the test to 18 cases with known organic changes and 12 cases of dubious organic diagnosis, and concluded that the DI failed both in detecting and confirming the presence of organic conditions resulting largely from traumatic brain injury. As a percentage-loss method for expressing psychological deficit, it was found inapplicable in two thirds of his cases. Diers and Brown (1950), using 25 cases of multiple sclerosis, concluded that the DI was not sensitive enough to be used clinically. Garfield and Fey (1948) found that an equal number of psychotic and nonpsychotic patients obtained pathologically high DI's, suggesting that the overlap between organics and functionals would be quite high. Margaret and Simpson (1948) found that the DI rating did not correlate with the psychiatrist's ratings of degree of deterioration. On the other hand, reasonably favorable results with the DI were reported by McFie and Piercy (1952). Using 56 brain-damaged patients and a cutting score of 10 per cent, they were able to identify 43 (71 per cent) of them; using a cutting score of 20 per cent, they identified 37 (66 per cent). No functional patients were tested.

Later studies regarding the general diagnostic usefulness of the WB have appeared to reinforce the notion of a cautious, approach to the

clinical application of relationships between test results and psychiatric condition. Frank (1956) correlated and factor analyzed the subtest scores of 60 subjects from nine diagnostic groups which, in a previous analysis, appeared homogeneous in subtest scores. Only two unrotated factors were isolated: VIQ and PIQ. The general conclusions were that the WB does not yield significant data as regards psychiatric diagnosis, and continues to sort subjects in terms of intellectual factors only. Cohen (1955) submitted WB profiles of 300 male veteran patients diagnosed as psychoneurotic, schizophrenic, or brain damaged to seven experienced clinical psychologists and had them attempt to classify each case. Only one of the seven psychologists correctly classified a significant number (132) of the 300 patients and only two others had above-chance success in the diagnosis of a single diagnostic group which in both cases was the brain damaged group. The judged classification correlated with the neuropsychiatric diagnosis between .13 and .22, which was deemed far too small to be of use clinically. It was concluded that there is some nonchance relationship between the WB pattern and the clinical diagnosis but that this relationship is detected by only a few clinicians and even then to only a degree having little practical value.

Everett (1956) found no significant relationship between the presence of organicity and the Hewson ratio, while McKeever and Gerstein (1958) found that the Hewson ratio classified 75 per cent of a group of schizophrenics as organics. Bryan and Brown (1957) found that the Hewson ratio identified 27 per cent of a nonorganic group as organic, and 38 per cent of a group of adolescents suspected of having CNS involvement

on the basis of clinical data were identified as organic, but that 67 per cent of patients with known organic involvement of a "mild" degree and 96 per cent of patients with a "moderate" to "marked" degree of organic impairment were correctly identified as organic.

Critique

It is doubtful whether any aspect of psychological testing has been more inadequately treated than the diagnostic assessment of brain damage. From a wide range of possible criticisms only some of the most obvious will be cited.

One of the most serious weaknesses in psychological investigations is the lack or misuse of control data. The pre-morbid level of psychological abilities is very rarely known. Therefore, in order to detect the defective performance of brain damaged subjects one requires data from normal controls. Hebb's (1945) article shows that it is particularly dangerous to use unstandardized tests and to assume a "norm" for the normal population. Using simple patterns that had to be reproduced with pieces of wood, Hebb found that "no pattern could be devised, which was so easy that all patients in the public wards of a general hospital could succeed with it in one minute, even though other tests showed that one was not dealing with a population of mental defectives" (p. 16). Hebb concludes that although this kind of material tends to be eliminated in tests which are adequately standardized, "in special tests which have not been standardized, there is a real danger of assuming that a variation from the norm, which is frequently obtained for the normal population, can be due

only to the effects of cerebral injury" (p. 17).

As implied in these statements, controls must be equated on any variable which might affect the test scores under investigations. The importance of the age factor is obvious, since various mental abilities decline with age (Wechsler, 1944; Shaie, et al., 1953; Reitan, 1955; Strother, et al., 1957; and Doppelt and Wallace, 1955). Reitan (1955) addressed himself to the problem of determining the relationship of the Halstead Impairment Index to chronological age. He reported using comparable groups that the relationship between age and test result was much higher for the group without neurologic or anamnestic evidence of brain damage. There was a sharp break in the direction of impairment by individuals 45 years of age and older. This break, as other studies indicate, may be a function of the subtests which comprise the Halstead battery. That is, the Index Score is a function of subtests composed of speed and visual perception tasks which have long been known to be measures which penalize older subjects. Consequently, as the following discussion will illustrate, a decline in mental abilities may be related to factors other than age per se. This contention finds support in the restandardization of the WAIS for older persons (Doppelt and Wallace, 1955). Working with a fairly large population (475) of subjects between 60-70 years of age, they report that there is <u>no</u> sharp drop in the scores of older people until age 70. Even after this age, decline on Verbal tests is relatively small. The mean scores of the oldest group do not fall a S.D. below the reference group (22.5 to 30 years of age) on most of the Verbal tests. The mean Performance Score for the same age group is more

than a S.D. below the corresponding mean of the reference group. Vocabulary, Information, Comprehension, and Arithmetic showed the smallest decline up to age 70. Among the Performance measures, the most marked decline was shown on the Digit Symbol test. Decline in Verbal, Performance and FS scores was marked after age 70.

Strother, et al., (1957) extended the range to include subjects between the ages of 70-84. Their results are consistent with the above (Doppelt & Wallace, 1955) and others (Bayley, 1955; Bayley and Oden, 1955 and Owens, 1953). Scores on Thurstone's Primary Mental Abilities (Intermediate Form) were obtained for a group of 50 college graduates, ranging in age from 70-84. Differential decline in these abilities occurs earliest and with greater loss in memory, in speed, and in reasoning and spatial abilities. Word fluency, verbal-meaning, and numerical abilities in this group of superior individuals remains well above the means for young adults until the middle 70's.

Differences in intelligence and education, however, can also affect performance on various tasks differentially. Weinstein and Teuber (1957) attempted to answer the question of whether pre-injury education and intellectual level bear any relation to post-injury loss. Their results did not support the hypothesis that pre-injury education and pre-injury scores on a general intelligence test are related to magnitude of loss after injury. Beech (1957) on the other hand, reported positive relationships. Performance on a perceptual task was radically changed when allowance was made for the initial differences in intelligence. Also, the more intelligent brain-damaged patients were able to compensate for their

disabilities. The effects of education and intelligence were also reported by Strong (1959). Other relevant factors such as subcultural background and socioeconomic conditions have been adequately spelled out elsewhere (Guertin, et al., 1962).

Many investigators neglect almost completely the elementary necessity for evaluating the nature of the brain damage. Most authors assume that brain damage is a unitary factor and consequently fail to choose their cases with sufficient care. That this is unsound can be shown from many sources. From an anatomical and physiological standpoint, there is no reason why all brain damaged patients should be grouped together. As Penfield and Evans (1935) and more recently Reitan (1962) point out, there is a wealth of difference between the brain damage resulting from scar formation on the temporal lobe following an accident, and the scar formation resulting from a temporal lobectomy. Meyer's (1961) review not only supports this contention but provides evidence to show that unless test deficit is carefully analyzed wrong conclusions can be drawn with regard to the nature of impairment. He cites several investigations which indicate that impairments on various tasks may be related to concomitant alterations of functions e.g., somato-sensory, aphasia, and epilepsy. Recently, investigators have reported differential effects in performance between left and right cerebral lesions (Reed & Reitan, 1963; Heimburger and Reitan, 1961). In short, if the nature of a deficit is not carefully delimited, the only valid conclusion that can be drawn is that some organic deficit produces some complex dysfunction resulting in impairment on a test. Finally, the importance of brain pathology as the only factor

in producing symptoms is no longer fully accepted. A high proportion of the "normal population" manifests certain abnormalities indicative of brain pathology (Busse, et al., 1956; Hill & Watterson, 1942; Williams, 1941). Certain pathologies have been shown to be neither the sole cause nor the sufficient condition for obtaining certain modifications of behavior (Battersby, et al., 1956; Rothschild, 1945; Crome, 1955). Consequently, adequate attention should be given to personality variables which contribute to the appearance of the symptoms.

Thinking Processes in Problem Solving

In his introduction to the translation of Karl Duncker's study on problem solving (1945), Köhler calls psychologists to task for their conspicuous neglect of the scientific investigation of thought processes. For Duncker (1945) " a problem arises when a living creature has a goal but does not know how this goal is to be reached" (p. 112). Practical and mathematical problems were given to subjects who were asked to "think aloud" in their attempts to solve them. This method differed from introspection in that the subject directed his attention to the problem rather than to himself thinking. From the results of these experiments he directed the questions, "How does the solution arise from the problem situation?" and "In what ways is the solution of a problem attained?" His conclusions were that the final solution is mediated by successive formulations of the problem. These formulations in their turn are mediated by heuristic methods.

Bloom and Broder (1950) in their study on "Problem Solving Processes of College Students," raised the question, "Do our present measures of achievement and aptitude reflect the quality of the examinees' thinking?" If there is a high correspondence between the accuracy of thought processes, then we are correct in emphasizing the more easily obtained thought products. However, they suggest that this is not the case. Both processes and products should complement one another in giving an accurate evaluation of the examinee.

In setting the design for their experiements, Bloom and Broder used the same method as Duncker - "thinking aloud." Although many of the results of these experiments as well as those of Duncker's were quite subjective, they nevertheless were an important step forward in the development and refinement of evaluative methods. They brought forth strong evidence that there is not a one-to-one relationship between thought processes and thought products. If evaluative methods are to be improved, it is necessary to develop more refined techniques for obtaining evidence of thought processes.

Heidbreder (1927) studied adults and children in the problem solving situation for the purpose of noting the general course of thought processes at different stages of development. Three problems were presented which were objectively as similar as possible. Upon each response the subject was asked the reason for this reaction. The character of the reasons offered were divided into eleven types. It was found that frequency and complexity of reasons differed for the various age groups as well as the types of reasons given. Consistent age differences

suggested that there is a developmental process from less mature to more mature levels of activity in giving reasons.

A technique somewhat similar to the Test of Diagnostic Skills (Rimoldi, 1955) was devised by Bryan (1954) for the purpose of evaluating electronic trouble shooting. This technique, called AUTOMASTS, differs in the method of administration and in the method of analysis. While taking the test the subjects are given choices of answers to the problems at different intervals. Performance is evaluated in terms of correct solutions, time of solution, number of steps, use of clues, and guesses.

Another similar technique presented by Glaser, Damrin, and Gardner (1954) is the Tab Item Technique. It was also used in electronic trouble shooting, although it can be applied to almost any type of problem. This technique consists in presenting the subject with a type of malfunction and a series of possible check procedures with the answers being covered by tabs. The subject removes the tabs from the procedures he wishes to employ. When he feels that he has collected sufficient information, he chooses one of a number of solutions that are also presented. If the selected solution is incorrect, the subject returns to the check procedures and gathers more information. Scoring methods of the Tab Item Technique have not yet been clearly defined. One method suggested is the number of checks employed. Another is to weigh the check procedures according to their relevance in isolating the defective unit.

Rimoldi's (1955) Test of Diagnostic Skills is an approach which attempts to get at this perplexing problem. Briefly, it is a technique which was originally developed to study the thinking processes in problem

solving, especially those relating to medical diagnosis (Rimoldi, 1955). The basic rationale that mental processes can be described by the sequence of questions a subject asks when solving a problem, however, is also applicable to other problem situations or to situations for which a "correct" solution does not exist (Rimoldi, 1960). In recent years, the technique has been applied to the appraisal of personality parameters (Gunn, 1961) and the study of the clinical methods employed by psychologists in analyzing Rorschach Data (Tabor, 1959)[1]. The technique will be considered in greater detail in the following sections.

General Summary

The studies reviewed in this section strongly point out that the assessment of organic involvement by traditional testing procedures is still a pressing problem which at best has yielded equivocal results. The diagnostic approaches covered in this survey have proceeded on the assumption that output measures are adequate in assessing the presence of organicity. This preoccupation with "signs," "patterns," and verbalized end-products, however, has not led to a satisfactory classification of people into various groups. These considerations

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[1]For a more detailed discussion of the technique and its application, the reader is referred to (Rimoldi, 1955, 1960, 1961a, 1961b; Rimoldi, Devane & Haley, 1961; Rimoldi & Haley, 1963; Rimoldi, et al., 1962; Rimoldi & Grib, 1960).

suggest that perhaps a change of emphasis, the study of thinking processes, which is not directly concerned with "correct" solutions may lead to a more precise determination of cerebral impairment and a more adequate differentiation of people into categories. This study addresses itself to this problem.

CHAPTER III

METHOD

Subjects

The brain-damaged (BD) patients were carefully selected from the neurological wards of fourteen cooperating hospitals. Cases were carefully selected with the assistance of the attending neurologists in order to eliminate patients with doubtful diagnosis of brain damage. Differential diagnosis was based upon complete neurological examination including adequate neurodiagraphic procedures (EEG, X-Ray, Angiogram and Pneumoencephalography). Senile patients, general paretics, patients with multiple sclerosis, chronic brain syndrome due to alcoholism, epilepsy without clear evidence of brain damage, and patients with a premorbid history of psychiatric disturbance were excluded. This was done to eliminate the obvious cases of psychiatric disorder. The nature of the experimental problems, moreover, (which are in the visual modality and which require the manipulation of 3 X 5 cards), and the need not to handicap patients unduly made it necessary to exclude those subjects with evidence of visual agnosia, and alexia, and who exhibited an inability to perform at least unilaterally.

The studies cited in the preceding review have conspicuously neglected considering the effects of <u>edema</u> and <u>time</u> (Penfield & Roberts, 1959; Wepman, 1962). Though the term edema is medically discussed in texts in clinical neurology (Baker, 1962; Alper, 1958; & Brain, 1961), the authors rarely proceed to delineate the effects of edema and time on behavior, particularly behavior elicited from test items. That these variables are important considerations for the neurodiagnostician is shown by the classic studies of Penfield and Roberts (1959), clinical experience, and research with brain damaged patients.

In their volume, Penfield and Roberts (1959) supply ample evidence indicating that following brain trauma or surgical invasion there are numerous pathophysiological changes such as tissue swelling where the brain appears "full" or "tense" (p. 141). During this period of cerebral edema and/or neuroparalytic edema (believed to be related to the lenth of time the cortex is exposed to the air and ultraviolet rays), which varies from several days to several weeks, the patient appears more aphasic, more confused, and severely damaged. His behavior during this period is not necessarily due to the residue of cerebral injury per se, but rather, to the effects of both edema and injury. If a patient is tested during this period (Milner, in Penfield and Roberts, 1959) he presents a distorted picture of generalized brain damage with marked deterioration (p. 148). With time, however, usually between several weeks and two years after damage, psychometric scores tend to give a more accurate picture of the residue of cerebral damage. But as this period (length of time since injury) increases, scores tend to regress toward the mean performance

(Milner, in Penfield and Roberts, 1959; Weinstein and Teuber, 1957; & Teuber, 1961), thus making it increasingly more difficult with present testing techniques to isolate "signs" of cerebral involvement. The supposition can be offered, therefore, that in order to increase the diagnostic sensitivity of any screening instrument, these effects, edema and time since injury, must be considered in diagnostic appraisal.

Also, an attempt was made to control for edema and time by testing the brain damaged patients no sooner than seven weeks after surgery, trauma, accident, or diagnosis of cerebral disease, and no longer than 19 months after injury. In the present sample, the mean time of testing was 8 months 4 days with a range of 1 month 21 days to 18 months 9 days. The final diagnostic distribution of brain damage patients comprising the present sample is as follows: ten patients with cerebral vascular accidents, six right side damage and four left side damage; four patients with post traumatic head injury, one right side damage and three left side; two surgical patients (tumor removal), right side; one patient with encepholopathy and one with demyelinating disease (N=18). The patients are white, American born, between the ages of 18 and 60 with at least 8 to 12 years of education. The composition of this group is shown in Table 1.

The controls (N=18) were hospitalized patients from various medical services of Hines Veterans Administration Hospital with negative neurological and anamestic findings of organic brain involvement and/or psychiatric disorder. The attending physician of each patient assisted in determining whether medication and/or treatment the patient was

receiving would affect visual or cognitive processes. The diagnostic distribution is as follows: two patients with digestive system disease; 6 patients with cardiac disease; 3 patients with arthritis; 2 patients with cancer; 1 patient for check-up; and 4 with orthopedic problems. Due to the nature of their illness, it was virtually impossible to control for length of hospitalization and time of testing. For this group, the mean time of testing was approximately 1 month 27 days from onset of illness and/or diagnosis (as could be best determined by medical records), with a range of 5 days to 14 months 7 days.

The brain damaged and non-brain damaged patients were matched as closely as possible for age, education, race, and occupational level. The occupational level was divided into three levels based upon DeWolfe's (1962) modification of Centers' Index (1949, Appendix I). As Table 1 points out, the matching was within one occupational level with no significant differences in age and education. Highest grade completed and occupation was used as a premorbid approximation of intellectual functioning (Williams, 1962).

Materials

In his monograph, Armitage (1946) lists a series of requirements screening instruments should have. The measure must be short, interesting and easy, relatively unaffected by pathological trends, and sample those functions that seem to suffer most as a result of brain injury (analysis and synthesis, ability to shift, ability to integrate two points of view or to perceive a double relationship, ability to plan ahead,

Table 1

Characteristics of Two Samples of Medical Patients

Ss	Occupation		Occupational Index		Age		Education	
	BD	NBD	BD	NBD	BD	NBD	BD	NBD
1	Janitor	Carpenter	3	2	59	57	8	8
2	Office Clerk	Floor Tiler	2	3	59	53	12	8
3	Guard	Steel Metal Worker	3	3	55	52	10	12
4	Salesman	Hair Stylist	2	2	50	52	12	12
5	Laborer	Salesman	3	2	50	52	12	12
6	Electrician	Tool & Die Operator	2	2	50	46	12	12
7	Laborer	Gas Station Attendant	3	3	48	45	12	12
8	Office Clerk	Machine Operator	2	3	44	45	12	10
9	Truck Driver	Salesman	3	2	44	45	9	12
10	Bus Driver	Cab Driver	3	3	44	45	9	12
11	Machine Operator	Carpenter	3	2	40	41	12	8
12	Office Clerk	Mobile Lift Operator	2	3	40	41	12	9
13	Bartender	Stage Hand	3	3	39	41	9	10
14	Salesman	Metal Spinner	2	2	37	40	12	12
15	Truck Driver	Office Clerk	3	2	32	33	9	12
16	Electrician	Machine Operator	2	3	28	28	12	12
17	Dock Hand	Personnel Clerk	3	2	21	19	12	12
18	Office Clerk	Hospital Corpsmen	2	2	19	18	12	12
M					42.17	41.83	11.0	10.94
SD					11.62	11.3	1.49	1.62

ability to anticipate, ability to stick to a point, perseverance and recall). The technique should have minimum dependance on previously learned material and directions should be simple, clear and easily understood. Finally, all performance tests should be of such a nature that they can be accomplished by gross muscular movements (Armitage, 1946: p. 22). In short, the test should elicit a relatively broad sample of behavior which will lend itself to qualitative and quantitative interpretation (Goldstein, 1959; Diller, 1962; Wepman, 1962; & Burgemeister; 1962).

A technique which meets the majority of these criteria and which also emphasizes mental processes as well as end products is that developed by Dr. Rimoldi (1955, 1960, 1961 & 1962). Briefly, it is a technique which was originally developed to study the thinking processes in problem solving, especially those relating to medical diagnosis (Rimoldi, 1955). The basic rationale, however, is also applicable to other problem situations or to situations for which a "correct" solution does not exist (Rimoldi, 1960). The applicability of the technique follows from the fact that it permits an analysis of the way in which a subject attempts to solve a particular problem. It proceeds by evaluating the sequence of questions asked by a subject as he goes about solving a problem as well as the solution itself.

The rationale underlying this research is based on the assumption that an important aspect of mental processes can be described by the sequence of questions that a subject asks when solving a problem. This sequence may in itself by pathognomonic of cerebral dysfunction and therefore useful in differential diagnosis.

The problems constructed for this research were carefully studied in two pilot studies conducted by the investigator. They are of two general types. The first type, which comprise the first four problems, deal with familiar geometric figures and figures with curved, dotted and straight lines (Appendix II, III, IV, V). The second type (Problem V, Appendix VI) deals with a concrete life situation in which a "schema" (a problem expressed in terms of a basic set of relationships) had been superimposed in order that scores could be derived in terms of the intrinsic nature or logical structure of the problem, rather than the performance of a particular criterion group (Rimoldi, et al., 1962 a, b; 1963).[1] For Problem V, the schemata can be represented as a tree (Fig. 1).

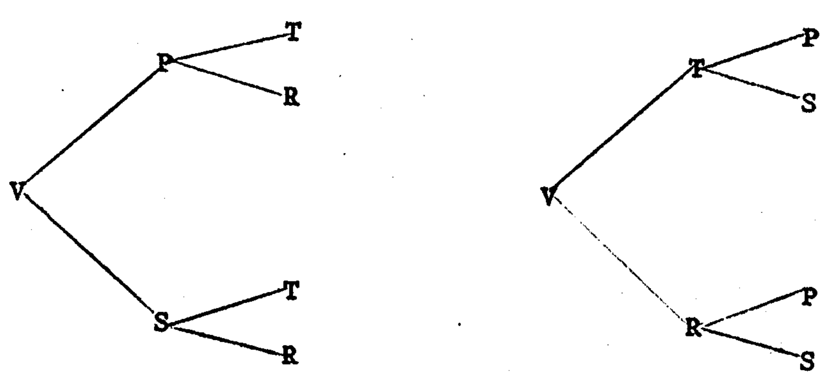

FIG. 1 Schemata for Problem V

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[1] For a more detailed discussion of the concept of "schema," the reader is referred to Rimoldi, H. J. A., Fogliatto, H. M., Haley, J. V., Reyes, I, Erdmann, J. B., & Zacharia, R., 1963; Rimoldi, H. J. A., & Haley, J. V., 1962; & Rimoldi, H. J. A., Haley, J. V., Fogliatto, H. M., & Erdmann, J. B., 1963.

Table 2

Fourfold Table Representing Schemata for Problem V

	Patients P	Staff S	
Refreshments R	4	10	14
Tickets T	6	5	11
	10	15	25 V Variety Show Committee

The letter V represents the variety show committee, P represents patients, S represents staff and T and R for individuals who sell tickets or take care of refreshments respectively. The question is: what is the number of staff members involved in the sale of tickets?

Once the structure of the problem is known, it is relatively easy to depict the best corresponding tactics (approach, sequence). From the questions appearing in Appendix VI, it is shown that question 6 should be first in all tactics and that it may be followed by 3 and 10 or by 5 and 9. Questions 3 and 10 can be interchanged so that each one of them may be asked in second or third order, and similarly, questions 5 and 9. The best tactics based upon the structure of this problem are: 6, 3, 10; 6, 10, 3; 6, 5, 9 and 6, 9, 5.

Each problem and corresponding set of questions needed to solve it appeared in a 8 X 12 inch folder. The problem was presented on a 5 X 8 card in the left pocket of the folder, and the corresponding questions the patients might want to ask in the right pockets. The questions were

presented on 3 X 5 cards -- one card per question -- and the corresponding answers were given on the back of each card. The cards (questions) were placed in slots on the right side of the folder in such a manner that only the questions on each card were visible. Appendix VII exhibits the manner in which the problems and questions were presented to each patient.

For purposes of recording the questions asked and the sequence in which they were selected, the experimenter assigned numbers according to the position the card occupied in the folder. The questions and corresponding numbers for each problem are presented in Appendix II, III, IV, V, VI.[2]

Finally for comparative purposes, both brain damaged and non-brain damaged patients were administered the Doppelt Test (1956) which estimates the FS score on the WAIS from scores of four subtests (Arit., Vocab., B.D. and P.A.).

Procedure

The medical patients represented in this study were all volunteers. Once they met the criteria of the investigation, they were approached and asked to participate. The non-brain damaged patients were seen on the wards and briefly told that some work was being done in order to come

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[2] In a separate study conducted by the investigator, no significant relationships were found between the sequence of a subjects performance and the order by which the cards appeared in the folder.

to a better understanding of how men hospitalized for certain types of illness could be helped. All questions were answered and when necessary the patients were told in general terms the nature of the research.

The brain damaged patients were approached in a similar fashion but, due to their general hypersensitivity to being examined, it became necessary in many instances to establish rapport before the actual testing. Usually this was done by making ward rounds with the doctor or by visiting them in familiar or comfortable settings, such as Occupational Therapy. Once the BD patient agreed to cooperate, he was brought to the testing room. An effort was made to relate to them on their non-paralyzed side in order to minimize the effects of sensory difficulties which may have been present on the paralyzed side. Most BD patients usually find it more easy to relate to others in terms of their "good side" (Diller, 1962). In addition, it became necessary to examine BD patients in several sessions due to their difficulty in adapting to new settings and to minimize the effects of fatigue.

Since these patients tend to be highly anxious and therefore keenly aware of failure, the examiner had to be very careful in testing not to arouse unnecessary anxiety which may have let to withdrawal or more failure. The few studies which have been done to determine the most appropriate form of instructions show that "urging" instructions on simple tasks rather than relaxing or supporting ones are more effective (Benton, 1960; Blackburn, 1958; Blackburn & Benton, 1955). It was decided that the instructions for the present study would employ all of the above considerations depending upon which (urging, supportive, and

encouraging) seemed most appropriate and functional for a given patient. As clinical experience has demonstrated, one cannot adhere to a rigid format when working with BD patients.

All of the medical patients were individually tested. The experimental problems were presented first, followed by the Doppelt Test. Once the patient was comfortably seated the 5 X 8 card representing Figure 2 was placed before him. These instructions were given:

> This is called Figure 2. Listen carefully and do as I say. Using this pointer (E hands S a pencil length pointer) point to the area marked A....B ....C....D. Now point to the areas below the middle line (C, D) and above (A, B). Now point to the areas to the left of the center line (A, C) and to the right (B, D). Here is Figure 3 (only the 5 X 8 card is presented). Point to the area marked A....B....C....D....E. Point to the areas that make up a triangle (A, B), and which areas have at least one border that is curved (D, E), and where is the smallest area (A). Here is Figure 4 (only the 5 X 8 card is presented). Point to the area marked A....B.... C....D....E....F. Which areas are above the solid straight line (A, B, C). Which areas are below (D, E, F). Point to the areas that have at least one dotted border (B, C, E, F) and at least one curved side (A, B, D, E). Now point to the areas that are to the left of the dotted line (A, B, D, E) and to the right (C, F).[3]

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[3]The purpose of this procedure is to eliminate patients that may have visual field problems such as visual agnosia. Current research now indicates (Wepman, 1962; Brain, 1961) that there may be size, shape, and form visual agnosias. Three brain damaged patients originally screened were omitted from the study at this stage, due to their inability to perform at this level. This observation supports Reitan's (1962) continued contention, that neurological examinations may not always be reliable in terms of thoroughness and diagnosis and therefore must be considered as a possible source of error in experimental designs.

If the patient successfully performed at this stage the practice problem (Appendix II) is presented in the folder with the corresponding questions. The folder is placed before the patient and E continues:

> As you can see Figure 1 is made up of a square which has been divided into four smaller areas (pointing) A, B, C, D. Now one of these areas has been picked and your job is to find out which one it is. You can do this, not by guessing, but by gathering information about this figure which you will find on the back of these questions (pointing). No one question has the answer. Begin by reading over all of the questions. When you find the first question you would like to have answered pull it from the folder and read the answer on the back of the card. There is one question and fact on each card. Keep asking questions until you have gathered enough facts to tell me which area has been selected. You can ask as many questions as you like and in any order that you like, but do not ask any more than you really need.

Before the other problems were presented the patient had to learn this problem to a criterion (correct solution). All questions were answered and any part of the instructions repeated or clarified if the patient wished. If necessary, the procedure was demonstrated. The purpose of this was to allow sufficient time for adequate familiarization with the various aspects of the problem and to be able to make more meaningful statements about which phase of memory is affected in brain damage, that is, the acquisition phase, the retention phase or the

reproductive phase (Ingham, 1952).[4]

If the practice problem was larned successfully, the other problems were presented individually as shown in Appendix III, IV, V, VI. No other instructions were given after the practice problem except, "remember you are to find the area that has been picked not by guessing but by collecting facts which you will find by asking questions that appear on the cards. When you have decided which area has been picked, let me know." All subsequent questions were handled by referring them back to the subject (do whatever you think is best, it's up to you).

Analysis of the Data[5]

The Rimoldi Technique lends itself to many levels of analysis, both quantitative and qualitative. For purposes of clarity and discussion the performance of the NBD patients on Problem II will be presented to illustrate the various methods which will be employed to analyze the problem solving processes for BD and NBD patients at the group and

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[4] Two BD patients from the original group tentatively screened for the project were eliminated at this phase. In summary, 25 BD patients were screened for the study, 3 were declared unsuitable due to various visual problems detected by the visual stimulus properties of problems II, III, IV; 2 were excluded due to their inability to learn the practice problem to a criterion and 2 did not want to participate in the study. The final BD sample N=18 represents the patients who met all of the criteria of the study. Though it would have been desirable to have a larger N, it was decided that the controls would have to remain in order to 1) assure that the data being transmitted to the cortex was relatively undistorted, so that 2) more meaningful statements regarding mental processes as related to cerebral impairment could be made.

[5] The author would like to express his appreciation to Drs. M. Meyer and H. Fogliatto for their assistance in the preparation of this section.

individual levels.

Subject 1 is presented the folder containing Problem II (Appendix III) and questions that he might wish to ask in order to arrive at the correct solution. Assuming that he understood the instructions, he first looks over all the cards and decides upon the one he wants to ask first, (usually this selection is the one which will be maximally informative). Having obtained his first fact he may stop or proceed selecting cards (questions) until he feels he has sufficient information to offer an answer. It is assumed that at every successive step the problem changes, and that what the subject knows and what he may still want to know is not a fixed property of the problem, but varies as the solution develops. The sequence of questions asked therefore, experimentally characterizes the process employed by the subject. Thus, it becomes apparent that any description of this process should not only include the number of choices made, reaction time, initial time for the first response, and the total response time, but also the type of choices made (popular-unpopular) and the order the questions were picked.

Table 3 indicates that S_1 made 3 selections. Card (question) 2, was selected first, card 4 second and card 3 third. S_2 made two selections. Card 2 was selected first and card 3 second and so forth for the remaining subjects. Looking at the totals, card 1 was selected 8 times; card 2, 12 times; card 3, 11 times; and card 4, 10 times. There were a total of 41 selections.

Table 3

Observed Frequencies and Order by Which Cards Were Selected by a Group of Non-Brain Damaged Patients on Problem II

	Questions				
Ss	1	2	3	4	f
1		1	3	2	3
2		1	2		2
3	1		2		2
4		2		1	2
5	2		1		2
6		1		2	2
7		3	1	2	3
8		2		1	2
9		2		1	2
10	1		2		2
11	1		2		2
12		2		1	2
13	1	2	3	4	4
14	1		2		2
15	1			2	2
16		2	1		2
17		2		1	2
18	1	2	3		3
f	8	12	11	10	41

Table 4

Frequencies of Statements Asked or Not Asked in Each Order by a Group of Non-Brain Damaged Patients on Problem II

	Cards				
Order	1	2	3	4	Sum
1	7	3	3	5	18
2	1	8	5	4	18
3	0	1	3	0	4
4	0	0	0	1	1
Sum	8	12	11	10	41
0	10	6	7	7	72

Table 4 summarizes Table 3 while including the frequency with which the items were selected or not selected in terms of order. For example, card 1 was selected 7 times in the first order, 1 time in the second order, 0 times in the third and fourth order. It was not selected in any order 10 times. Card 2 was selected 3 times in the first order, 8 times in the second order and 1 time in the third order and 6 times in no order, and so forth for the remaining items. From Table 4, the following statistics are obtained 1) Utility Indexes for each question and 2) a matrix of weights (proportions).

The Utility Index (Ui) indicates the usefulness of a particular question in terms of the information it is supposed to provide for the solution of the problem. For the present study a modification was employed to normalize their distribution. The normalizing modification is as follows:

$$Ui_N = \frac{Fs}{\Sigma\Sigma Fs} \qquad \text{(Rimoldi, 1962, p. 37)}$$

Where Ui_N = normalized Utility Index

Fs = the frequency with which a card was selected by a particular group

$\Sigma\Sigma Fs$ = the sum total of selections made by the group

This modification renders the Ui for the total number of cards equal to 1.00, regardless of the number of subjects in a group or the number of observations (selections) the group makes. This allows comparisons across groups to be made which can be tested for significant differences.

For present study this statistic was employed to evaluate the homogeneity of the various groups and whether the processes employed for each problem differ significantly. From Table 4 and using the above formula, Table 5 can be developed.

Table 5

Data for Cumulation of Utility Indexes for a Group of Non-Brain Damaged Patients on Problem II

Question	Rank	Frequency	Ui	UiMax.	UiMin.
2	1	12	.29	.29	.20
3	2	11	.27	.56	.44
4	3	10	.24	.80	.71
1	4	8	.20	1.00	1.00

In Table 5 the questions are ranked[6] in decreasing order according to the value of their Ui. These indices are then cumulated, thus yielding a curve of maximum performance (when cumulating from higher to lower) and a minimum curve (when cumulating from lower to higher).

6. The Kolmogorov-Smirnov Two-Sample Test is appropriate after the Ui's for each question has been ranked, providing the samples are independent. The Kolmogorov-Smirnov Two-Sample is a nonparametric test of significance which evaluates distances at each step of a cumulative performance or distribution (Siegel, 1956, p. 128).

Figure 2 depicts the maximum and minimum curves for a group of NBD patients on Problem II.

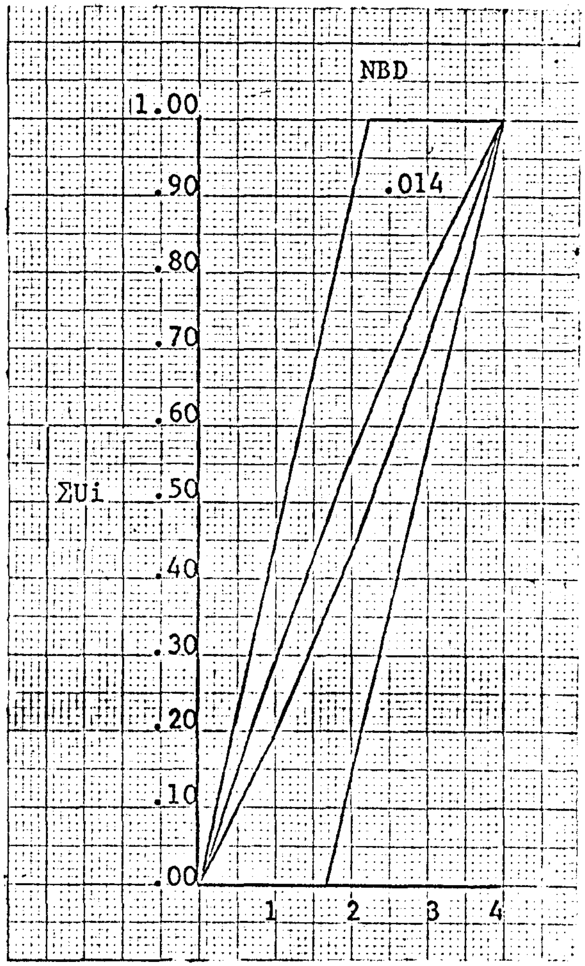


FIG. 2 Maximun and Minimum Curves Generated by a Group of Non-Brain Damaged Patients on Problem II

Drawing a parallelogram enclosing the ellipsoid formed by the two curves enables one to obtain a ratio between the area of the ellipsoid and the area of the parallelogram. The slope of the line for the parallelogram is obtained using the formula:

$$Ip = \frac{F}{S}$$

Where Ip = point of intercept for the slope of the line and 1.00 on the abcissa.

F = sum total of all selections made by the group.

S = number of subjects in the group.

If all the questions have the same utility indices, the two curves would degenerate into a straight line with its slope equal to the constant Ui. But, when the Ui is different for the various questions, the maximum and minimum curves separate, and if some cards have Ui of one and the remaining questions have a Ui of zero, the ellipsoid becomes a parallelogram. The ratio between the area of the ellipsoid and the parallelogram may be taken as an index of homogeneity of the group, that is, the amount of agreement among the subjects concerning the utility of each question. This may be written as follows:

$$Hi = \frac{Ea}{Pa}$$

Where Hi = the index of homogeneity for a group.

Ea = the area of the ellipsoid.

Pa = the area of the parallelogram.

In so far as the parallelogram was normalized by employing a Ui based upon total selections made, the size of the ellipsoid and parallelogram is always in an area space of 1.00.

Proceeding from Table 4 a matrix of weights can be developed. Table 6 can be transformed into a table of proportions with each cell

representing the total number of selections made in that order by a particular group. The formula can be written:

$$P = \frac{Fs}{\Sigma\Sigma F}$$

Where P = the proportion of total number of selections.

Fs = the frequency of card selection in this order.

$\Sigma\Sigma F$ = the total number of selections made by the group.

These proportions are presented in Table 6.

Table 6

Observed Proportions of Questions Asked or Not Asked in Each Order for Non-Brain Damaged Patients on Problem II

	Questions				
Order	1	2	3	4	Sums
1	.097	.042	.042	.070	.251
2	.014	.111	.070	.056	.251
3	.000	.014	.042	.000	.056
4	.000	.000	.000	.014	.014
Sums	.111	.167	.154	.140	.572
0	.139	.083	.096	.110	.428

In this table, the proportions within each cell represents the utility of that question in that particular order. For this problem, question 1 in the first order is shown to be most popular (.097) with

question 4 being the second most popular and so forth. Note that the table sums to (1.00). These proportions, therefore, can be used as weights for each item selected in a particular order. Though these proportions can be employed in various ways, only the ones employed in the present study will be described.

For the present attempt, a matrix of proportions was developed for each of the experimental problems in order to establish empirical norms and to describe individual performance in terms of these norms in order that comparisons could be made on a personal level.

In order to establish the empirical indices for the experimental problems employed in this study, a group of subjects (NBD) who may be descriptive of the norm is given the problem. From their performance (i.e., Table 4) a table of proportions (such as Table 6) is developed. This matrix becomes the table of weights for each question in a specific order of selection which is used to score an individual. Table 6 is the table of proportions generated on Problem II by the NBD patients. Each patient can be scored in terms of these weights and individual performance curves plotted. The formula for the Performance Score is:

$$Psj = \sum Cwj$$

where Psj = the performance score for subject j.

and $\sum Cwj$ = the cell weight for the items selected by subject j added.

Subject 1 for example, selected (Table 3) questions 2, 4, and 3. He would accumulate .042 + .056 + .042 = .140. These values can then be calculated for each subject of a particular group and compared to the

criterion group. In addition, individual performance curves can be plotted depicting the various manners of approach used by various subjects. Figure 3 illustrates the individual performance curve for NBD subject 1 on Problem II.

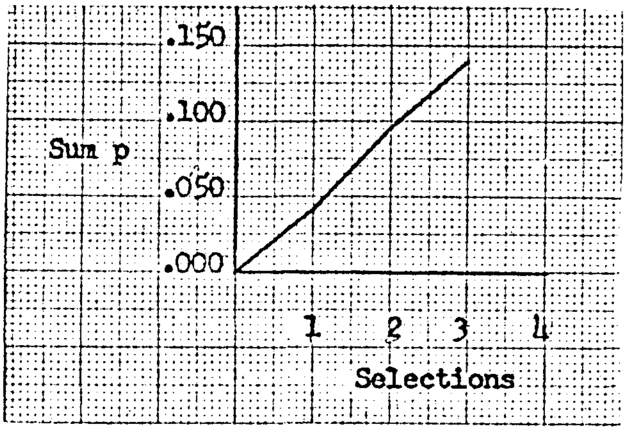


FIG. 3 Individual Performance Curve by Order Analysis
for a Non-Brain Damaged Subject on Problem II

Thus far, the analysis has been concerned with group and individual comparisons relative to each other and to a criterion performance represented in this study by the NBD patients. The question may be legitimately raised that insofar as the present study addresses itself to mental processes (selecting questions to acquire information for problem solution) might some of the transformations implied by Information Theory be used to analyze and interpret performance both on the group and individual levels.[7] This would indicate how BD and NBD patients can be characterized when evaluated in terms of the content of the problem and the necessary "bits of information" needed for its solution.

7. The author is deeply indebted to Mr. Gary Burger for his invaluable assistance in clarifying these concepts and critical appraisal of this section.

The concept of "uncertainty," operationally defined as $-\Sigma p \log_2 P$, (Attneave, 1959) provides a point of departure and a convenient way of characterizing the degree of lawfulness in performance. The maximum uncertainty of performance for a particular problem can be established by determining the associated uncertainty value under the hypothesis that subjects will behave in a completely random fashion. Thus, if a problem has a specified number of questions, a table of proportions can be constructed representing a completely random pattern of selections of questions.[8] An uncertainty value for this table can be obtained by applying the logarithmic transformation:

$$\text{Uncertainty} = -\Sigma p \log_2 p$$ (Shannon-Wiener transformation in Attneave, 1959, p. 8)

The uncertainty value associated with a given table of random performance will be a function of the number of questions in the particular problem under consideration. This random matrix and its associated uncertainty value can be used to specify random or completely unlawful performance on that particular problem.

Similarly, observed matrices, based on actual group performance, have an uncertainty value which can be calculated using the Shannon-Wiener transformation described above. This uncertainty value cannot exceed that of the random table described above. The ratio $\frac{\text{observed uncertainty}}{\text{random uncertainty}}$ can be calculated and used to express the degree of lawfulness (or unlawfulness) in the performance of a group of subjects. As this index

8. This table is based on the assumption that subjects may choose any number of questions in any order and that each subject chooses at least one question.

approaches 1.00 (which is its upper limit) the unlawfulness of behavior of the group increases. As this index approaches zero (which is its lower limit), the lawfulness of the behavior of the group increases. Thus, groups can be characterized in terms of their lawfulness or unlawfulness of behavior on a particular problem.

Table 7 gives the proportions and uncertainty values for a problem containing 4 questions under the hypothesis of completely random behavior. Tables 8 and 9 present the proportions and uncertainty values of two hypothetical groups for the same problem. The ratio $\frac{\text{observed uncertainty}}{\text{random uncertainty}}$ are also presented. Notice that the ratios for group Y is higher than that of group X, indicating a closer approximation to random (unlawful) behavior. The meaning of these ratios should become apparent upon inspection of the matrices.

Table 7

Hypothetical Matrix Showing Proportions and Uncertainty Value for a Problem Containing 4 Questions Under the Hypothesis of Completely Random Behavior

	Questions			
Order	1	2	3	4
1	.0816	.0816	.0816	.0816
2	.0765	.0765	.0765	.0765
3	.0612	.0612	.0612	.0612
4	.0306	.0306	.0306	.0306

Uncertainty = 3.9288

Table 8

Proportions and Uncertainty Value for Hypothetical Group

X for the Same Problem
(Observed)

Order	Questions 1	2	3	4
1	.25			
2		.25		
3			.25	
4				.25

$\frac{\text{Observed}}{\text{Random}} = .509$

Uncertainty = 2.00

Table 9

Proportions and Uncertainty Value for Hypothetical Group

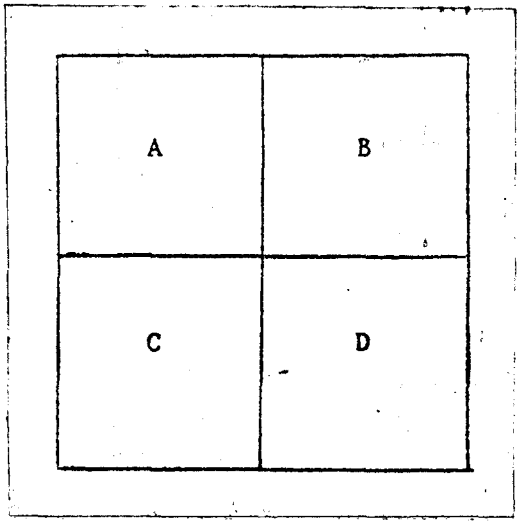
Y for the Same Problem
(Observed)

Order	Questions 1	2	3	4
1	.10	.10	.10	.05
2	.05		.20	
3	.07	.03		.10
4	.05	.10	.05	

$\frac{\text{Observed}}{\text{Random}} = .868$

Uncertainty = 3.4102

The above paragraphs have described how the concept of uncertainty, as defined in information theory, can be used to characterize group performance. Information theory can also be applied to the performance of individuals. This is done by utilizing the concept of "bits" of information obtained by a subject as he is solving a particular problem. A "bit" of information, as defined by information theory, is obtained when a subject, by asking a particular question, is able to reduce the number of possible answers to the problem by 50%. For instance, if a subject is told to determine the area picked by the experimenter for Problem II in Figure 4 below, he will obtain 1 bit of information if he asks question 1, for he has reduced the possible answers in half. If after question 1, question 2 is asked, no bits of information are obtained since the number of possible answers has not been reduced.



<u>Questions</u>

1. Is it in the upper half of the square?	1. Yes, it is in the upper half of the square.
2. Is it in the lower half of the square?	2. No, it is not in the lower half of the square.
3. Is it to the right of the center line?	3. No, it is not to the right of the center line.
4. Is it to the left of the center line?	4. Yes, it is to the left of the center line.

PRE-SELECTED AREA IS A

FIG. 4 Experimental Problem II and Corresponding Questions

The number of bits of information required to solve such a problem is equal to the logarithm (to the base 2) of the total number of possibilities (H=log m). Thus, performance curves can be drawn representing the rate at which a particular subject accumulates the neccessary bits of information to solve the problem. Since there are four possible areas in Fig. 4 two bits ($\log_2 4=2$) of information are required to solve the problem. If a subject does not obtain two bits of information in his questions, he cannot solve the problem unless he guesses. Figure 5 below illustrates two hypothetical performance curves for the Problem II.

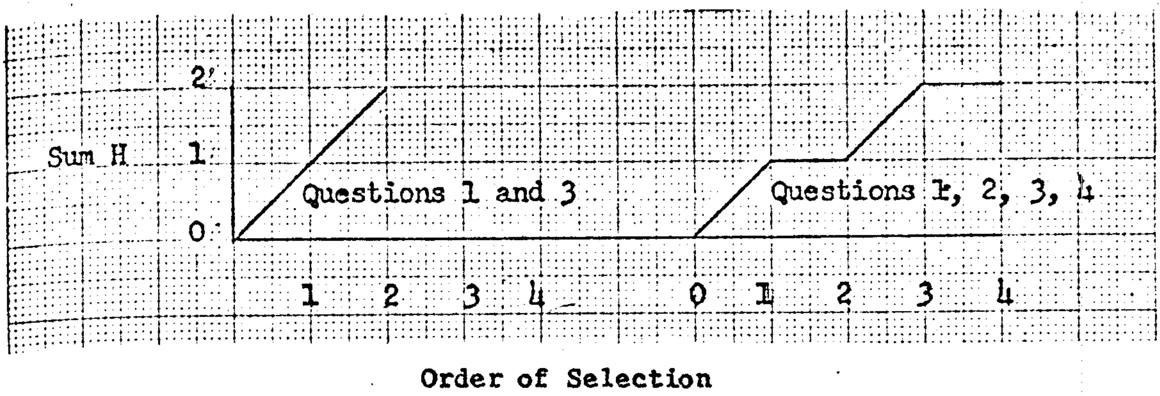


FIG. 5 Hypothetical Performance Curves for Problem II

These performance curves clearly illustrate differences by which subjects' reduce the number of possible answers to a given problem. Plateaus in the curve indicates that the question asked gave no additional information. Continuation of questioning after the necessary two bits of information to solve the problem had been obtained may indicate inefficient processing of information, failure to perceive relationships, poor retention, lack of attention, and so forth.

It was mentioned earlier in this section, when discussing the experimental problems used in this study, that an attempt was made in Problem V to superimpose on a concrete life situation a schema and set of questions. The logical structure of the problem itself will suggest those tactics that will lend themselves more directly to the correct solution. These tactics therefore can be used as a set of norms in scoring individuals independently of how a given group of subjects behave in problem solution. That is, a subject can be scored in terms of how he follows the intrinsic logical structure of the problem.

Table 10

Tactics for Problem V

Tactics	1	2	3	4	5	6	7	8	9	10
	Questions									
a	0	0	2	0	0	1	0	0	0	3
b	0	0	3	0	0	1	0	0	0	2
c	0	0	0	0	2	1	0	0	3	0
d	0	0	0	0	3	1	0	0	2	0

Table 10 indicates that question 6 should be first in all tactics and that it may be followed by 3 and 10 or by 5 and 9. Both 3 and 10 can be interchanged too so that each one of them may be asked in second or third order, and similarly, question 5 and 9.

When scoring the performance of a given subject, a score of 1.00 or .00 may be assigned to each successive choice according to its agreement with the norm. Thus, if tactic a is used for scoring purposes, a subject selecting question 6, 3 and 10 in this order, will obtain a total of 3.000 and so would a subject selecting questions 6, 3, 10 and 7.

If the subject selected questions 6, 10 and 3, he would obtain, using tactic a, a score of 1.00 for question 6, and a score of .00 for questions 10 and 3. Scored in terms of tactic b, the same subject would obtain a total score of 3.00. In order to be fair, every subject should then be scored in terms of all the theoretically developed tactics. Since this may be confusing and will increase the amount of work un-

necessarily, all these tactics were pooled together and weights were assigned to each question in each order according to its frequency of occurrence in that order. For our problem, the set of weights is given in Table 11.

Table 11

Frequency with which Each Card is Expected to be Chosen

	Questions										
Order	1	2	3	4	5	6	7	8	9	10	Sum
1						4					4
2			1		1				1	1	4
3			1		1				1	1	4
0	4	4	2	4	2	0	4	4	2	2	28
Sum	4	4	4	4	4	4	4	4	4	4	40

The entries in Table 11 indicate the frequencies with which each card is expected to be chosen considering all the possible tactics. The "0" row corresponds to the number of times that a particular question is not located in any postion of the described tactics.

Table 12

Transformed Proportions in Terms of Expected Frequencies

	Questions										
Order	1	2	3	4	5	6	7	8	9	10	Sum
1						.100					.100
2			.025		.025				.025	.025	.100
3			.025		.025				.025	.025	.100
0	.100	.100	.050	.100	.050		.100	.100	.050	.050	.700
Sum	.100	.100	.100	.100	.100	.100	.100	.100	.100	.100	1.000

For scoring purposes these frequencies are transformed into proportions of the total (Table 12).

Theoretically, the number of rows should be equal to the number of columns. Since no tactic had more than three choices, orders 4 through 10 are not included in Tables 11 and 12.

Each subject is scored by accumulating the proportions of the successive questions asked. He may also be scored independently by accumulating the proportions of the questions not asked (0 order). In this way, the subject can be evaluated in terms of what he does not do as well as in terms of what he does do.

The performance curve corresponding to each subject can be represented graphically by plotting on the ordinate the sum of the values corresponding to the questions asked, and on the abscissa, the successive steps.

CHAPTER IV

RESULTS I

In this chapter, the results are analyzed in terms of: 1) general response characteristics - number of cards selected, number of correct solutions, and reaction times; and 2) Rimoldi's Methods - utility index, group ellipsoids, individual performances by order analysis and schema analysis of Problem V. In Chapter V, results will be analyzed in terms of: 1) Information Theory group analysis and individual performance curves; 2) Doppelt Test results; and 3) Qualitative analysis of the data.

General Response Characteristics

A. Number of Cards Selected. As Table 13 indicates, the number of cards selected by BD and NBD subjects is similar. The "t" values were not significantly different for any problem or for all problems combined.

B. Number of Correct Responses. If the control and experimental groups are similar in terms of number of items asked, the next concern would be whether the problems have been correctly solved.

Table 14 presents data for correct and incorrect solutions and not-attempted trials. Using the Fisher-Yates test of significance,[9] it was

---

[9]Latscha, R. Test of significance in a 2 X 2 contingency table: extension of Finney's tables. Biometrika., 1953, 40, 74-86.

Table 13

Number of Questions Selected by Each Patient for Each Problem and Mean Number of Questions Selected and Standard Deviation for Each Problem

	Experimental Problems							
Ss	II		III		IV		V	
	BD	NBD	BD	NBD	BD	NBD	BD	NBD
1	2	3	1	5	1	7	0	9
2	4	2	5	5	7	3	6	3
3	4	2	1	5	0	3	0	2
4	3	2	9	2	3	3	2	3
5	2	2	6	6	3	4	2	3
6	4	2	10	2	0	3	0	4
7	4	3	7	8	10	7	9	0
8	4	2	10	7	10	3	10	4
9	2	2	2	2	4	3	[illegible]	2
10	2	2	7	7	2	4	0	4
11	4	2	7	3	10	3	1	4
12	0	2	0	3	0	9	0	3
13	0	4	0	5	0	6	0	3
14	2	2	4	6	3	3	3	2
15	2	2	2	2	1	3	5	3
16	0	2	0	2	0	3	0	4
17	2	2	3	7	3	3	2	4
18	2	3	3	6	4	5	2	5
M	2.389	2.278	4.278	4.611	3.389	4.167	2.556	3.444
SD	1.420	.624	3.461	2.090	3.567	1.855	2.617	1.789

Table 14

Correct and Incorrect Solutions to Experimental Problems for a Group of Brain Damaged and Non-Brain Damaged Patients*

Ss	Experimental Problems: II		III		IV		V	
	BD	NBD	BD	NBD	BD	NBD	BD	NBD
1	+	-	-	+	-	+	NA	-
2	+	+	+	+	-	+	-	-
3	+	+	-	+	NA	+	NA	-
4	+	+	-	+	+	+	-	-
5	+	+	-	+	-	+	-	-
6	-	+	-	+	NA	+	NA	+
7	+	+	+	+	+	+	-	NA
8	-	+	-	+	-	+	-	-
9	-	+	-	+	-	+	-	-
10	-	+	-	+	-	+	-	-
11	-	+	-	+	-	+	NA	+
12	NA	+	NA	+	NA	+	NA	+
13	NA	+	NA	+	NA	-	NA	+
14	+	+	+	+	+	+	-	-
15	+	+	-	+	-	+	[illegible]	+
16	NA	+	NA	+	NA	+	NA	-
17	+	+	-	+	-	+	-	-
18	+	+	+	+	-	+	-	-
Totals								
+	10	17	4	18**	3	17**	0	5
-	5	1	11	0	10	1	11	12
NA	3		3		5		7	1

*Key

- \+ Correct Solution
- \- Incorrect Solution
- NA Not Attempted

** $p < .005$

found that in terms of number of correct solutions, there is a significant difference between groups beyond the .005 level of significance for Problems III and IV. When both groups were compared in terms of total correct solutions for all of the problems, significance was reached beyond the .001 level. The criterion of three or more correct solutions would be met by two BD Ss and would fail to be met by only one NBD S.

Not only did NBD Ss give more correct answers, but they attempted more problems. Despite the generally poor performance of the BD patients and the degree to which the subjects did not attempt all or some of the problems, one cannot proceed, at least at this level of analysis, to the generalization that these Ss were unable to perform or that no thinking was taking place. What seems to emerge if we limit ourselves to the findings yielded in Tables 13 and 14 is:

1. that number of questions asked is not significantly different.
2. number of correct solutions is significantly different.
3. that some BD patients tend not to publicly engage in tasks that require logical analysis.

C. Reaction and Total Response Time Comparisons. Appendix VIII and IX list the reaction time characteristics for both groups of medical patients. When reaction time indices were compared between groups in terms of average time per response, total response time, and average time for the first response for each problem and all problems combined, no significant "t" values at the .10 level or better were obtained.

Analysis by Rimoldi Methods

A. Utility Index. The basic rationale underlying this approach has been presented earlier and need not be repeated here.* It can be briefly defined as the ratio between the number of times a given question has been asked and the total number of selections made by the group. It is a measure which can be taken as a relative information value empirically assigned to a question by a group of subjects.

Appendix X through XVII provides data in terms of observed frequencies and order by which questions were selected for both groups of patients for all problems. Table 15 summarizes these appendices in terms of utility indices: An estimate of the relative importance given to each question by the patients for all the problems. Figure 6 indicates graphically these patterns of utility indexes. Exploring the contents of Table 15 one notes that all questions were selected in varying frequencies by both groups and that there is a tendency to perceive th[illegible] of each question for the various problems in about the same manner. This is more clearly illustrated in Figure 6 which shows how utility index patterns approximate each other except for questions 2 and 9 (p .05) for Problem IV, and question 10 (p .01) for Problem V. These questions can be considered as having greater relevance for the NBD patients in terms of being perceived as more useful for problem solution. Item 4 for Problem III and item 10 for Problem III just failed to meet the .05 level of confidence. The importance of these results lies in the fact that despite the general agreement on which items to select, the BD patients still perform significantly more poorly (Table II).

Table 15

Utility Indexes for Questions on Experimental Problems for a Group of Brain Injured and Non-Brain Injured Patients

Questions	Experimental Problems							
	II		III		IV		V	
	BD	NBD	BD	NBD	BD	NBD	BD	NBD
1	.23	.20	.06	.08	.05	.05	.09	.02
2	.28	.29	.09	.14	.07	.16*	.09	.02
3	.33	.27	.08	.12	.11	.07	.13	.19
4	.16	.24	.16	.14	.13	.17	.06	.02
5			.12	.11	.07	.05	.11	.06
6			.12	.08	.13	.07	.15	.23
7			.09	.07	.11	.12	.09	.03
8			.09	.13	.13	.13	.04	.03
9			.06	.05	.13	.04*	.13	.19
10			.13	.06	.07	.13	.11	.21**

Kolmogorov-Smirnov Two Tail Test

* p .05
**p .01

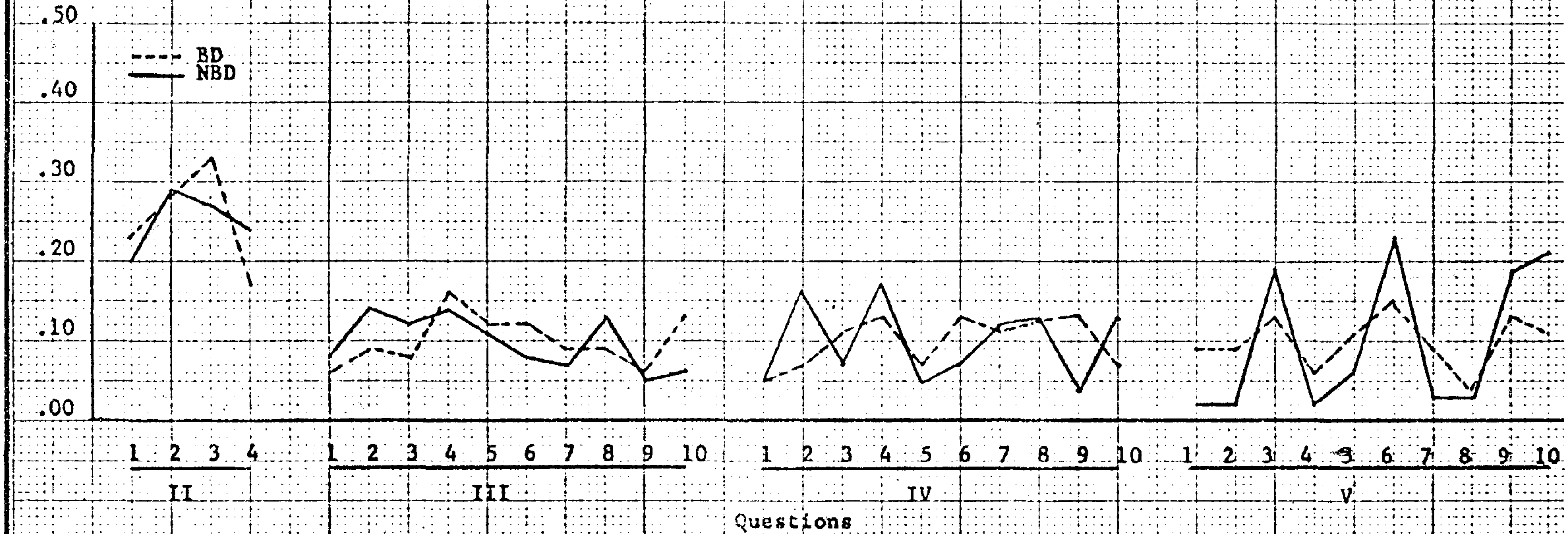


FIG. 6 Patterns of Utility Indexes on Experimental Problems Obtained from Brain Damaged and Non-Brain Damaged Patie

B. Analysis of Group Performance Ellipsoids. It will be recalled that the utility index is the ratio of the number of times a given question has been asked by a group to the total number of selections made by the group. If there is no discrimination among items, all the items will have the same utility index. If, however, the Ss discriminated among items, items will have different utility indices.

If questions are selected in terms of their empirical utility indices from higher to lower and again from lower to higher one obtains two curves: a maximum efficiency curve and a minimum efficiency curve. Between these curves an ellipsoid is generated.

The distance separating (or area between) these curves corresponds to the extent to which the Ss discriminated among the items. However, since the logical structure of the problem influences the amount of discrimination possible, this should also be taken into account. The maximum utility of the items can be assessed logically. If questions are selected from highest logical utility to lowest; and also, from lowest logical utility to highest, a parallelogram is generated. The parallelogram must always enclose the empirical ellipsoid.

The ratio of the area of the ellipsoid, based on empirical utility indices, to the area of the parallelogram, based on logical utility indices, expresses the extent to which a group of Ss discriminated among items in terms of maximum discrimination permitted by the logical structure of the problem. This is called the Index of Homogeneity (Hi), which can vary from zero to 1.00.

Figure 7 through 10 depict ellipsoids and corresponding parallelograms and Indices of Homogeneity (Hi) generated by performances of BD and NBD patients. The index of homogeneity for Problem II is .052 and .014 for BD and NBD patients respectively, thus indicating that for both groups there is little discrimination as to which questions were logically most useful. One possible explanation for this is the small number of questions provided for this problem. Figure 8 (Probelm III), however, shows more discrimination particularly for the NBD patients (Hi = .315). When this ratio is compared to that of the BD patients (Hi = .288), the difference just fails to reach significance at the .05 level (Kolmogorov-Smirnov Two-Tail Test). The values of the BD and NBD ellipsoids are significantly different at the .05 level for Problem IV (Figure 9) and at the .01 level for Problem V (Figure 10). In general, as the problems become relatively complex, the NBD Ss are better able to discriminate the more useful items from the logically less useful ones.

C. Analysis of Individual Performance. Utility Index and ellipsoid values, though useful for group comparisons have certain limitations if the focus of attention is the individual. The small number of questions per problem makes it easy for an individual to accumulate a high performance score by merely selecting all of the questions. If one is to appraise process, it becomes necessary to include at this level of analysis when cards of high utility were selected. Evaluation by order analysis provides a more differentiating and accurate approach for individual performance and comparison. Appendices XVIII through XXV list the observed proportions of questions asked or not asked in each order for both groups of medical

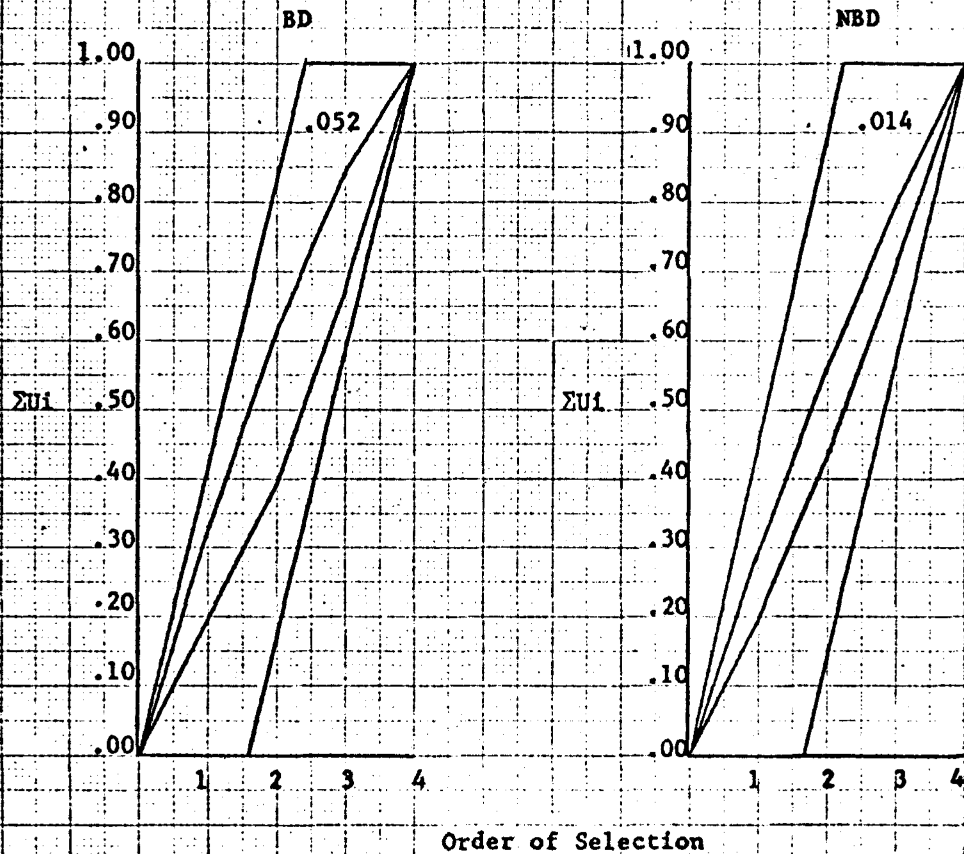


FIG. 7 Ellipsoids and Corresponding Parallelograms Generated by Performances of Brain Damaged and Non-Brain Damaged Patients on Problem II.

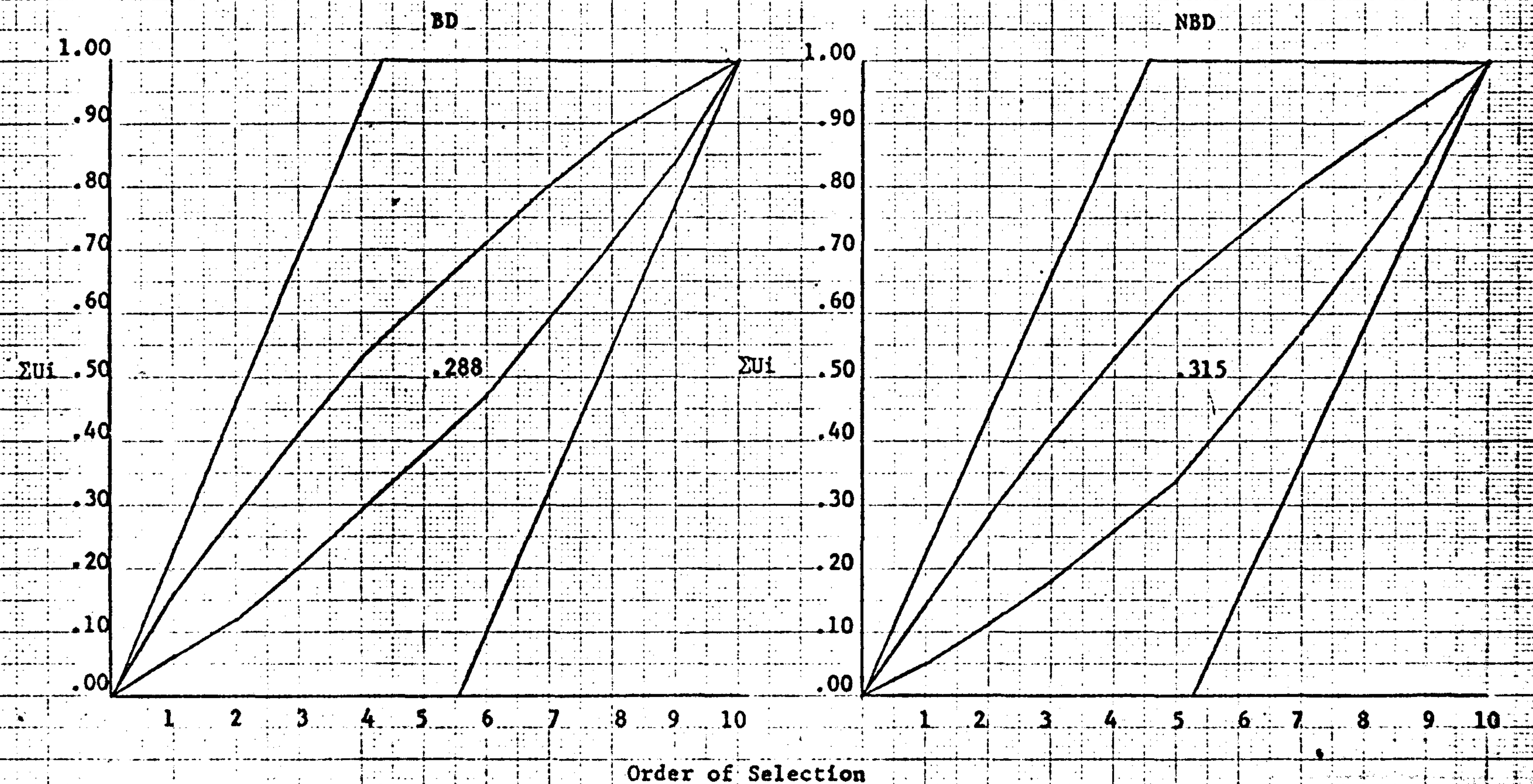


FIG. 8 Ellipsoids and Corresponding Parallelograms Generated by Performances of Brain Damaged and Non-Damaged Patients on Problem III.

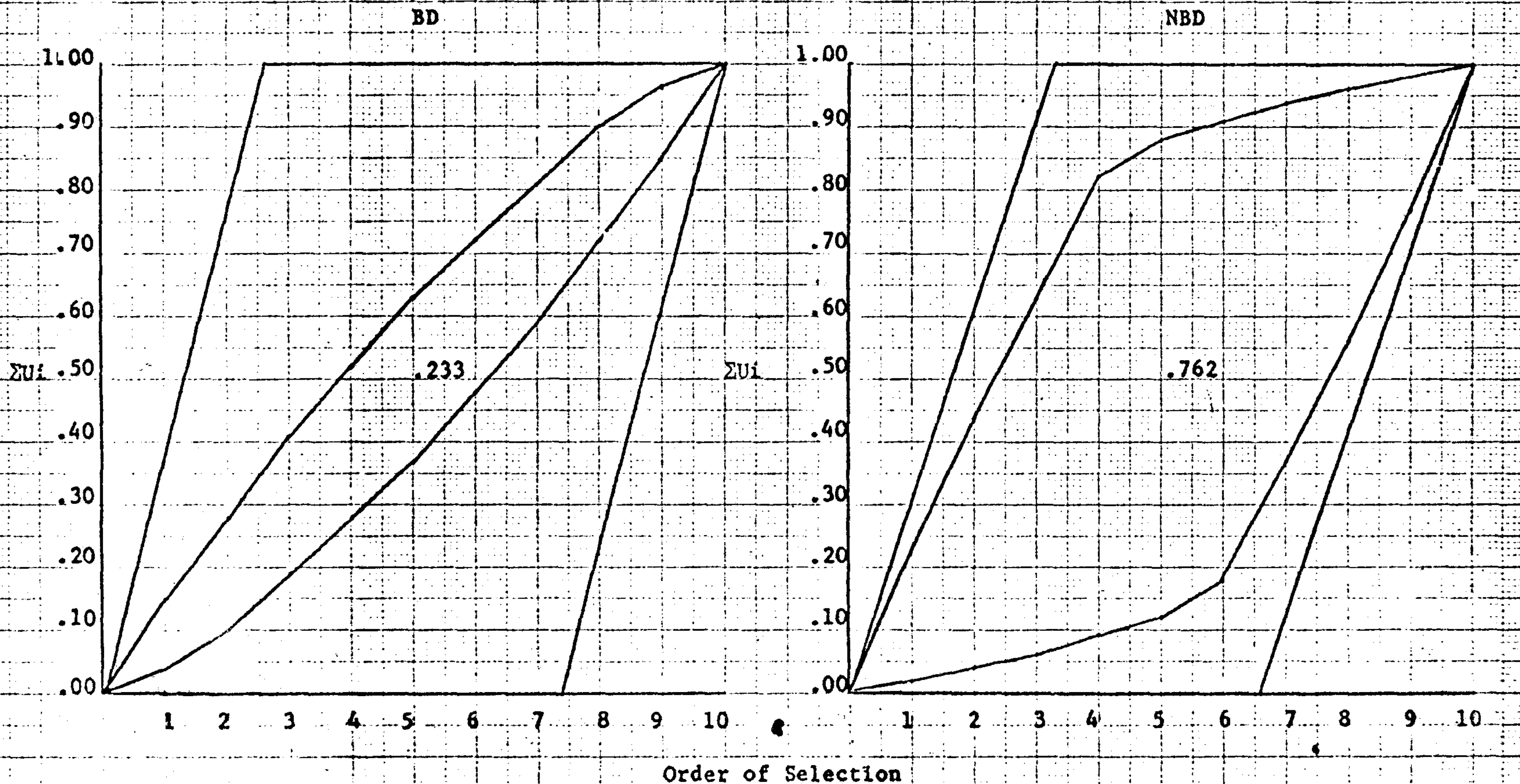


FIG.10 Ellipsoids and Corresponding Parallelograms Generated by Performances of Brain Damaged and Non-Damaged Patients on Problem V.

patients for all problems. The total sum of these values is a summary statement of the tactics used by the subject (Table 16).

The performance of every subject can be graphically represented by adding these proportions (observed) according to the value of the question in the observed order. Appendices XXVII through XLIII depict graphic representations of individual performances for both groups for all problems.

It is to be noted that these results though logically related, are not identical with the number of correct solutions criteria presented in Table 14. Let us assume that Problems II, III, IV and V become progressively more complex. If we then assume that using information to solution, is somewhat more difficult then seeking the correct solution, we obtain the following. For Problem II both BD and NBD groups ask the same useful questions and solve the easiest problem (no significant differences for Problem II, Tables 14 and 15). In Problem III, both groups ask questions of similar utility (no significant difference, Table 15) but only the NBD group correctly uses the information (no significant differences, Table 14). In Problem IV, the BD group does relatively poor in asking useful questions (significant differences, Table 15) and also fails to ob ain the correct solution (significant differences, Table 14). The NBD group obtained the correct solution. In Problem V, the BD group asks relatively poor questions (significant differences, Table 15) and also fails to obtain correct solutions (Table 14). However, Problem V is so difficult that even the NBD group cannot <u>use</u> the information it possesses, hence no significant differences (Table 14).

Table 16

Performance Scores by Order Analysis, Individual Scores, Means and Standard Deviations for Brain Damaged and Non-Brain Damaged Patients

Ss	Experimental Problems II		III		IV		V	
	BD	NBD	BD	NBD	BD	NBD	BD	NBD
1	.112	.140	.006	.068		.068		.092
2	.182	.112	.073	.056	.034	.034	.017	.061
3	.168	.167	.116	.100		.061		.067
4	.250	.181	.009	.039	.017	.050	.050	.083
5	.153	.056	.061	.100	.040	.072	.023	.078
6	.168	.098	.040	.028		.034		.066
7	.264	.112	.112	.091	.057	.068	.017	
8	.264	.181	.118	.112	.057	.045	.017	.094
9	.056	.181	.017	.034	.044	.056	.029	.056
10	.167	.167	.051	.117	.028	.078		.051
11	.264	.167	.068	.045	.057	.072	.022	.089
12		.181		.050		.103		.050
13		.264		.062		.052		.096
14	.181	.167	.023	.100	.029	.044	.066	.056
15	.167	.153	.039	.028	.022	.055	.011	.078
16		.153		.039		.055		.044
17	.112	.181	.017	.106	.033	.039	.022	.067
18	.153	.250	.012	.057	.055	.056	.011	.051
M	.177	.161	.049	.068	.039	.058*	.026	.069**
SD	.061	.049	.037	.031	.014	.017	.017	.017

* p .01 (non-paired "t" test)
** p .001

D. Schema Analysis of Experimental Problem V According to Rimoldi Method. It will be remembered that an attempt was made in Problem V to superimpose on a concrete life situation, a schema and set of questions. Table 10 in the previous chapter lists the tactics for this problem. That is, those manners of approach that lend themselves more directly to correct solution. From these tactics norms can be derived for scoring individuals. Table 12 lists the transformed proportions in terms of expected frequencies.

The findings shown in Table 17 and those reported throughout this section strongly indicate that Problem V is a difficult problem for all patients. This is reflected in Table 14 where seventeen NBD patients attempted the problem and only five achieved correct solutions. Eleven BD patients attempted the problem and no correct solutions were obtained. Seven BD patients made no attempt to solve the problem.

Table 14 shows that NBD Ss 6, 11, 12, 13 and 15 obtained correct solutions. One would suspect that their selections would be similar to the tactics set up for the problem. Table 17 and Appendices LIX through LXI partially support this contention. As can be seen in Table 17 only NBD subjects 6 and 16 obtained the necessary schema values for solutions. Yet, as Table 14 clearly indicates, NBD S 16 was not successful whereas NBD Ss 11, 12, 13, and 15 were. These subjects, however, only accumulated .05, .05, .05, and .00 schema values respectively (Table 17). Even when the experimenter pulled out those questions which were irrelevant in terms of the schemata ("Pulling Out Technique," Rimoldi et al., 1963), the above values were not appreciably changed.

Table 17

Cumulated Schema Values for Problem V

Ss	BD-	NBD
1		.05
2		
3		
4		.05
5		
6		.20
7		
8		.05
9		
10		
11		.05
12		.05
13		.05
14	.15	
15	.10	
16		.20
17	.05	
18	.15	
M	.112	.0778
S.D.	.035	.067

A possible explanation for this can be gleamed from Appendix XVI which contains the observed frequencies and order by which questions were selected by NBD patients. Subject 11, for example, picked card 3 in the first order; card 6 in the second order; card 9 in the third order and card 10 in the fourth order, and so forth for Ss 12, 13 and 15. All these subjects attended to most of the crucial questions though not in the "best" sequence, as can best be determined by their behavior. What seems to be suggested is that though these subjects do not approach the problem in the most desirable manner, once they obtain the necessary information, they are able to manipulate the data in their thinking and arrive at a correct solution. Because this manipulation is not translated into behavior (tactics) one cannot assume that it has not occurred. Much more work needs to be done before more definitive statements can be made.

CHAPTER V

RESULTS II

Information Theory

A. Group Analysis. Using the transformations of information theory described earlier, measures of "uncertainty" can be obtained. Table 18 presents the maximum uncertainty values (randomness) under the hypothesis that patients will behave in a completely random fashion for all of the problems. These random values represent the upper limit for observed group performance for the respective problems. As Table 18 shows, these values are 4.2624, 6.744, 6.744, and 6.744 for Problems II, III, IV, and V respectively. Table 18 also indicates the uncertainty values based upon the actual performance of both groups. The ratios $\frac{\text{observed uncertainty}}{\text{random uncertainty}}$ are also presented and are used to express the degree of lawfulness (or unlawfulness) in the performance of the experimental and control groups. As this index approaches zero (which is its lower limit), the lawfulness of the groups' behavior increases.

Notice that the observed ratios for all problems for the NBD patients are lower then the BD patients. This suggests that the NBD groups performance approximates more lawful behavior as compared to the BD group.

Table 18

Observed and Random Information Values on Experimental Problems for a Group of Brain Damaged and Non-Brain Damaged Patients

Problems	NBD		Random	BD	
	Information Values				
	Observed	Observed / Random		Observed / Random	Observed
II	3.6521	.8568	4.2624	.8767	3.7368
III	5.1496	.7636	6.744	.8192	5.5245
IV	5.0057	.7422	6.744	.7558	5.0972
V	4.5690	.6775	6.744	.7037	4.7455

B. Individual Performance Curves. Briefly, the number of bits of information required to solve Problems II, III, and IV are equal to the logarithm (to the base two) of the total number of possibilities. For Problem II this equals 4, thus two bits (two selections represent the maximum performance curve) are needed ($\log_2 4=2.000$); Problem III has 5 possibilities, thus 2.32193 bits are needed ($\mathrm{Log}_2 5=2.32193$) or 3 selections; there are 6 possibilities for Problem IV, thus requiring 2.58496 bits of information or at least 3 selections.

According to Information Theory a 'logical' subject does not rely on luck. He chooses questions according to information value. A good question approaches the ideal norm of reducing uncertainty by one-half. Thus a positive or negative answer will be equally useful. Such a subject would not manifest a plateau or ask a question after he had enough information to give the solution.

Appendices XLIV through XLVI illustrate the maximum performance curves and the obtained performance curves secured from both groups of Ss for Problem II. The curves obtained from the BD group show 12 plateaux, that is, asking questions that yield no additional information, and asking 7 additional questions after the necessary two bits of information had been obtained. Fifteen BD patients secured enough bits to solve the problem and 3 made no attempt at solution. Yet, as Table 14 points out, only 10 BD patients achieved the correct solution. This means that 5 BD patients secured the necessary information but were unable to bring it to bear on the problem.

The NBD group is characterized by 5 plateaux and asking only 2 questions after sufficient information was available. All NBD patients secured the necessary bits for problem solution and 17 obtained the correct solution. When the total number of patients for both groups were compared in terms of having acquired the necessary information for problem solution, no significant values at the .10 or better were obtained (Fisher-Yates Exact Probability Test).

Appendices XLVII through LII show performance curves for Problem III. The correct solution can be obtained in 3 or more selections which can yield 2.32193 bits of information. Performance by the BD patients is

typified by 15 plateaux and 24 redundant questions. Fifteen BD patients attempted the problem but only 11 secured sufficient information. From this group of 11 BD patients only 4 patients achieved correct solutions (Table 14). Thus 7 BD patients had sufficient information but were unable to arrive at a correct response.

All of the NBD patients attempted and correctly solved this problem. Ten plateaux were generated, 26 redundant questions were asked, but only 16 patients secured the necessary information. The curves secured from NBD patients 9 and 14 indicate that though a correct response was elicited, their selections did not enable them to secure the necessary bits of information. Both patients obtained 1.32193 bits of information. Their responses appear to be more a product of guessing. When both groups were compared in terms of total number of patients who secured sufficient information, no significant values at the .10 level or better were obtained (Fisher-Yates Exact Probability Test). Significance was reached at the .01 level when both groups were compared in terms of acquiring enough information and solving the problem correctly. That is, all the 16 NBD patients who obtained sufficient "bits" of information made correct responses, while only 4 of the 11 BD patients who had sufficient information achieved correct solutions.

In Appendices LIII through LVIII, one notes that the maximum performance curve for Problem IV can be achieved in 3 selections. The BD patients generated 14 plateaux and asked 9 questions after all the required information had been secured. Six BD patients achieved enough

information to solve the problem. But, as Table 14 shows, only 3 were able to arrive at a correct solution.

The NBD patients generated 14 plateaux and asked 12 redundant questions. All NBD patients attempted the problem and 17 achieved correct solutions. The present analysis indicates, however, that NBD patients 2, 6, and 8 did not accumulate the necessary information from their selections. Consequently their responses were guesses. When both groups were compared in terms of total number of subjects who had secured the required information, significance was reached at the .072 level (Fisher-Yates Exact Probability Test). That is, a significantly greater number of NBD patients obtained the required bits of information in order to solve the problem.

When the accumulated information values were compared for all problems, only those obtained for Problem IV reach the .05 level of confidence (Table 19).

Analysis of Cognitive Changes Measured by a Short Form of a General Intelligence Test (Doppelt)

At this stage of analysis an attempt was made for comparative purposes to evaluate the performance of both experimental and controls on a short form Intelligence Test such as the Doppelt (1956). This test employs four WAIS subtests to arrive at an approximation of the FS score.

Table 20 presents sealed scores and estimated I.Q.'s obtained from performances on Arithemetic, Vocabulary, Block Design, and Picture

Table 19

Cumulated Information Values for Problems II, III, IV

Means and Standard Deviations for a Group

of Brain Damaged and Non-Brain Damaged Patients

	Experimental Problems					
Ss	II		III		IV	
	BD	NBD	BD	NBD	BD	NBD
1	2.000	2.000	.32193	2.32193	1.000	2.58496
2	2.000	2.000	2.32193	2.32193	2.58496	1.58496
3	2.000	2.000	.32193	2.32193		2.58496
4	2.000	2.000	2.32193	2.32193	2.58496	2.58496
5	2.000	2.000	2.32193	2.32193	2.58496	2.58496
6	2.000	2.000	2.32193	2.32193		1.58496
7	2.000	2.000	2.32193	2.32193	2.58496	2.58496
8	2.000	2.000	2.32193	2.32193	2.58496	1.58496
9	2.000	2.000	1.32193	1.32193	1.58496	2.58496
10	2.000	2.000	2.32193	2.32193	1.58496	2.58496
11	2.000	2.000	2.32193	2.32193	2.58496	2.58496
12		2.000		2.32193		2.58496
13		2.000		2.32193		2.58496
14	2.000	2.000	2.32193	1.32193	1.58496	2.58496
15	2.000	2.000	2.32193	2.32193	.58496	2.58496
16		2.000		2.32193		2.58496
17	2.000	2.000	.73697	2.32193	1.58496	2.58496
18	2.000	2.000	2.32193	2.32193	1.58496	2.58496
M	2.000	2.000	1.8831	2.2108	1.9246	2.4183*
SD			.761	.311	.671	.456

* p .05 (non-paired "t" test)

Table 20

Doppelt Scale Scores (WAIS) Means and Standard Deviations for a Group of Brain Damaged and Non-Brain Damaged Patients

Ss	Arit.		Vocab.		B.D.		P.A.		Estimated I.Q.	
	BD	NBD	BD	NBD	BD	NBD	BD	NBD	BD	NBD
1	7	10	7	10	9	10	6	8	92	105
2	9	15	15	16	9	11	6	9	107	122
3	6	16	11	14	9	9	9	9	101	112
4	10	12	13	11	9	16	7	10	109	114
5	7	13	9	16	4	8	6	9	84	114
6	7	14	10	14	3	15	4	12	81	128
7	7	14	14	10	6	10	6	10	95	111
8	3	13	9	12	3	10	0	10	62	113
9	5	12	10	16	6	7	6	8	82	110
10	5	13	11	10	6	9	6	8	82	105
11	9	14	9	11	7	15	9	14	93	122
12	6	7	9	10	6	11	7	10	84	105
13	5	9	9	12	9	11	7	7	87	100
14	15	17	13	11	7	10	9	14	108	119
15	5	14	9	13	7	9	7	16	82	118
16	7	8	8	14	6	13	6	11	81	109
17	8	12	9	12	7	9	11	12	93	109
18	10	10	9	10	6	11	6	15	89	111
M	7.28	12.39*	10.17	12.33**	6.61	10.78*	6.56	10.66*	89.56	112.61*
SD	2.70	2.70	2.18	2.20	1.94	2.48	2.31	2.63	11.78	7.11

* p .001 (non-paired "t" test)
** p .005

Arrangement, which comprise the Doppelt. Significant differences can be seen on all scores for the BD patients, particularly for Arit., B.D., P.A., and Full Scale I.Q. These results are similar to those reported in the literature (Fitzhugh, Fitzhugh, & Reitan, 1961; Reed & Reitan, 1963; Morrow & Mark, 1955) where significant relationships are reported between brain damage and cognitive deficit.

It an attempt to see if other possible cues or relationships might emerge from the present data, Table 21 was compiled. As can be observed, this Table attempts to organize in some meaningful fashion, correct and incorrect solutions, not attempted trials, interms of diagnosis, laterality, I.Q., Age, Education, elapsed time since injury, and occupation for this sample of brain damaged patients.

The relatively small N and the composition of the sample make it difficult to isolate possible trends. Some impressions are suggested, however. BD subjects (7 and 14) who performed successfully on 3 of the 4 problems both had a diagnosis of cerebral vascular accident in the right hemisphere, achieved I.Q.'s within the normal range, were between the ages of 37-48, completed 12 years of education, and were tested between 8 to 12 months after injury. Employing their performance as a point of departure, one notes that individuals with comparable educational backgrounds, I.Q.'s, diagnosis and laterality (Ss 2, 18, and 4) do more poorly on the experimental problems, but not as poorly as the remaining subjects.

In terms of laterality, a relatively equal dispersion is seen. With the exception of Ss 7 and 14, patients with a diagnosis of CVA,

Table 21

Correct (+) and Incorrect (-) Solutions and Not Attempted (NA) Problems in Terms of Diagnosis, Laterality, I.Q., Age, Education, and Elapsed Time Since Injury for a Group of Brain Damaged Patients

Ss	Problems II	III	IV	V	Diagnosis	Laterality	Doppelt I.Q.	Age	Ed.	Occ.	Elapsed Time Since Injury
7	+	+	+	-	CVA	R	95	48	12	Laborer	8' 17"
14	+	+	+	-	CVA	R	108	37	12	Salesman	12' 11"
2	+	+	-	-	Trauma	R	107	59	12	Office Clerk	4' 6"
18	+	+	-	-	Trauma	R	89	19	12	Office Clerk	1' 27"
4	+	-	+	-	CVA	L	109	50	12	Salesman	4' 20"
15	+	-	-	-	Trauma	L	82	32	9	Truck Driver	10' 14"
17	+	-	-	-	Trauma	L	93	21	12	Dock Hand	9' 15"
1	+	-	-	NA	CVA	R	92	59	8	Janitor	1' 21"
3	+	-	NA	NA	CVA	R	101	55	10	Guard	3' 12"
5	+	-	-	-	CVA	L	84	50	12	Laborer	2'
9	-	-	-	-	CVA	R	82	44	9	Truck Driver	1' 27"
10	-	-	-	-	CVA	R	82	43	12	Bus Driver	1' 18"
8	-	-	-	-	CVA	L	62	44	12	Office Clerk	7' 25"
11	-	-	-	NA	Encephalopathy	L	93	40	12	Machine Operator	18' 9"
6	-	-	NA	NA	CVA	R	81	50	12	Electronic	19' 5"
16	NA	NA	NA	NA	Trauma	R	81	28	12	Electrician	13' 8"
12	NA	NA	NA	NA	Trauma	L	84	40	12	Office Clerk	10' 12"
13	NA	NA	NA	NA	Demyelinating Disease	F	87	39	9	Bartender	11' 16"

Trauma, are somewhat evenly distributed in terms of not attempted trials, correct and incorrect solutions. There is, however, the slight trend that patients with right side damage perform more satisfactorily in problem solving.

An interesting observation is that BD Ss 1, 3, 11, and 17, all were able to achieve I.Q.'s within the normal range of intelligence yet were unable to perform most of the experimental problems. Patients within the dull-normal range BD Ss 5, 6, 8, 9, 10, 12, 13, 15, 16, and 18, did not attempt problems or were unsuccessful. Finally age, pre-injury education and occupation, and elapsed time since injury do not appear to be related to cognitive deficit, at least under the conditions of the present study.

Qualitative Analysis of the Data

The preceding sections have provided some experimental data supporting Goldstein's contention, (Goldstein & Scheerer, 1941; Goldstein, 1959) that brain damage patients can be characterized as being unable to assume the "abstract attitude." This is reflected in their inability to assume a definite mental set, to shift reflectively from one aspect of a situation to another, to keep in mind various aspects of a task or any presentation simultaneously, to grasp the essential of a whole, that is, break it up into pieces, isolate them, and synthesize them, to abstract common properties reflectively (Goldstein, 1959, p. 774).

One of the major difficulties exhibited by the BD patients was their inability to understand the ideas contained within the instructions

and then bringing this knowledge to bear on attacking the problem. Many patients had to be constantly encouraged and supported. Instructions had to be repeated and the procedure demonstrated in all examination except for BD Ss 7 and 14.

The "typical" organic patient in this study sometimes proceeds by selecting cards which do not reflect any plan (serializing in both order: questions 10, 9, 8 and so forth, or 1, 2, 3, 4 etc.). He often misreads cards and finds himself repeatedly returning to previously asked questions. Sometimes he may have a "hunch," and tries to find "the" card that will then confirm it ("I think it's going to be area D" or "This time I'm sure it's in the square"). If an answer is offered, it is often but remotely related to the information he has secured. Inquiry results in responses such as "If it's not the smallest area, it must be the largest," or "that area of the card has finger marks on it, so it must be it," and "It has to be B because it follows A." These responses usually follow questions such as "Is it to the right of the smallest area?" (Problem III, Ques. 10), Or "Is it to the left of the dotted line?" (Problem IV, Ques. 4). This is very similar to the "stimulus bound" descriptions of Goldsteins' studies where organics tend to display a concrete orientation to their environment. That is, performance which is determined by the stimulus properties of a particular object or situation. In this study responses such as the above were given despite the fact that during the selection process the organic obtains information that would have indicated that he was pursuing an unfruitful course of action.

Though the organic may feel that his answer is not adequate, he

attempts to cover-up, talk-away, or justify his reply. Even if he is somewhat aware of the inadequacy of his answer, he experiences marked difficulty in initiating a new course of action. Once he gives his answer, it is difficult for him to consider new bits of information. At this point, the brain damage patient attempts to elicit behavioral cues from the examiner which he then attempts to utilize as guide lines for the adequacy of his responses. Any display of disappointment, disfavor and/or dissatisfaction is responded to by withdrawal or self-depreciating remarks. Their frustration tolerance in these situations is very low.

These observations though indicative of the general behavior of the BD patients comprising this sample have to be modified in certain instances. The data does not unequivocally support Goldsteins' impressions. The performance of BD subjects 7 and 14 certainly illustrates that some BD patients perform as well as normals. The coping mechanisms of these patients provides striking evidence that much research has to be done before statements can be made concerning the disabling effects of injury on the person per se and the degree to which "organic patterns" are a function of the interaction of the lesion and the person who sustains it. It is apparent that an individual's coping mechanisms, such as the strength of his desire to get well, his desire to make the most of his residual capacities, the habits he has developed reacting to failure and lastly the extent of his premorbid intellectual endowment and education, are crucial variables for diagnostic assessment in neuropathology.

The normals were able to follow a relatively systematic approach to the problems. They were able to utilize basic information and were able

to organize it and bring it to bear on attacking the problem. Their behavior was flexible. That is, they appeared more willing to reach their conclusions after logical considerations. They were able to shift during problem solution if the information warranted it. Where the organics looked to E for assistance, the normals actively sought the bits of information which would lead to the correct solution. The normals actively initiated the process which led to their replies.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Approaches to the study of psychological correlates of brain damage have employed diagnostic signs, single variable tests, scatter patterns and qualitative techniques. The study of thinking processes involved in problem solving represented another method of analysis in the assessment of cerebral impairment. This change of emphasis which pays adequate attention to both verbalized end products and process suggests a fruitful though untapped area of investigation.

In this study, five experimental problems were prepared and administered with a standard short form General Intelligence Test (Doppelt, 1956) to a group of brain damaged patients (N = 18) and a group of hospitalized patients (N = 18) from various medical services. Diagnosis of brain damage was based upon medical history, neurological examination, and appropriate laboratory procedures. All patients were matched as closely as possible in terms of age, sex, education, race and occupation. An attempt was also made to control for the effects of cerebral edema and length of time since damage for the organic patients.

The basic assumption underlying this project was that complex mental processes can be described and evaluated by the sequence of questions asked by a subject in solving a problem (Rimoldi, 1955). These questions were analyzed and interpreted in terms of techniques developed by Rimoldi and his associates (Rimoldi, Haley & Fogliatto, 1962; Rimoldi, Fogliatto,

Haley, Reyes, Erdmann & Zacharia, 1962) and certain transformations derived from Information Theory (Attneave, 1959). The following constitute the major findings.

No significant differences were found in terms of number of cards selected for each problem for all problems combined. Comparisons between groups for number of correct solutions were significant for Problem III, and IV and in terms of total correct for all problems. Moreover, three out of four correct solutions correctly identified all but two brain damaged patients and misidentified one non-brain damage patient. In addition, BD patients tended not to attempt the problems.

Reaction and total response time indices indicated no significant differences between groups.

Analysis of Utility Index data shows that in a few cases (3) does the selection of a given item differentiate between BD and NBD groups.

In terms of Information Theory, the behavior of the NBD patients was relatively more lawful. Both groups were characterized by plateaux and redundancies. The NBD group obtained significantly more information than did the BD group only in the case of Problem IV. When both groups were compared in terms of acquiring the necessary "bits" of information and obtaining the correct solution significance was reached only for Problem III.

Emerging from the analysis according to the Rimoldi [illegible] Information Theory was the observation that while many of the NBD Patients do not proceed in terms of the "best" strategy, they are able

to arrive at a correct solution once the information has been accumulated. These patients apparently are able to meaningfully manipulate "bits" of information without necessarily translating this process into behavior (sequence of questions).

At a final level of psychometric comparison, there were significant differences between groups on a short form of the WAIS (Doppelt, 1956). There were significant decrements in Arithematic, Vocabulary, Block Design, Picture Arrangement and Full Scale Scores.

The general conclusion is reached that as this stage of knowledge, process does not appear to be a better indicator than product (correct solutions) of cerebral dysfunction.

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APPENDIX I

Modification of the Centers' Occupational Index*

	Classification	Description
Level 1	Large business	bankers, manufacturers, large department-store owners and managers.
	Professional	physicians, dentists, professors, teachers, ministers, engineers, lawyers, etc.
	Small business	small retail dealers, contractors, proprietors of repair shops employing others, etc. Includes owners & managers.
Level 2	White-collar workers	clerks, salesmen, agents, semi-professional workers, technicians, representatives.
	Farm owners and managers	persons who own or manage a farm, ranch, grove, etc.
	Skilled workers and foremen	carpenters, machinists, electricians, plumbers, printers, etc. Includes foremen, barbers, & cooks if not domestic.
Level 3	Semi-skilled workers	truck drivers, machine operators, service-station attendants, waiters, countermen, etc.
	Farm tenants and farm laborers	
	Unskilled workers	sweepers, porters, janitors, streetcleaners, construction men, and all jobs requiring almost no training.

* The modification of this scale (Centers', 1949) was by Alan S. DeWolfe. The effect of affective tone on the verbal behavior of process and reactive schizophrenics. J. abnormal soc. Psychol., 1962, 64, 450-455.

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APPENDIX I

Modification of the Centers' Occupational Index*

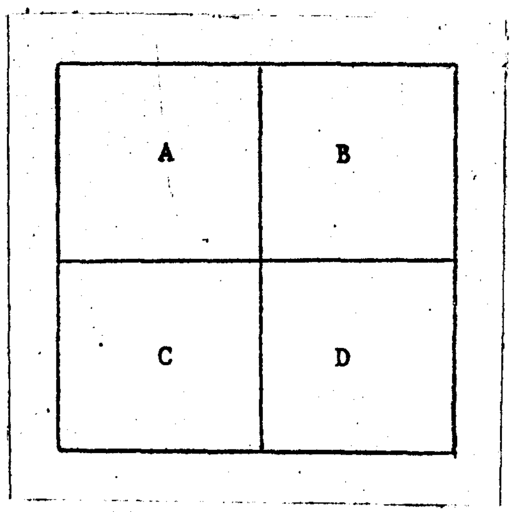
	Classification	Description
Level 1	Large business	bankers, manufacturers, large department-store owners and managers.
	Professional	physicians, dentists, professors, teachers, ministers, engineers, lawyers, etc.
	Small business	small retail dealers, contractors, proprietors of repair shops employing others, etc. Includes owners & managers.
Level 2	White-collar workers	clerks, salesmen, agents, semi-professional workers, technicians, representatives.
	Farm owners and managers	persons who own or manage a farm, ranch, grove, etc.
	Skilled workers and foremen	carpenters, machinists, electricians, plumbers, printers, etc. Includes foremen, barbers, & cooks if not domestic.
Level 3	Semi-skilled workers	truck drivers, machine operators, service-station attendants, waiters, countermen, etc.
	Farm tenants and farm laborers	
	Unskilled workers	sweepers, porters, janitors, streetcleaners, construction men, and all jobs requiring almost no training.

* The modification of this scale (Centers', 1949) was by Alan S. DeWolfe. The effect of affective tone on the verbal behavior of process and reactive schizophrenics. J. abnormal soc. Psychol., 1962, 64, 450-455.

APPENDIX II

PRACTICE PROBLEM

Figure 1



QUESTIONS

1. Is it in the upper half of the square?
2. Is it in the lower half of the square?
3. Is it to the right of the center line?
4. Is it to the left of the center line?

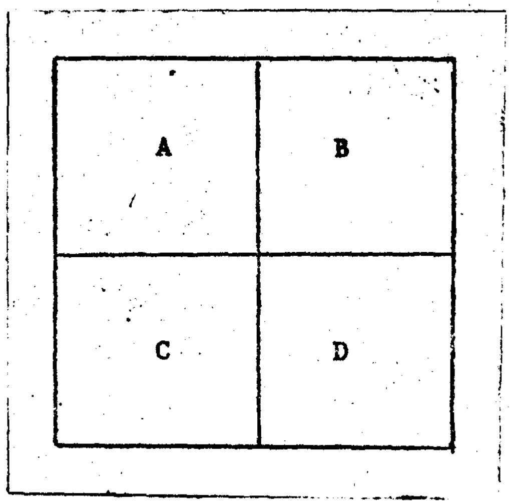
1. Yes, it is in the upper half of the square.
2. No, it is not in the lower half of the square.
3. No, it is not to the right of the center line.
4. Yes, it is to the left of the center line.

PRE-SELECTED AREA IS A

APPENDIX III

PROBLEM II

Figure 2



QUESTIONS

1. Is it in the upper half of the square?
2. Is it in the lower half of the square?
3. Is it to the right of the center line?
4. Is it to the left of the center line?

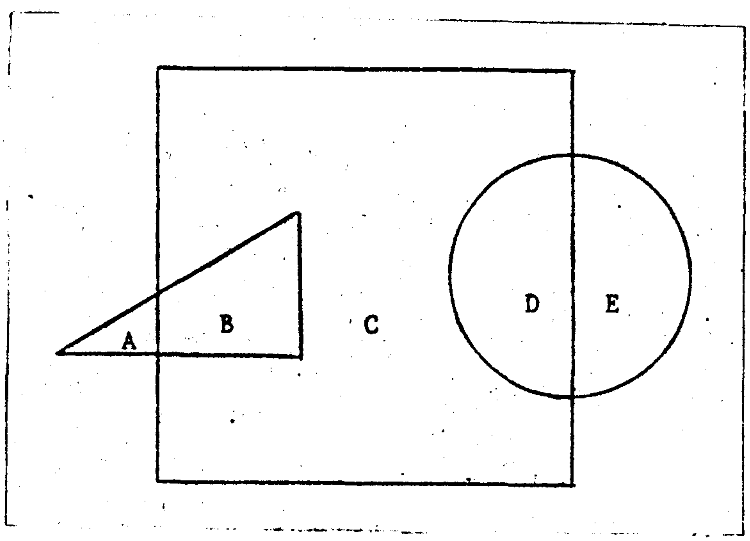
1. No, it is not in the upper half of the square.
2. Yes, it is in the lower half of the square.
3. No, it is not to the right of the center line.
4. Yes, it is to the left of the center line.

PRE-SELECTED AREA IS C

APPENDIX IV

PROBLEM III

Figure 3



QUESTIONS

1. Is it the smallest area?
2. Is it the largest area?
3. Is it outside the square?
4. Is it within the square?
5. Are all sides straight?
6. Is it within two geometric figures?
7. Does it have at least three straight sides?
8. Is one border curved?
9. Is it in a triangle?
10. Is it to the right of the smallest area?

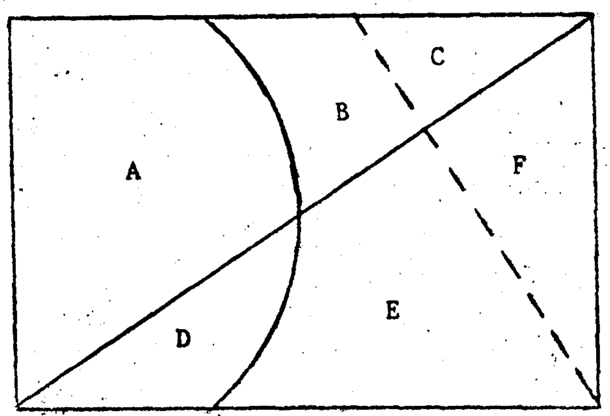
1. No, it is not the smallest area.
2. No, it is not the largest area.
3. No, it is not outside the square.
4. Yes, it is within the square.
5. No, all sides are not straight.
6. Yes, it is within two geometric figures.
7. No, it does not have at least three straight sides.
8. Yes, one border is curved.
9. No, it is not in a triangle.
10. Yes, it is to the right of the smallest area.

PRE-SELECTED AREA D

APPENDIX V

PROBLEM IV

Figure 4



QUESTIONS

1. Are all of the sides straight?	1. No, all of the sides are not straight.
2. Does it have at least one curved side?	2. Yes, it has at least one curved side.
3. Are all sides of the area solid?	3. No, all the sides of the area are not solid.
4. Does it have at least one dotted side?	4. Yes, it has at least one dotted side.
5. Are there more than three sides?	5. Yes, there are more than three sides.
6. Is it to the right of the dotted line?	6. No, it is not to the right of the dotted line.
7. Is it to the left of the dotted line?	7. Yes, it is to the left of the dotted line.
8. Is it below the solid straight line?	8. No, it is not below the solid straight line.
9. Do the sides form a triangle?	9. No, the sides do not form a triangle.
10. Is it above the solid straight line?	10. Yes, it is above the solid straight line.

PRE-SELECTED AREA B

APPENDIX VI

PROBLEM V

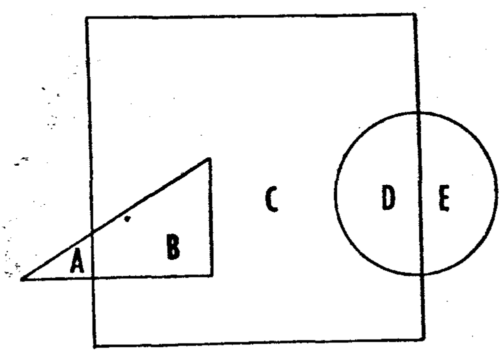
At Hines Hospital, the annual Variety Show is about to be held. A Variety Show committee has been selected to handle ticket sales and the refreshments during intermission. Both patients and staff members are on the committee. A part of the committee will take care of the ticket sales and another part will take care of the refreshments. The list of staff members involved with the sale of tickets for the show has been lost. From the other information available which you will find in the questions, your object will be to discover the number of staff members involved in the sale of tickets.

QUESTIONS

1. Is Hines Hospital the only Veterans Hospital in the state? No
2. How many people attended the Variety Show last year? 640
3. How many patients are on the committee? 10
4. Are there more staff members at Hines than other V. A. Hospitals? Yes
5. How many of the Variety Show committee are assigned to supply refreshments? 14
6. What is the total number of people on the Variety Show committee? 25
7. How much time would the committee as a whole spend in preparation for the show? 275 hours
8. How much time would the average committee member contribute? 2 hours
9. How many patients on the committee are involved in the sale of tickets? 6
10. How many staff members are on the refreshment part of the committee? 10

	Patients	Staff Members	
Refreshments	4	10	14
Tickets	6	5	11
	10	15	25

Sequence 6, 5, 9 or 6, 3, 10



Is it the small·st area ?

Is it the largest area ?

Is it outside the square ?

Is it within the square ?

Are all sides straight ?

Is it within two geometric figures ?

Does it have at least three straight sides ?

Is one border curved ?

Is it in a triangle ?

Is it to the right of the smallest area ?

APPENDIX VII

Display Folder Showing Stimulus Figure and Corresponding Questions for Problem II

APPENDIX VIII

Reaction Time (RT), Total Response Time (TR), Average Time Per Response (T/R)

and Average Time for 1st Response (T/1R) for Experimental Problems

(expressed in seconds) for a Group of Brain Damaged Patients

Ss	Experimental Problems II		III		IV		V		Totals		
	RT	TR	RT	TR	RT	TR	RT	TR	TR	T/R	T/1R
1	20	70	15	110	5	111			291	97.0	13.33
2	8	105	20	465	11	265	40	310	1145	286.25	19.75
3	10	50	12	26					76	38.0	11.00
4	5	50	7	260	4	50	10	70	430	107.5	6.5
5	8	45	17	370	28	140	167	226	781	195.25	55.00
6	6	65	20	180					245	122.5	13.00
7	16	40	32	91	46	170	10	385	686	171.5	26.00
8	20	125	5	430	5	450	6	415	1420	355.0	9.00
9	21	42	18	105	32	125	3	115	387	96.8	18.50
10	29	48	23	385	19	65			498	166.0	23.67
11	12	56	5	250	3	205			511	170.33	6.67
12											
13											
14	14	33	42	215	10	70	24	140	458	114.5	22.5
15	5	36	25	50	12	100	25	216	402	100.5	16.75
16											
17	14	105	100	120	95	175	145	190	590	147.5	88.50
18	7	14	9	65	4	50	6	45	174	43.5	6.5
M	13	58.933	23.333	208.133	21.076	152	43.3	211.2	539.6	147.47	22.444
SD	7.081	30.605	23.509	145.992	25.806	110.149	59.864	126.525	357.019	84.29	21.932

APPENDIX IX

Reaction Time (RT), Total Response Time (TR), Average Time Per Response (T/R)

and Average Time for 1st Response (T/1R) for Experimental Problems

(expressed in seconds) for a Group of Non-Brain Damaged Patients

Ss	Experimental Problems: II		III		IV		V		Totals		
	RT	TR	RT	TR	RT	TR	RT	TR	TR	T/R	T/1R
1	36	160	45	170	56	314	220	534	1178	294.5	89.25
2	3	15	4	177	9	50	13	130	372	93.0	7.25
3	11	44	8	80	36	119	13	55	298	74.5	17.0
4	8	25	16	105	45	120	45	290	540	135.0	28.5
5	8	52	6	85	9	99	7	120	356	89.0	7.5
6	7	16	6	30	15	48	10	155	249	62.3	9.5
7	20	90	20	175	24	355			620	206.7	21.33
8	8	18	13	146	12	55	14	145	364	91.0	11.75
9	8	15	22	40	22	75	14	130	260	65.0	16.5
10	4	40	10	110	35	160	70	215	525	131.3	29.75
11	3	16	18	45	12	43	13	220	324	81.0	11.5
12	9	24	8	48	4	90	12	58	220	55.0	8.25
13	10	45	16	115	20	85	30	235	380	95.0	19.0
14	5	35	10	190	8	45	42	145	415	103.8	16.25
15	2	17	22	45	32	90	75	150	302	75.5	32.75
16	9	23	22	43	20	48	55	350	464	116.0	26.5
17	6	18	6	95	4	22	5	115	250	62.5	5.25
18	8	33	8	55	5	47	8	230	365	91.3	7.25
M	9.166	38.111	14.444	97.444	20.444	103.611	38	186.882	415.667	112.356	20.282
SD	7.802	35.78	9.830	54.277	15.026	91.104	52.065	117.306	219.295	72.080	19.243

APPENDIX X

Observed Frequencies and Order by Which Questions Were Selected for a Group of Non-Brain Damaged Patients

PROBLEM II

	Questions				
Ss	1	2	3	4	f
1		1	3	2	3
2		1	2		2
3	1		2		2
4		2		1	2
5	2		1		2
6		1		2	2
7		3	1	2	3
8		2		1	2
9		2		1	2
10	1		2		2
11	1		2		2
12		2		1	2
13	1	2	3	4	4
14	1		2		2
15	1			2	2
16		2	1		2
17		2		1	2
18	1	2	3		3
f	8	12	11	10	41

APPENDIX XI

Observed Frequencies and Order by Which Questions Were Selected for a Group of Brain Damaged Patients

PROBLEM II

Ss	Questions 1	2	3	4	f
1		1	2		2
2	4	1	2	3	4
3	4	3	2	1	4
4	1	2	3		3
5		2	1		2
6	4	3	2	1	4
7	1	2	3	4	4
8	1	2	3	4	4
9	2		1		2
10	1		2		2
11	1	2	3	4	4
12					0
13					0
14		2	1		2
15	1		2		2
16					0
17		1	2		2
18		2	1		2
f	10	12	14	7	43

APPENDIX XII

Observed Frequencies and Order by Which Questions Were Selected for a Group of Non-Brain Damaged Patients

PROBLEM III

	Questions										
Ss	1	2	3	4	5	6	7	8	9	10	f
1			3	4	1			2		5	5
2	3	2		1		4		5			5
3	1	2	3		4	5					5
4				2				1			2
5	1	3	2	6			4	5			6
6			1		2						2
7	2	1	3	4	5	6	7	8			8
8	1	3	2		4	5		6		7	7
9		1			2						2
10	1	2	3	4		5	6	7			7
11		1		2	3						3
12		2		1				3			3
13				1			2	3	4	5	5
14	1	3	2	6		4			5		6
15			1		2						2
16				2				1			2
17		3	2			7	6	1	4	5	7
18		4		2	5		3		6	1	6
f	7	12	10	12	9	7	6	11	4	5	83

APPENDIX XIII

Observed Frequencies and Order by Which Questions Were Selected for a Group of Brain Damaged Patients

PROBLEM III

	Questions										
Ss	1	2	3	4	5	6	7	8	9	10	f
1										1	1
2		4		1	2		3	5			5
3										1	1
4	1	2	3	4	7	8	5		6	9	9
5		2		1	4			5	3	6	6
6	10	9	8	7	6	5	4	3	2	1	10
7	1	2	3	4	5	6	7				7
8	1	2	3	4	5	6	7	8	9	10	10
9					2	1					2
10			5	1		4	6	2	3	7	7
11	3	2	4	1	5	6	7				7
12											0
13											0
14				4	3	1				2	4
15				2				1			2
16											0
17				1		2				3	3
18				3				2		1	3
f	5	7	6	12	9	9	7	7	5	10	77

APPENDIX XIV

Observed Frequencies and Order by Which Questions Were Selected for a Group of Non-Brain Damaged Patients

PROBLEM IV

	Questions										
Ss	1	2	3	4	5	6	7	8	9	10	f
1		7		1	6		5	2	4	3	7
2	2						1			3	3
3	1			2				3			3
4				1			3			2	3
5		1	2			3		4			4
6		3			1					2	3
7		2	3	6	5	1		4	7		7
8		2					1			3	3
9		1	3							2	3
10		1	2	3				4			4
11		1		2				3			3
12	1	7	5	2	8	3	6	4	9		9
13	1	2		3			4	5		6	6
14		3		2						1	3
15				1			2	3			3
16				1		2		3			3
17				3			2			1	3
18		1		5		2	3			4	5
f	4	12	5	13	4	5	9	10	3	10	75

APPENDIX XV

Observed Frequencies and Order by Which Questions Were Selected for a Group of Brain Damaged Patients

PROBLEM IV

	Questions										
Ss	1	2	3	4	5	6	7	8	9	10	f
1								1			1
2			5	4		3	6	7	2	1	7
3											0
4			1				2	3			3
5				3		1				2	3
6											0
7	1	2	3	4	5	6	7	8	9	10	10
8	1	2	3	4	5	6	7	8	9	10	10
9			2	1	4	3					4
10							1			2	2
11	1	2	3	4	5	6	7	8	9	10	10
12											0
13											0
14				3		1		2			3
15				1							1
16											0
17			3				2			1	3
18		3				2		4		1	4
f	3	4	7	8	4	8	7	8	4	8	61

APPENDIX XVI

Observed Frequencies and Order by Which Questions Were Selected for a Group of Non-Brain Damaged Patients

PROBLEM V

	Questions										
Ss	1	2	3	4	5	6	7	8	9	10	f
1	6	7	9		1	4	2	5	8	3	9
2						3			2	1	3
3			1			2					2
4			1						2	3	3
5			3			2				1	3
6			2			1			4	3	4
7											0
8			1		4				2	3	4
9						2			1		2
10					4	3		2	1		4
11			1			2			3	4	4
12				1			2			3	3
13			1			2				3	3
14						2			1		2
15			3			2				1	3
16			2			1			3	4	4
17			4			3			2	1	4
18			3		1	5			4	2	5
f	1	1	12	1	4	14	2	2	12	13	62

APPENDIX XVII

Observed Frequencies and Order by Which Questions Were Selected for a Group of Brain Damaged Patients

PROBLEM V

	Questions										
Ss	1	2	3	4	5	6	7	8	9	10	f
1											0
2	1	2	3	4	5	6					6
3											0
4			1						2		2
5									1	2	2
6											0
7	1	2	3	4	5	6	7	8	9		9
8	1	2	3	4	5	6	7	8	9	10	10
9						4	3		1	2	4
10											0
11										1	1
12											0
13											0
14						1			2	3	3
15	3	2	5			1	4				5
16											0
17			2		1						2
18					2	1					2
f	4	4	6	3	5	7	4	2	6	5	46

APPENDIX XVIII

Observed Proportions of Questions Asked or Not Asked in Each Order for a Group of Brain Damaged Patients

PROBLEM II

Order	Questions 1	2	3	4	Sum
1	.100	.050	.050	.050	.250
2	.017	.117	.117	.000	.251
3	.000	.033	.067	.017	.117
4	.050	.000	.000	.050	.100
Sum	.167	.200	.233	.133	.733
0	.083	.050	.017	.117	.367

APPENDIX XIX

Observed Proportions of Questions Asked or Not Asked in Each Order for a Group of Non-Brain Damaged Patients

PROBLEM II

Order	Questions 1	2	3	4	Sum
1	.097	.042	.042	.070	.251
2	.014	.111	.070	.056	.251
3	.000	.014	.042	.000	.056
4	.000	.000	.000	.014	.014
Sum	.111	.167	.154	.140	.572
0	.139	.083	.096	.110	.428

APPENDIX XX

Observed Proportions of Questions Asked or Not Asked in Each Order for a Group of Brain Damaged Patients

PROBLEM III

Order	1	2	3	4	5	6	7	8	9	10	Sum
					Questions						
1	.020	.000	.000	.033	.000	.013	.000	.007	.000	.027	.100
2	.000	.033	.000	.007	.013	.007	.000	.013	.007	.007	.087
3	.007	.000	.020	.007	.007	.000	.007	.007	.013	.007	.075
4	.000	.007	.007	.027	.007	.007	.007	.000	.000	.000	.062
5	.000	.000	.007	.000	.020	.007	.007	.013	.000	.000	.054
6	.000	.000	.000	.000	.007	.020	.007	.000	.007	.007	.048
7	.000	.000	.000	.007	.007	.000	.020	.000	.000	.007	.041
8	.000	.000	.007	.000	.000	.007	.000	.007	.000	.000	.021
9	.000	.007	.000	.000	.000	.000	.000	.000	.007	.007	.021
10	.007	.000	.000	.000	.000	.000	.000	.000	.000	.007	.014
Sum	.033	.047	.040	.080	.060	.060	.047	.047	.033	.067	.514
0	.067	.053	.060	.020	.040	.040	.053	.053	.067	.033	.486

APPENDIX XXI

Observed Proportions of Questions Asked or Not Asked in Each Order for a Group of Non-Brain Damaged Patients

PROBLEM III

	Questions										
Order	1	2	3	4	5	6	7	8	9	10	Sum
1	.028	.017	.011	.017	.006	.000	.000	.017	.000	.006	.102
2	.006	.022	.022	.022	.017	.000	.006	.006	.000	.000	.101
3	.006	.022	.022	.000	.006	.000	.006	.011	.000	.000	.073
4	.000	.006	.000	.017	.011	.011	.006	.000	.011	.000	.062
5	.000	.000	.000	.000	.011	.017	.000	.011	.006	.017	.062
6	.000	.000	.000	.011	.000	.006	.011	.006	.006	.000	.040
7	.000	.000	.000	.000	.000	.006	.006	.006	.000	.006	.024
8	.000	.000	.000	.000	.000	.000	.000	.006	.000	.000	.006
9	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
10	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
Sum	.040	.067	.055	.067	.051	.040	.035	.063	.023	.029	.470
0	.060	.033	.045	.033	.049	.060	.065	.037	.077	.071	.530

APPENDIX XXII

Observed Proportions of Questions Asked or Not Asked in Each Order for a Group of Brain Damaged Patients

PROBLEM IV

Order	Questions 1	2	3	4	5	6	7	8	9	10	Sum
1	.023	.000	.008	.015	.000	.015	.008	.008	.000	.023	.100
2	.000	.023	.008	.000	.000	.008	.015	.008	.008	.015	.085
3	.000	.008	.031	.015	.000	.015	.000	.008	.000	.000	.077
4	.000	.000	.000	.031	.008	.000	.000	.008	.000	.000	.047
5	.000	.000	.008	.000	.023	.000	.000	.000	.000	.000	.031
6	.000	.000	.000	.000	.000	.023	.008	.000	.000	.000	.031
7	.000	.000	.000	.000	.000	.000	.023	.008	.000	.000	.031
8	.000	.000	.000	.000	.000	.000	.000	.023	.000	.000	.023
9	.000	.000	.000	.000	.000	.000	.000	.000	.023	.000	.023
10	.000	.000	.000	.000	.000	.000	.000	.000	.000	.023	.023
Sum	.023	.031	.054	.062	.031	.062	.054	.062	.031	.062	.472
0	.077	.069	.046	.038	.069	.038	.046	.038	.069	.038	.528

APPENDIX XXIII

Observed Proportions of Questions Asked or Not Asked in Each Order for a Group of Non-Brain Damaged Patients

PROBLEM IV

Order	Questions 1	2	3	4	5	6	7	8	9	10	Sum
1	.017	.028	.000	.022	.006	.006	.011	.000	.000	.011	.101
2	.006	.017	.011	.022	.000	.011	.011	.006	.000	.017	.101
3	.000	.011	.011	.017	.000	.011	.011	.022	.000	.017	.100
4	.000	.000	.000	.000	.000	.000	.006	.022	.006	.006	.040
5	.000	.000	.006	.006	.006	.000	.006	.006	.000	.000	.030
6	.000	.000	.000	.006	.006	.000	.006	.000	.000	.006	.024
7	.000	.011	.000	.000	.000	.000	.000	.000	.006	.000	.017
8	.000	.000	.000	.000	.006	.000	.000	.000	.000	.000	.006
9	.000	.000	.000	.000	.000	.000	.000	.000	.006	.000	.006
10	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
Sum	.023	.067	.028	.073	.024	.028	.051	.056	.018	.057	.425
0	.077	.033	.072	.027	.076	.072	.049	.044	.082	.043	.575

APPENDIX XXIV

Observed Proportions of Questions Asked or Not Asked

in Each Order for a Group of Brain Damaged Patients

PROBLEM V

	Questions										
Order	1	2	3	4	5	6	7	8	9	10	Sum
1	.027	.000	.009	.000	.009	.027	.000	.000	.018	.009	.099
2	.000	.036	.009	.000	.009	.000	.000	.000	.018	.018	.090
3	.009	.000	.027	.000	.000	.000	.009	.000	.000	.009	.054
4	.000	.000	.000	.027	.000	.009	.009	.000	.000	.000	.045
5	.000	.000	.009	.000	.027	.000	.000	.000	.000	.000	.036
6	.000	.000	.000	.000	.000	.027	.000	.000	.000	.000	.027
7	.000	.000	.000	.000	.000	.000	.018	.000	.000	.000	.018
8	.000	.000	.000	.000	.000	.000	.000	.018	.000	.000	.018
9	.000	.000	.000	.000	.000	.000	.000	.000	.018	.000	.018
10	.000	.000	.000	.000	.000	.000	.000	.000	.000	.009	.009
Sum	.036	.036	.055	.027	.045	.064	.036	.018	.055	.045	.417
0	.064	.064	.045	.073	.055	.036	.064	.082	.045	.055	.583

APPENDIX XXV

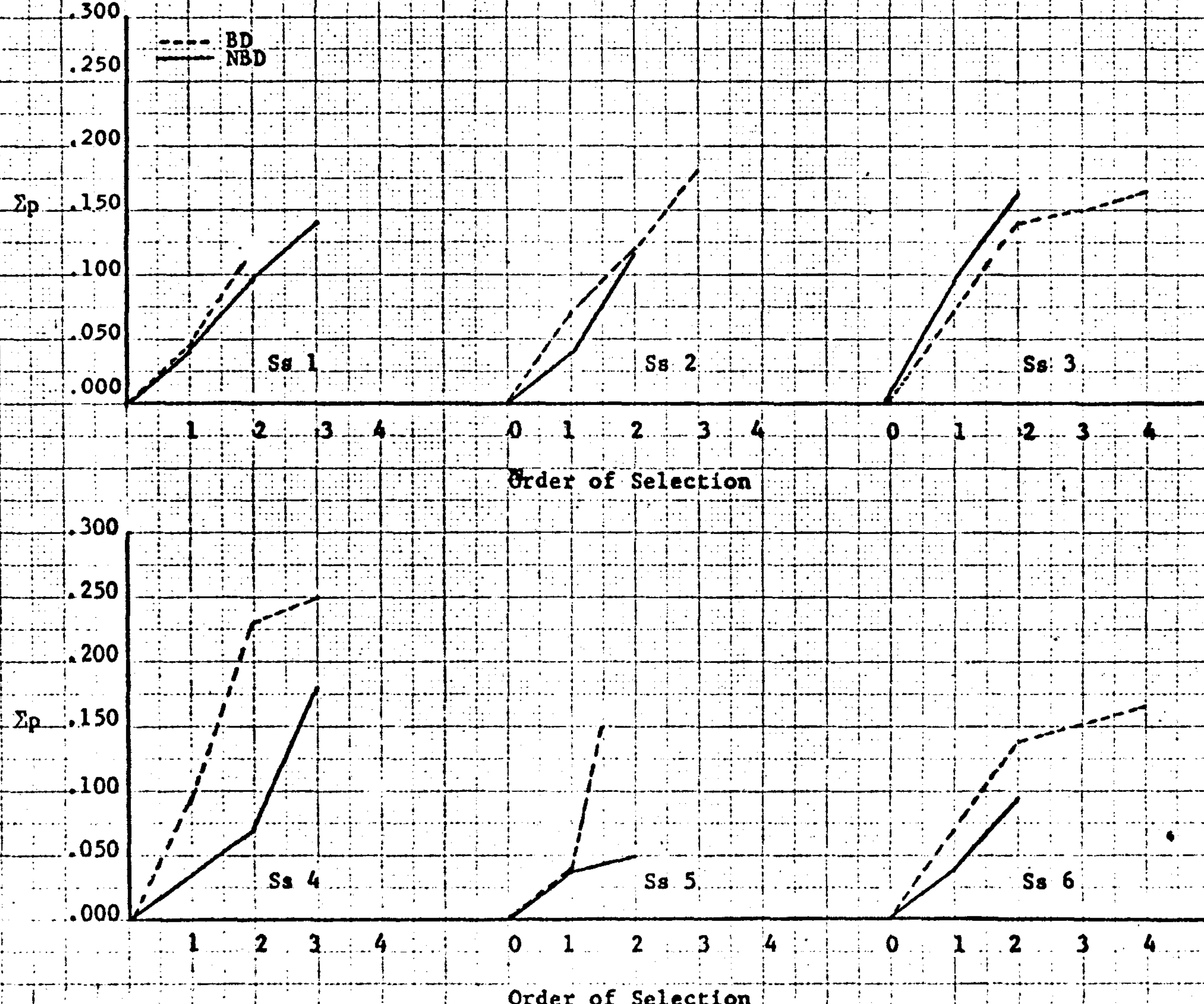
Observed Proportions of Questions Asked or Not Asked

in Each Order for a Group of Non-Brain Damaged

Patients

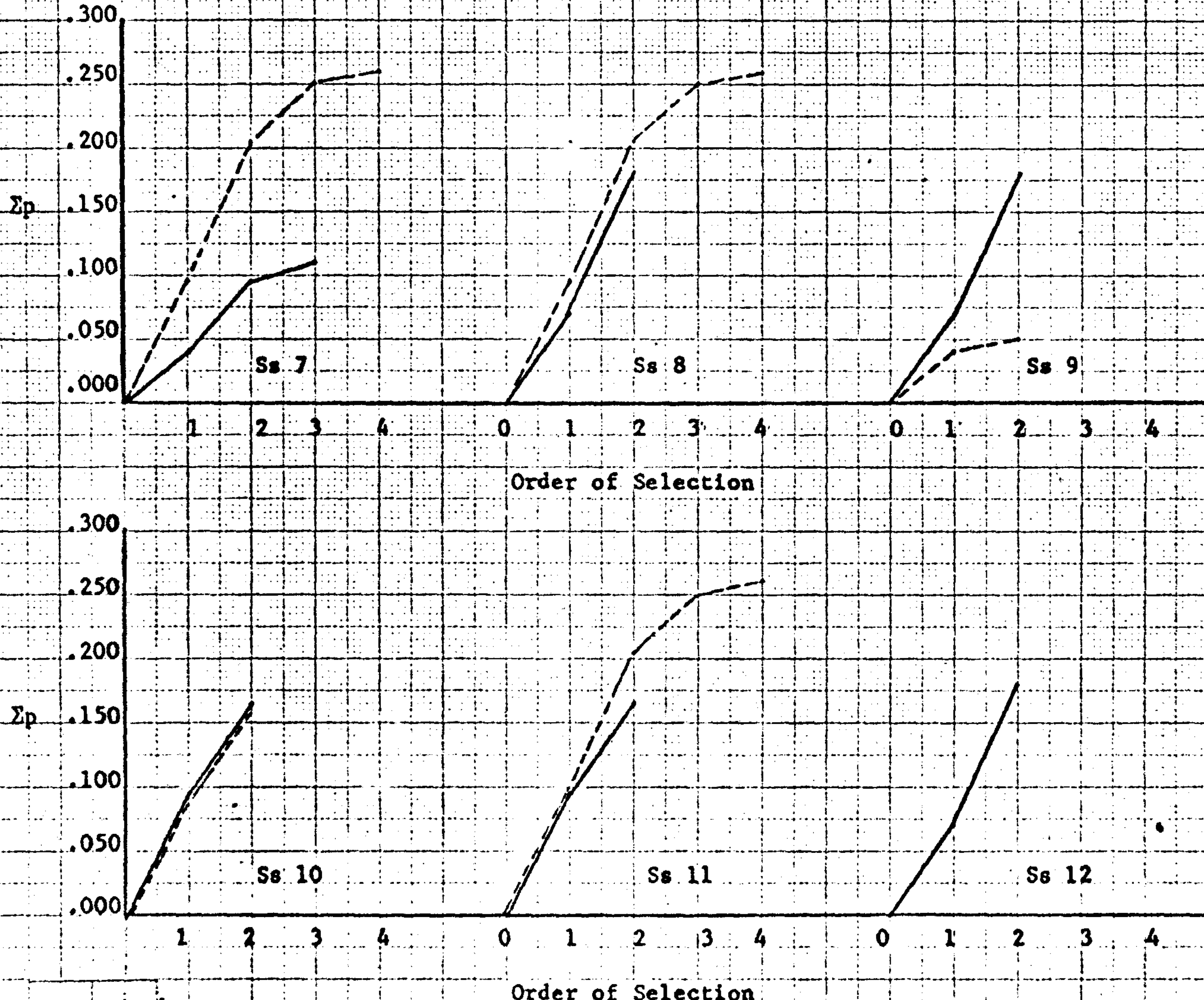
PROBLEM V

Order	Questions 1	2	3	4	5	6	7	8	9	10	Sum
1	.000	.000	.029	.006	.012	.012	.000	.000	.018	.024	.093
2	.000	.000	.012	.000	.000	.041	.012	.006	.024	.006	.101
3	.000	.000	.018	.000	.000	.018	.000	.000	.012	.035	.083
4	.000	.000	.006	.000	.012	.006	.000	.000	.012	.012	.048
5	.000	.000	.000	.000	.000	.006	.000	.006	.000	.000	.012
6	.006	.000	.000	.000	.000	.000	.000	.000	.000	.000	.006
7	.000	.006	.000	.000	.000	.000	.000	.000	.000	.000	.006
8	.000	.000	.000	.000	.000	.000	.000	.000	.006	.000	.006
9	.000	.000	.006	.000	.000	.000	.000	.000	.000	.000	.006
10	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
Sum	.006	.006	.071	.006	.024	.082	.012	.012	.071	.076	.366
0	.094	.094	.029	.094	.076	.018	.088	.088	.029	.024	.634



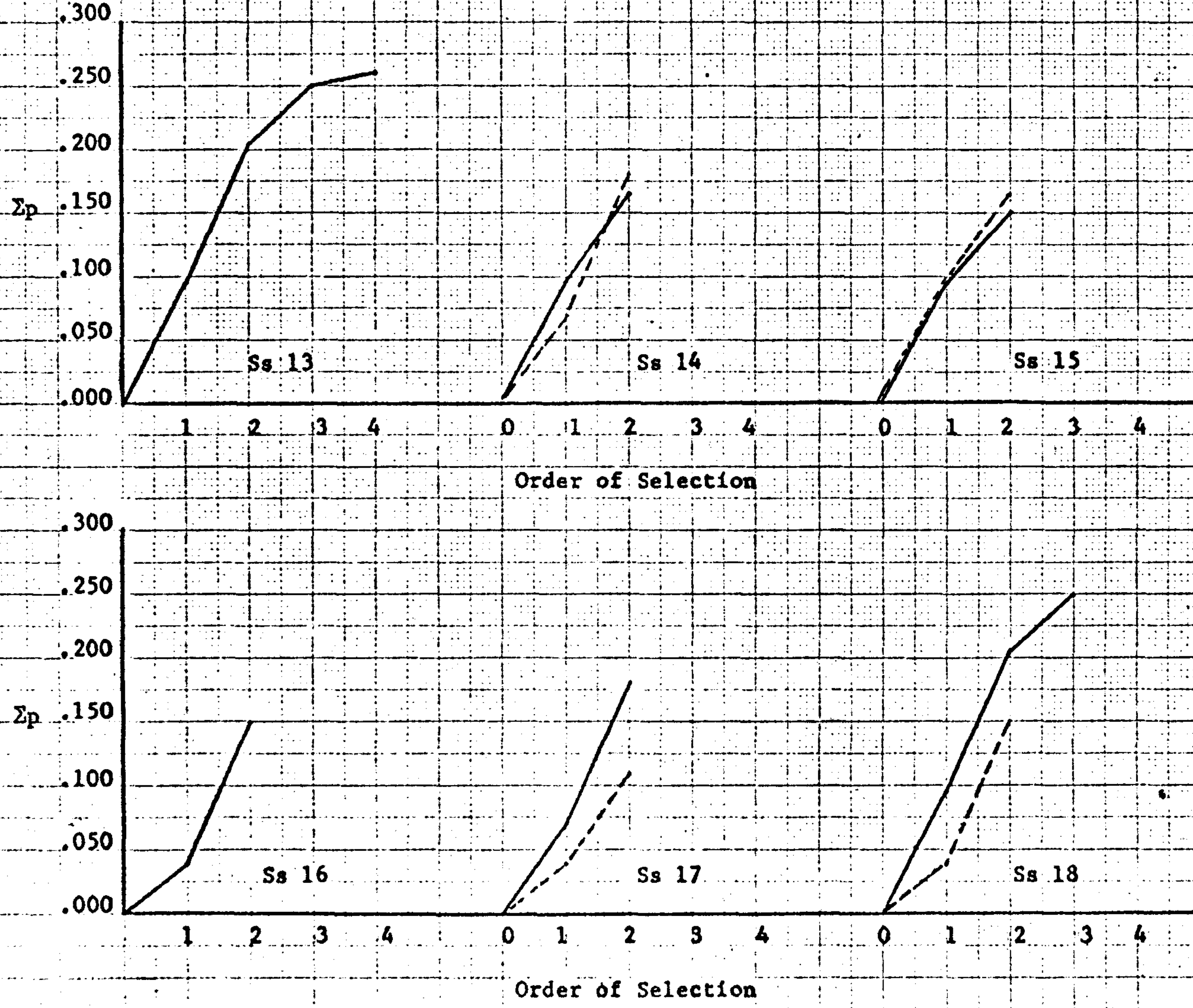
Individual Performance Curves by Order Analysis for a Group of Brain Damaged and Non-Brain Damaged Patients on Problem II.

APPENDIX XXVII



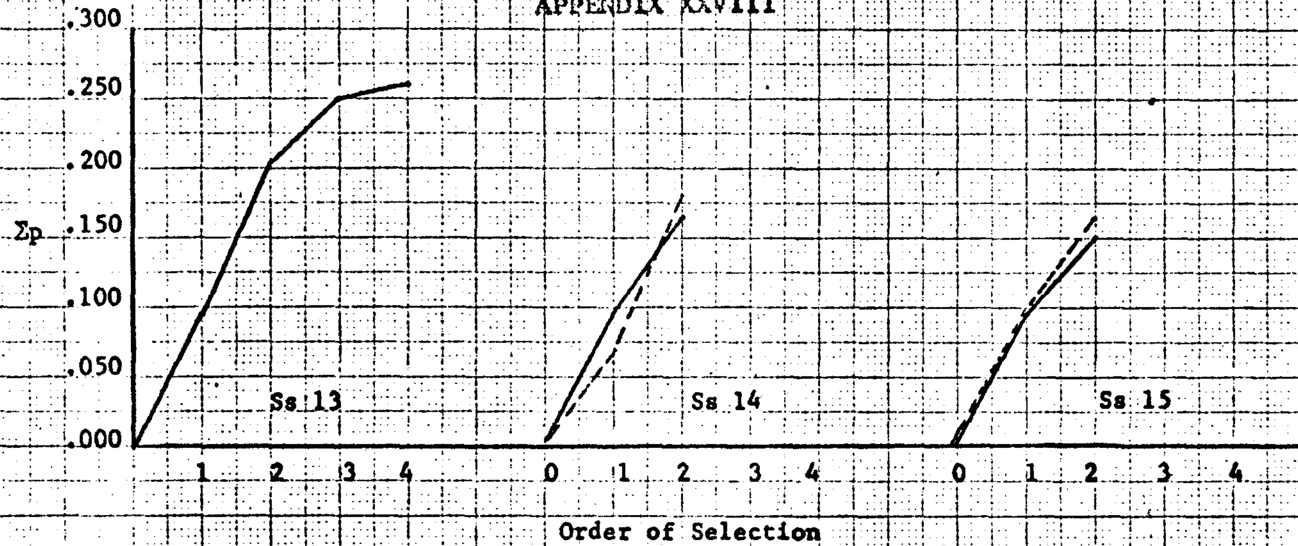
Individual Performance Curves by Order Analysis for a Group of Brain Damaged and Non-Brain Damaged Patients on Problem II

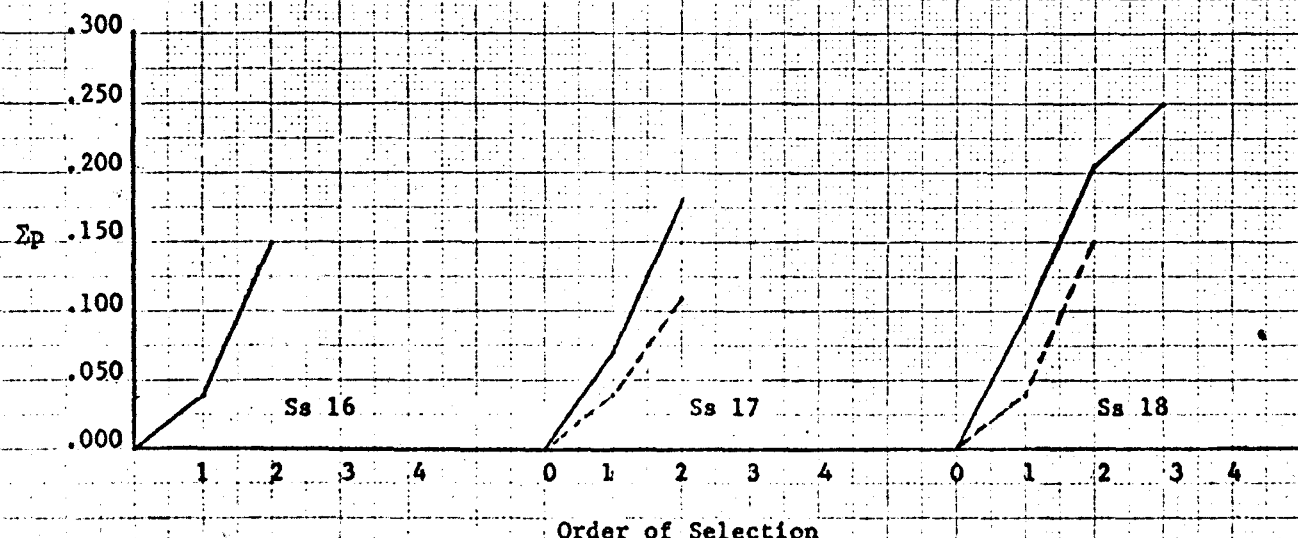
APPENDIX XXVIII



Individual Performance Curves by Order Analysis for a Group of Brain Damaged and Non-Brain Damaged Patients on Problem II

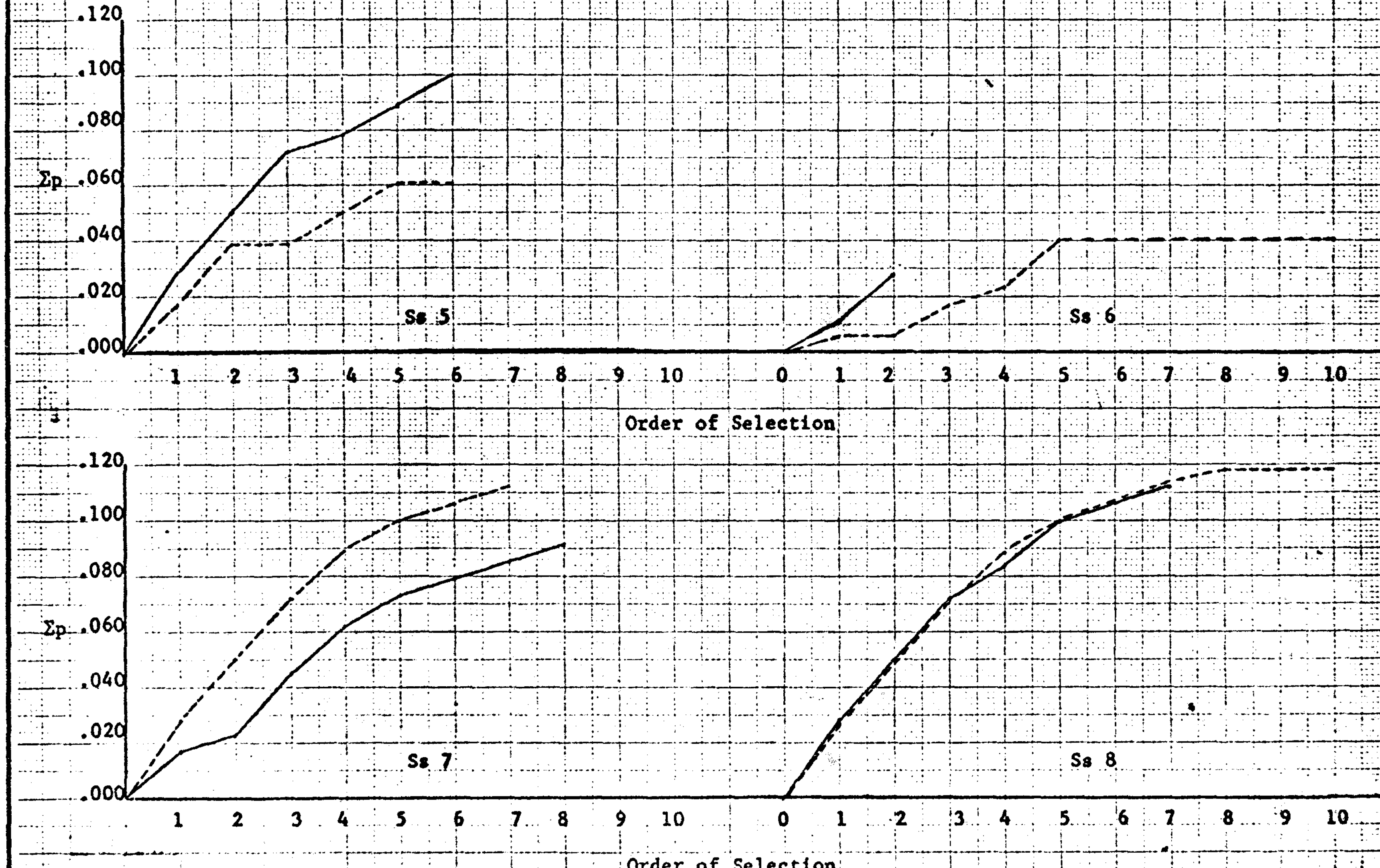
APPENDIX XXVIII





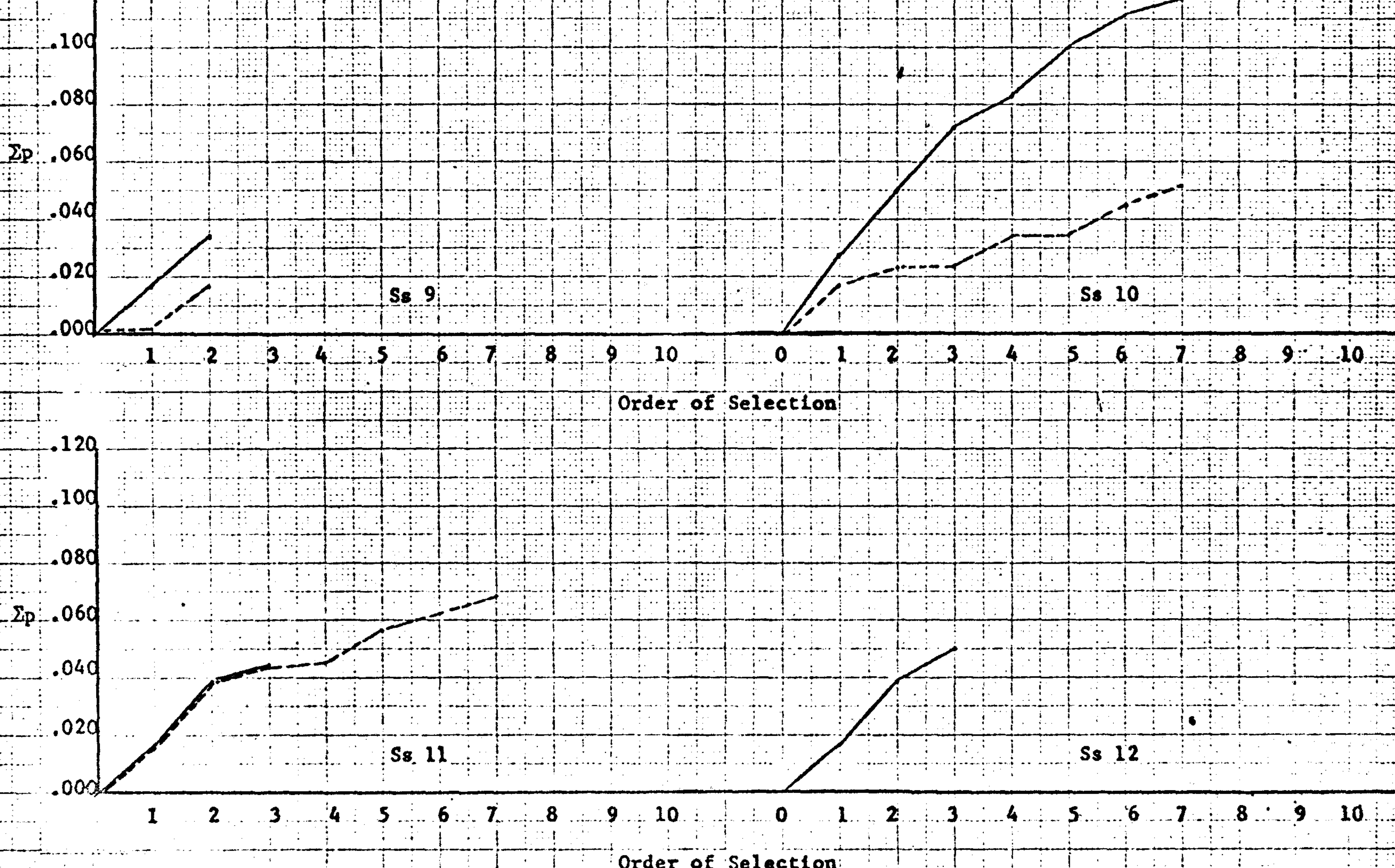
Individual Performance Curves by Order Analysis for a Group of Brain Damaged and Non-Brain Damaged Patients on Problem II

APPENDIX XXX



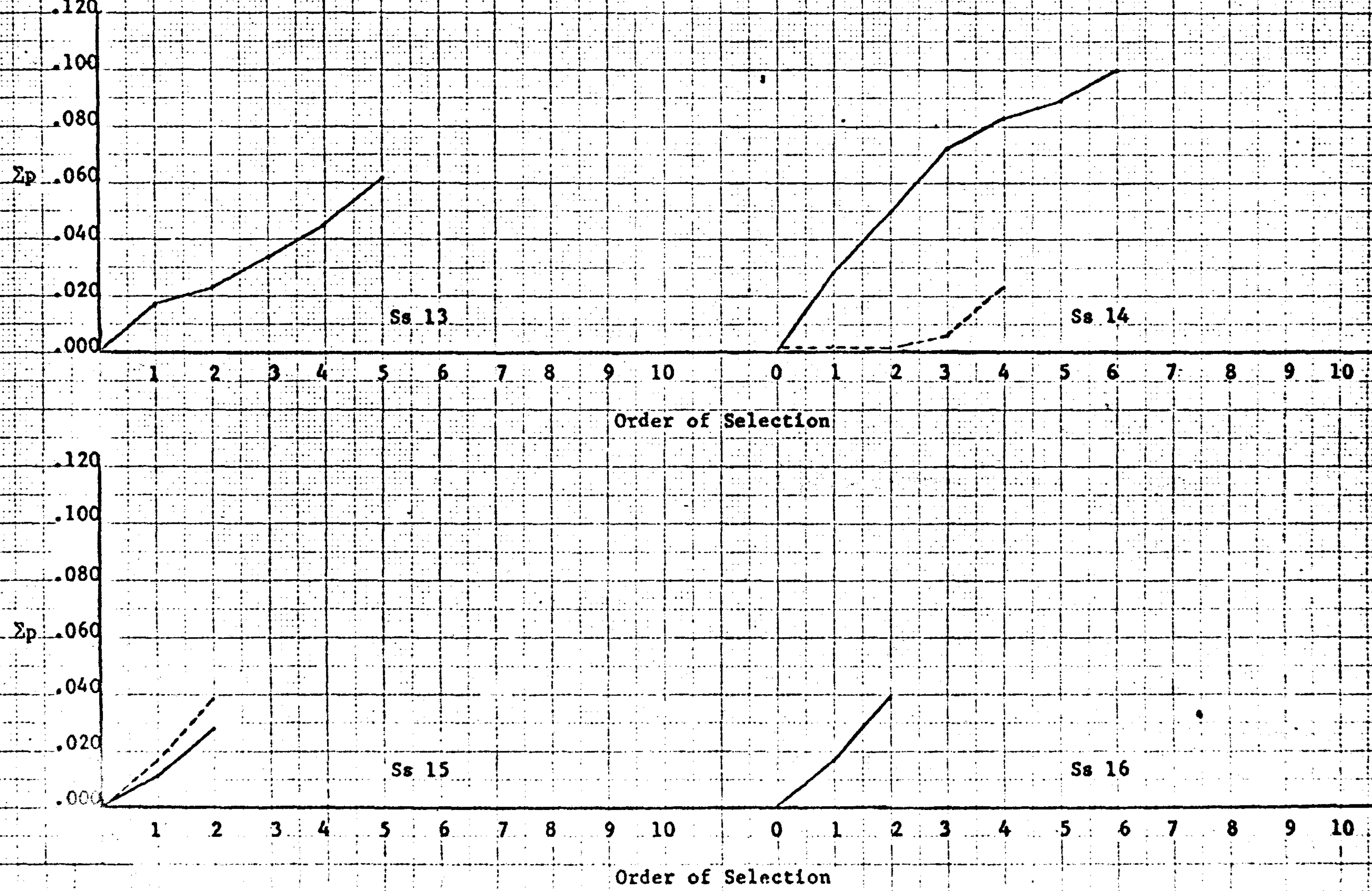
Individual Performance Curves by Order Analysis for a Group of Brain Damaged and Non-Brain Damaged Patients on Problem III.

APPENDIX XXXI



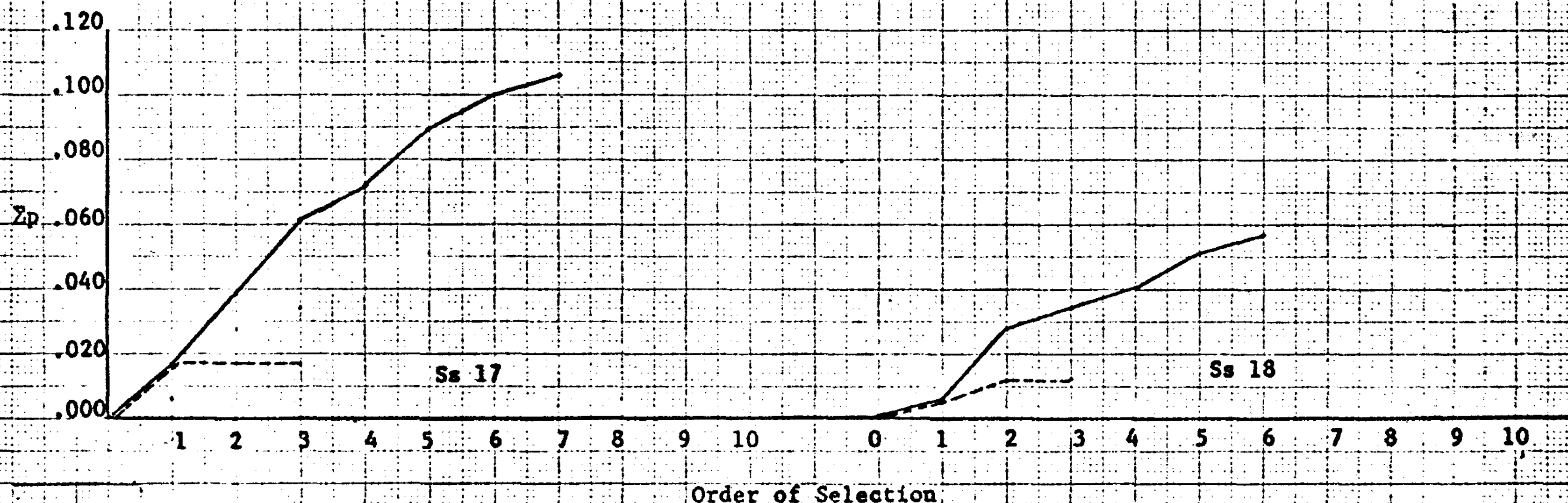
Individual Performance Curves by Order Analysis for a Group of Brain Damaged and Non-Brain Damaged Patients on Problem III.

APPENDIX XXXII



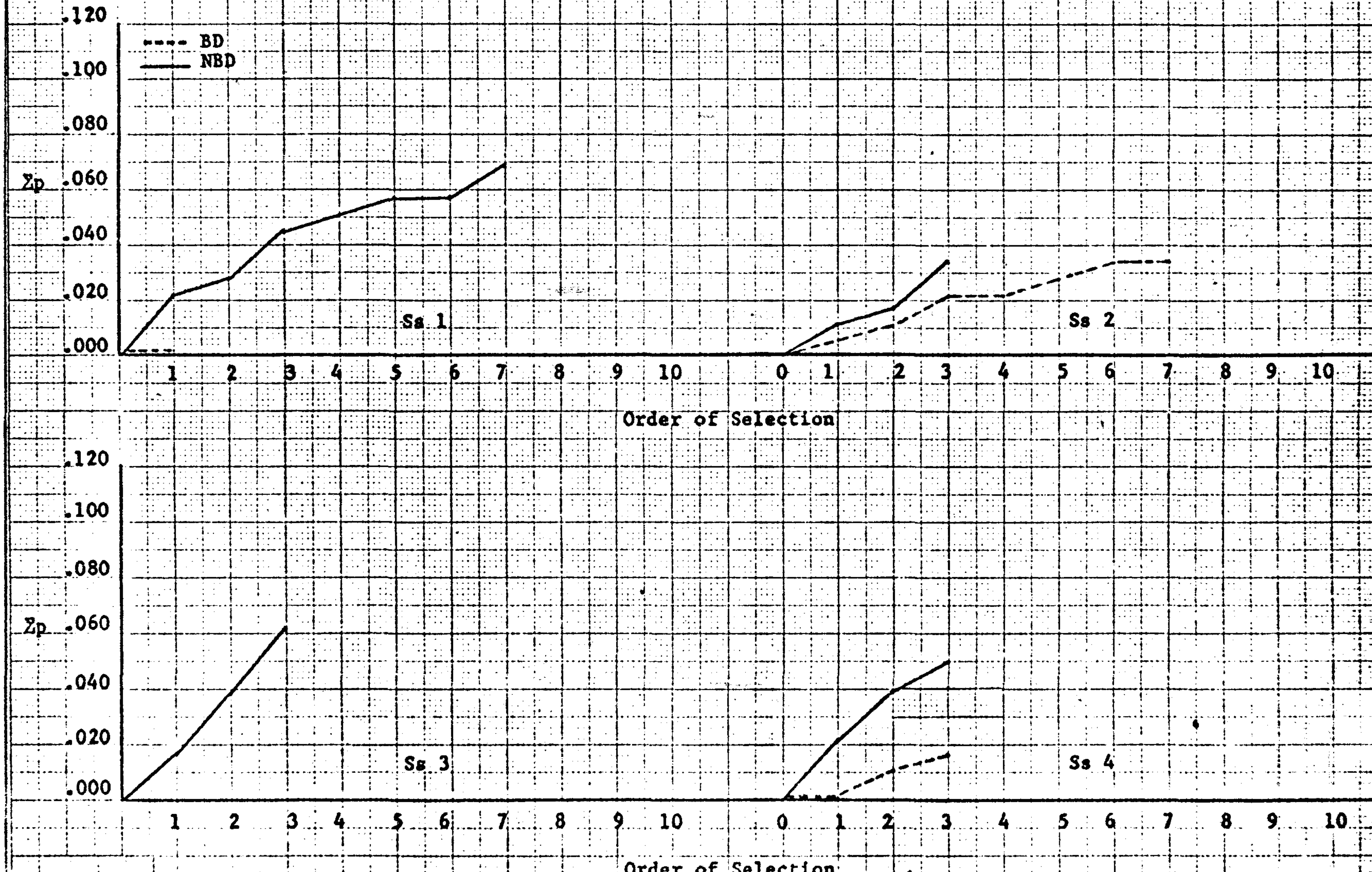
' Individual Performance Curves by Order Analysis for a Group of Brain Damaged and Non-Brain Damaged Patients on Problem III.

APPENDIX XXXIII



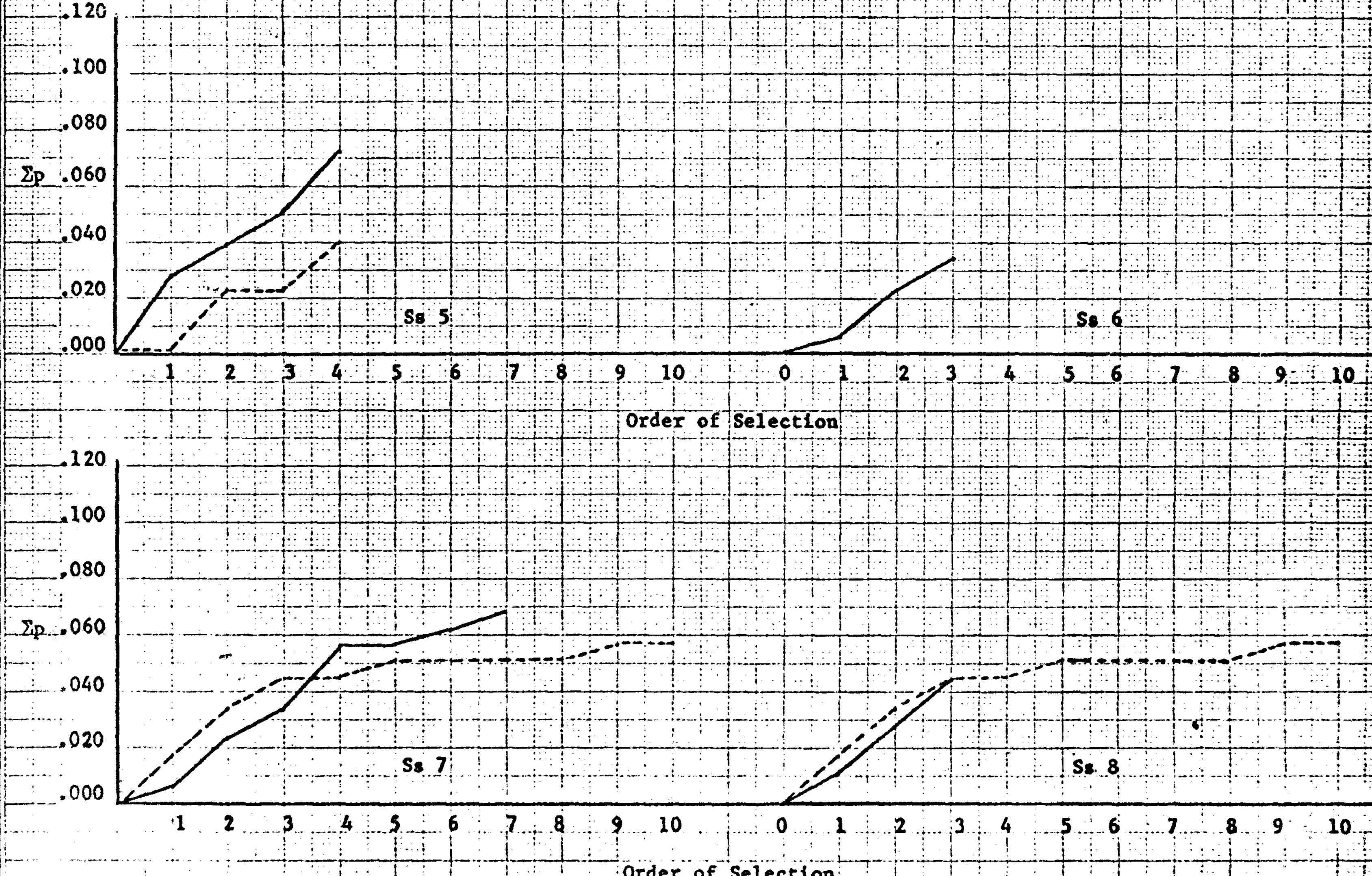
Individual Performance Curves by Order Analysis for a Group of Brain Damaged and Non-Brain Damaged Patients on Problem III.

APPENDIX XXXIV



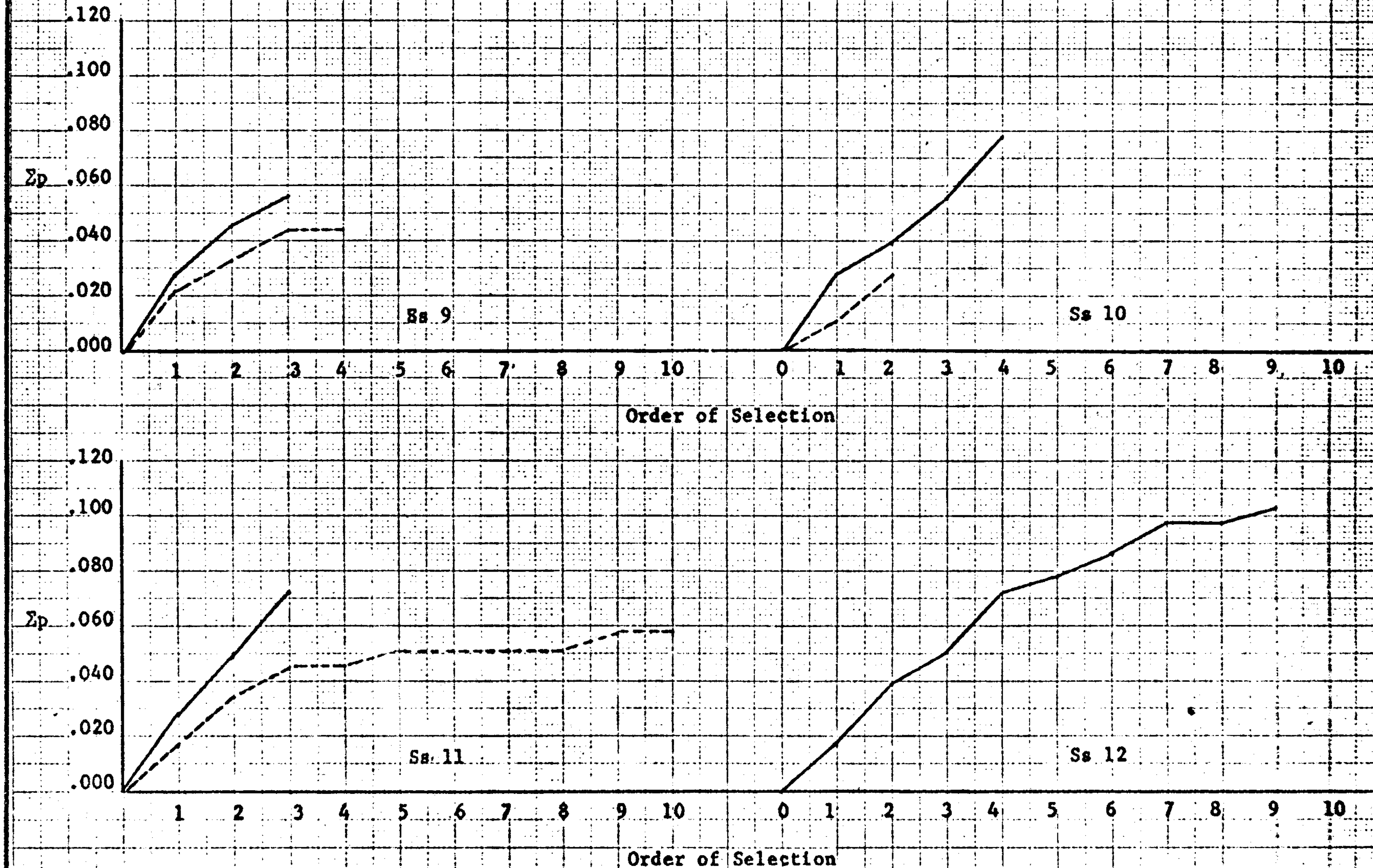
Individual Performance Curves by Order Analysis for a Group of Brain Damaged and Non-Brain Damaged Patients on Problem IV.

APPENDIX XXXV



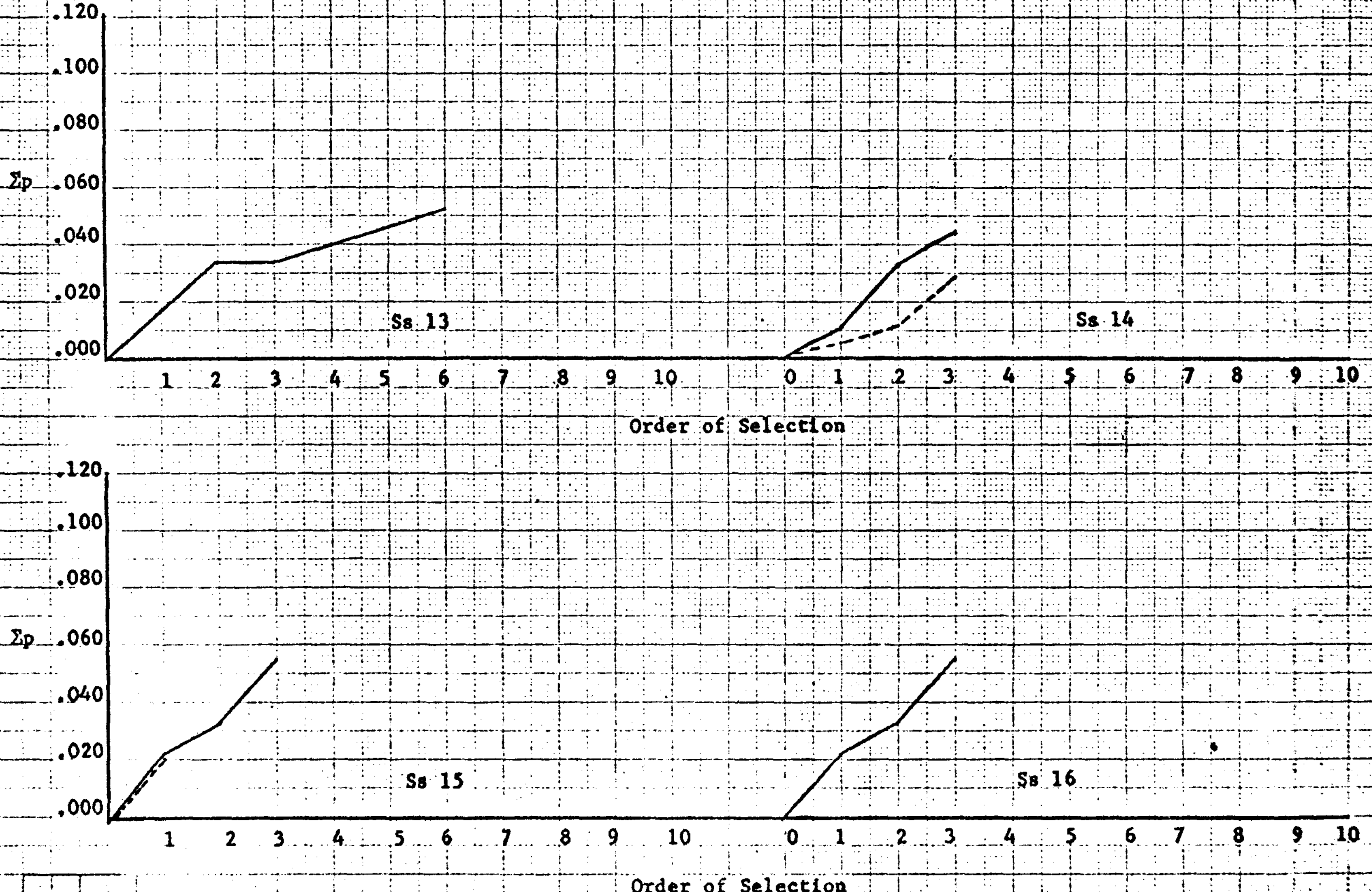
Individual Performance Curves by Order Analysis for a Group of Brain Damaged and Non-Brain Damaged Patients on Problem IV.

APPENDIX XXXVI



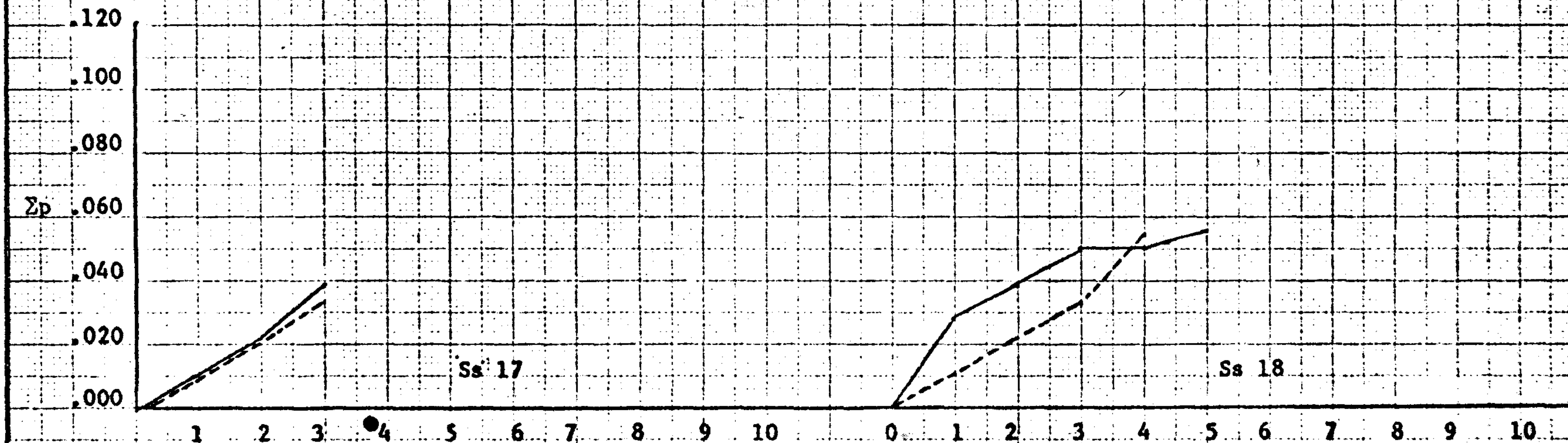
Individual Performance Curves by Order Analysis for a Group of Brain Damaged and Non-Brain Damaged Patients on Problem IV.

APPENDIX XXXVII



Individual Performance Curves by Order Analysis for a Group of Brain Damaged and Non-Brain Damaged Patients on Problem IV.

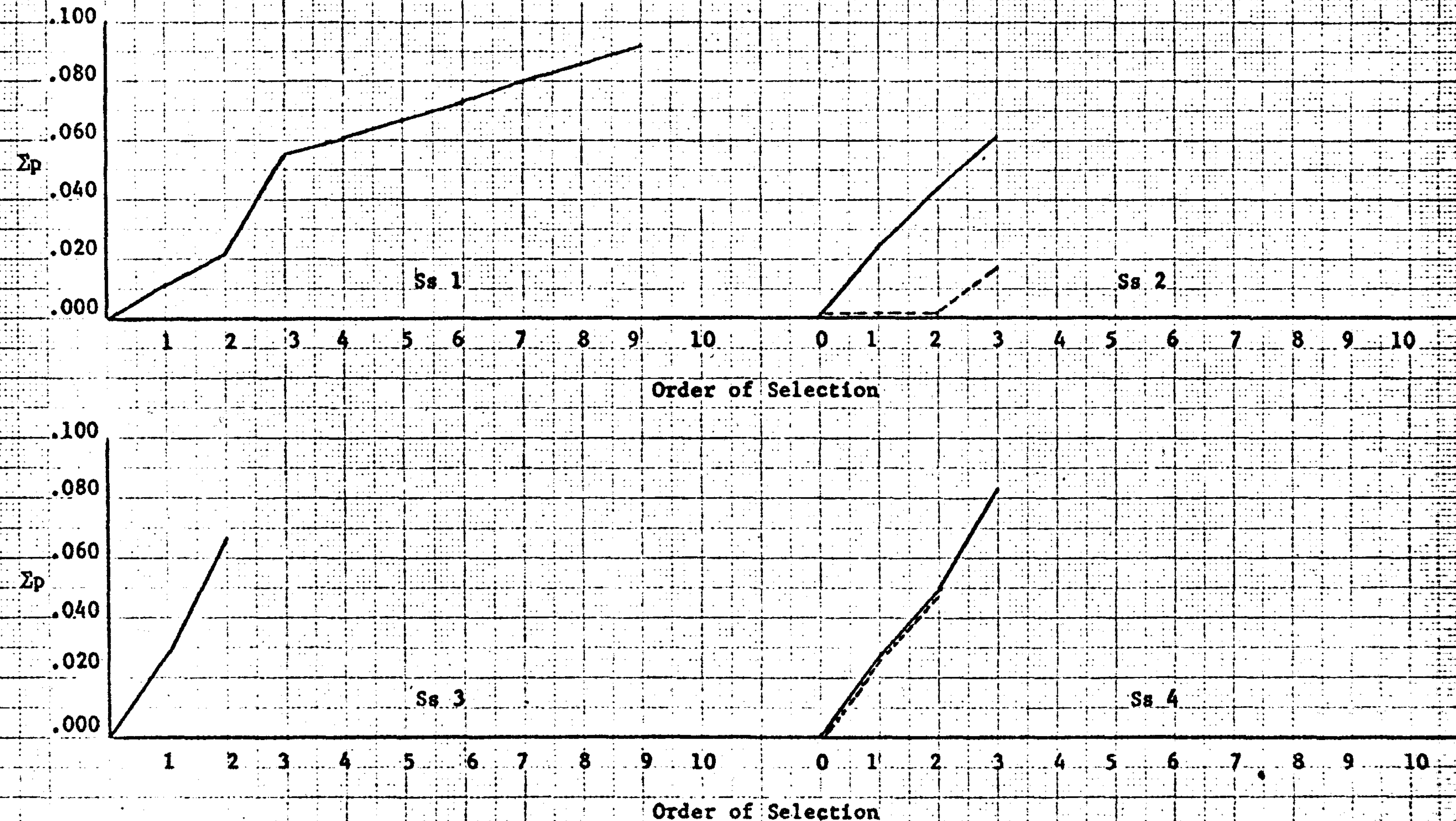
APPENDIX XXXVIII



Order of Selection

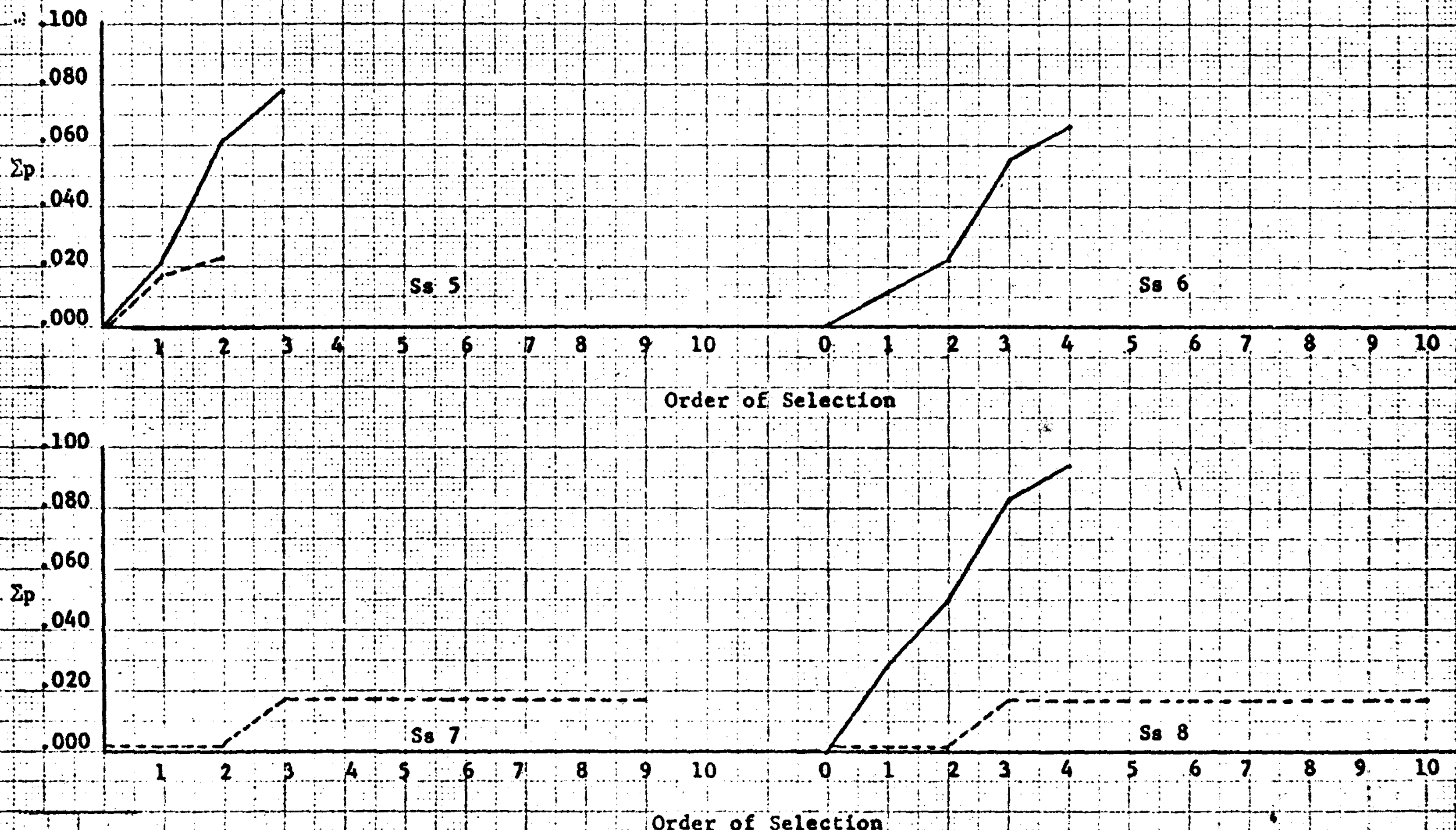
Individual Performance Curves by Order Analysis for a Group of Brain Damaged and Non-Brain Damaged Patients on Problem IV.

APPENDIX XXXIX



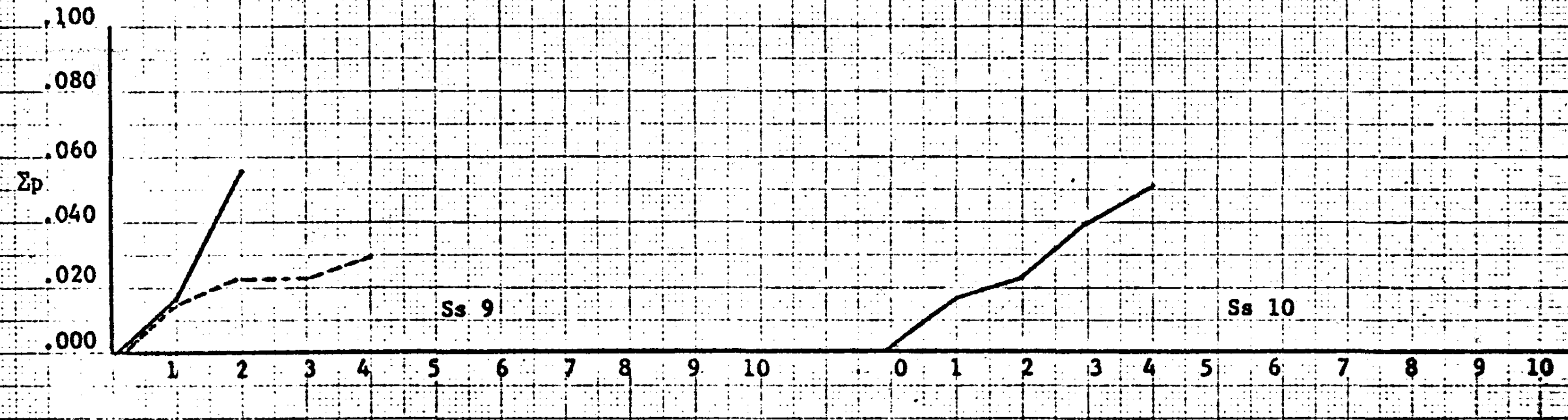
Individual Performance Curves by Order Analysis for a Group of Brain Damaged and Non-Brain Damaged Patients on Problem V.

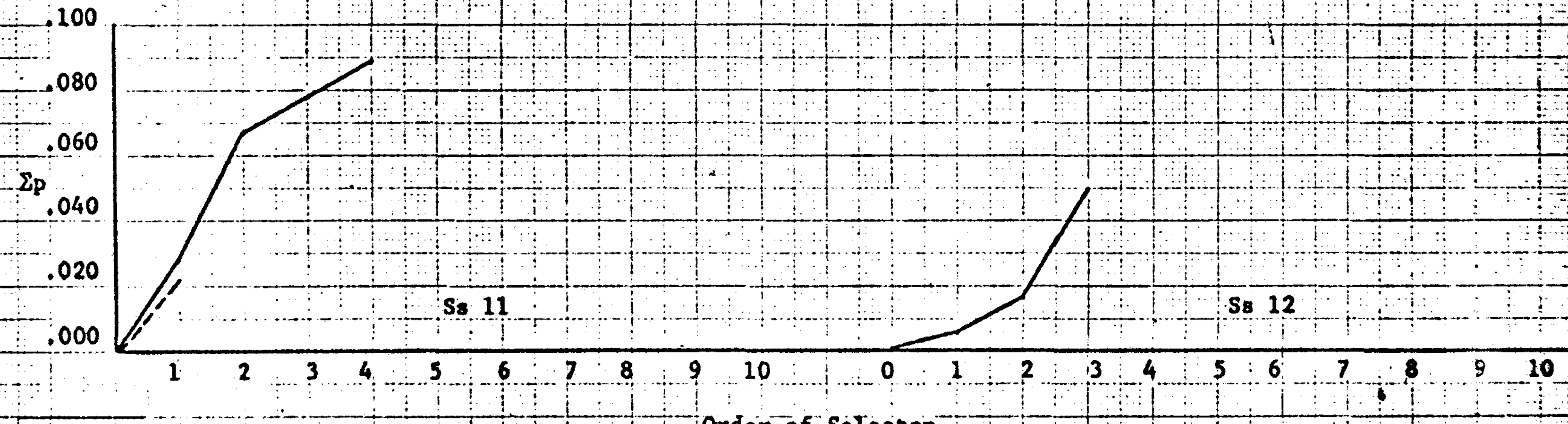
APPENDIX XL



Individual Performance Curves by Order Analysis for a Group of Brain Damaged and Non-Brain Damaged Patients on Problem V.

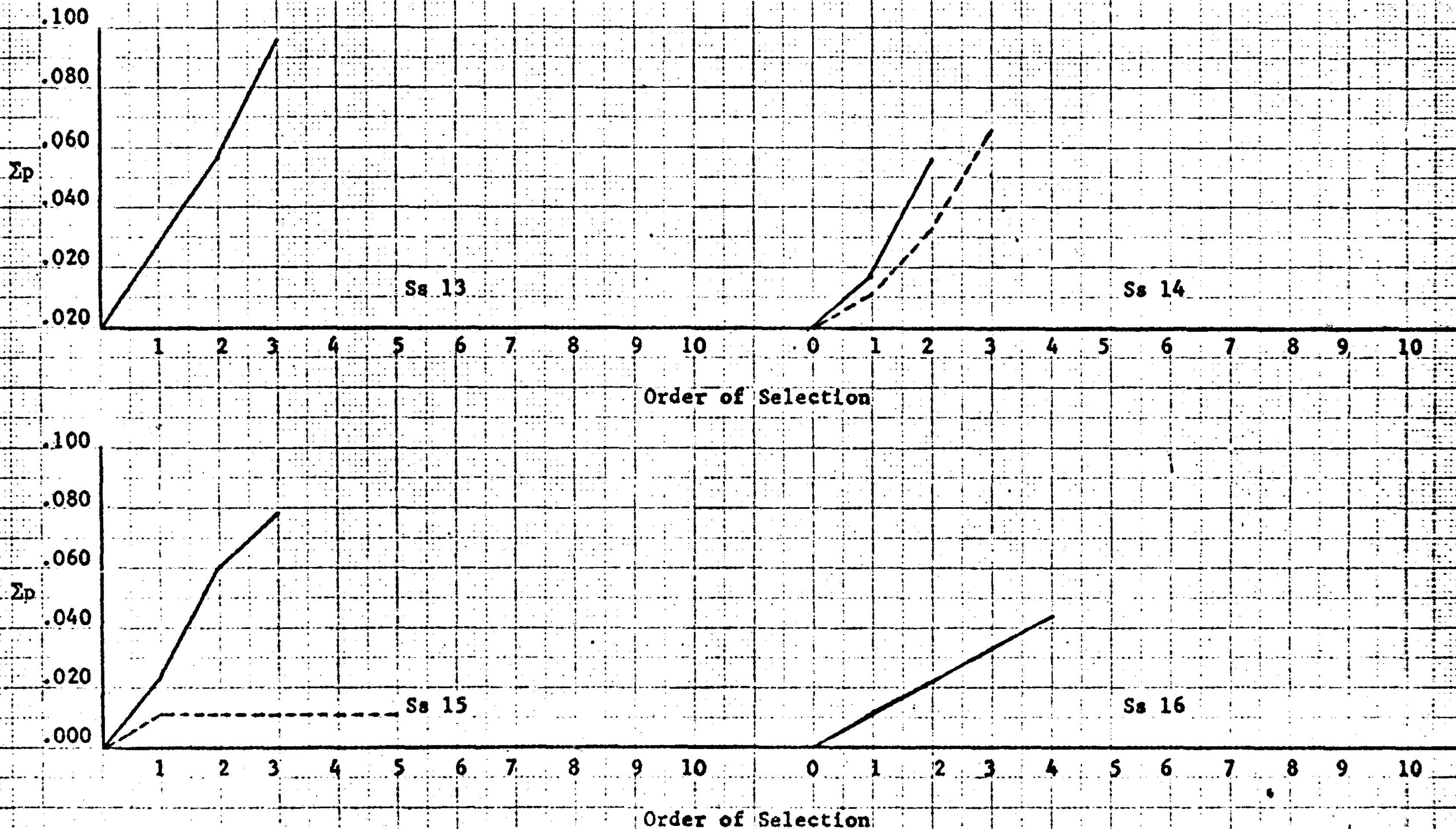
APPENDIX XLI





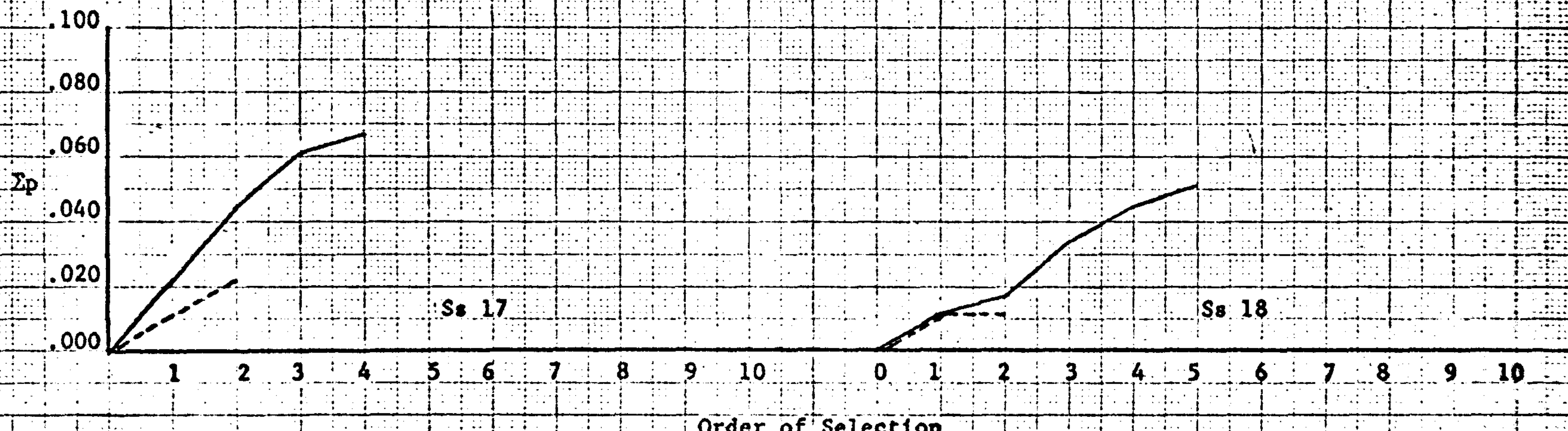
Individual Performance Curves by Order Analysis for a Group of Brain Damaged and Non-Brain Damaged Patients on Problem V.

APPENDIX XLII



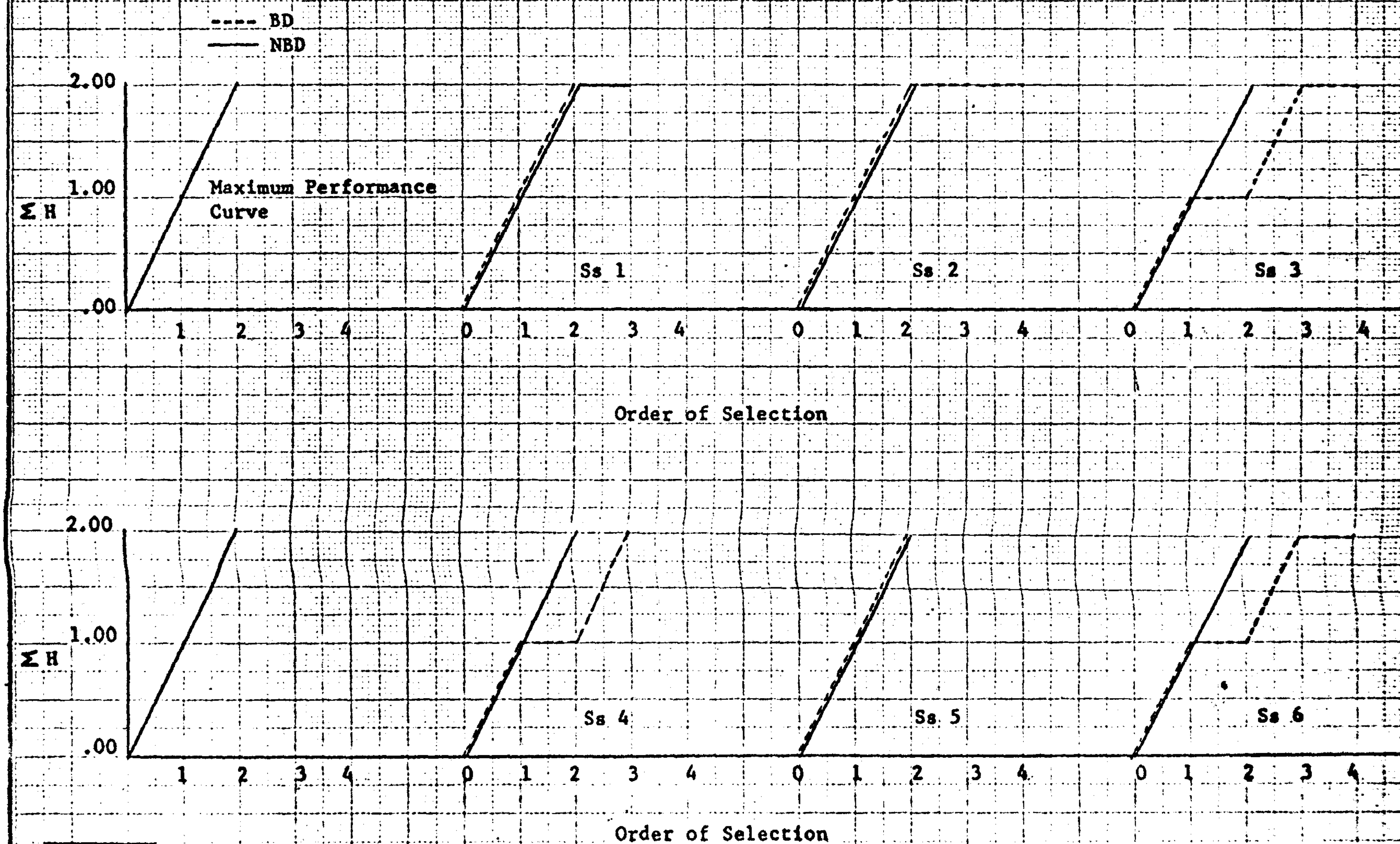
Individual Performance Curves by Order Analysis for a Group of Brain Damaged and Non-Brain Damaged Patients on Problem V.

APPENDIX XLIII

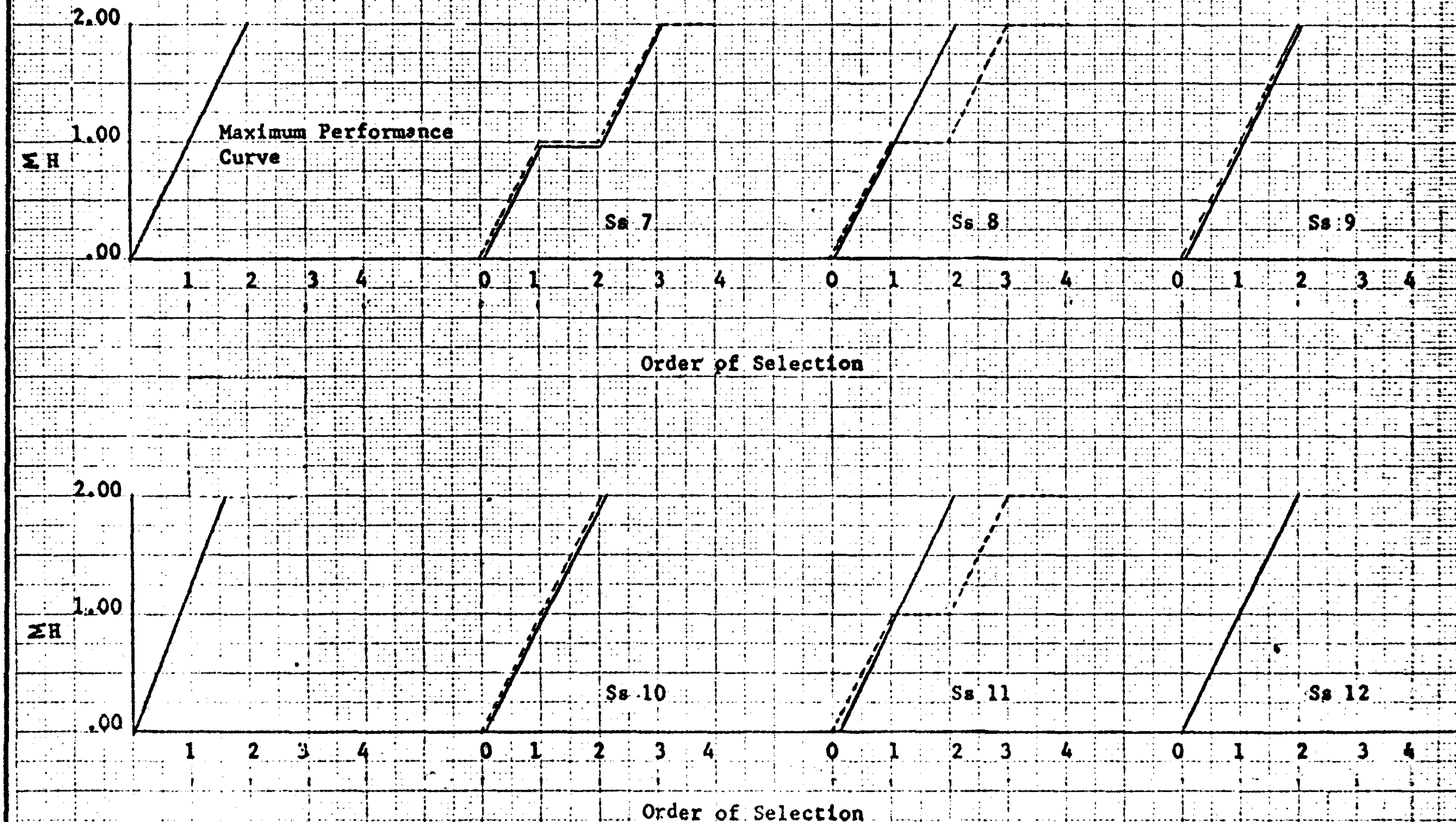


Individual Performance Curves by Order Analysis for a Group of Brain Damaged and Non-Brain Damaged Patients on Problem V.

APPENDIX XLIV

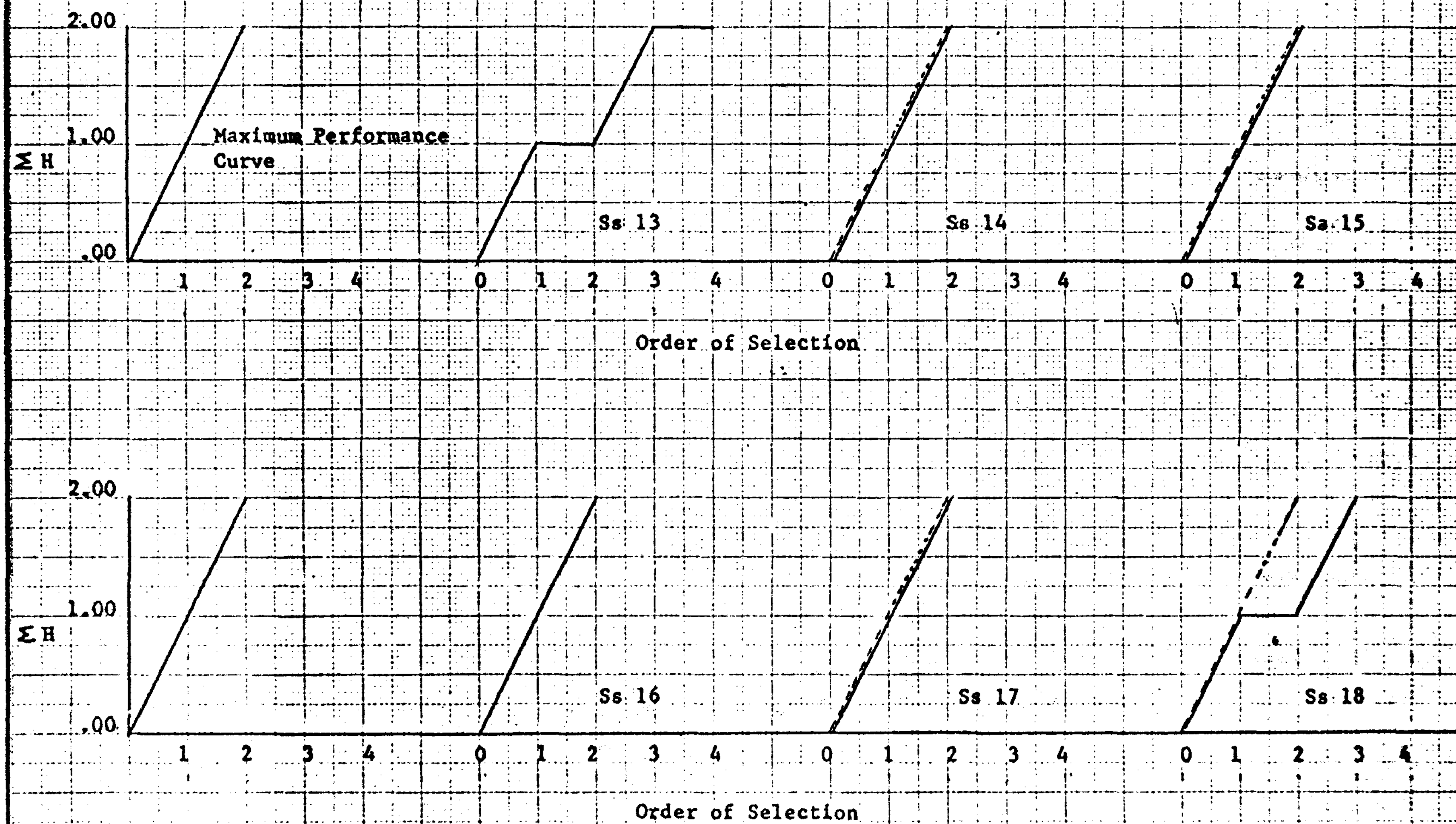


Individual Performance Curves According to Accumulated " Bits of Information " for Problem II.



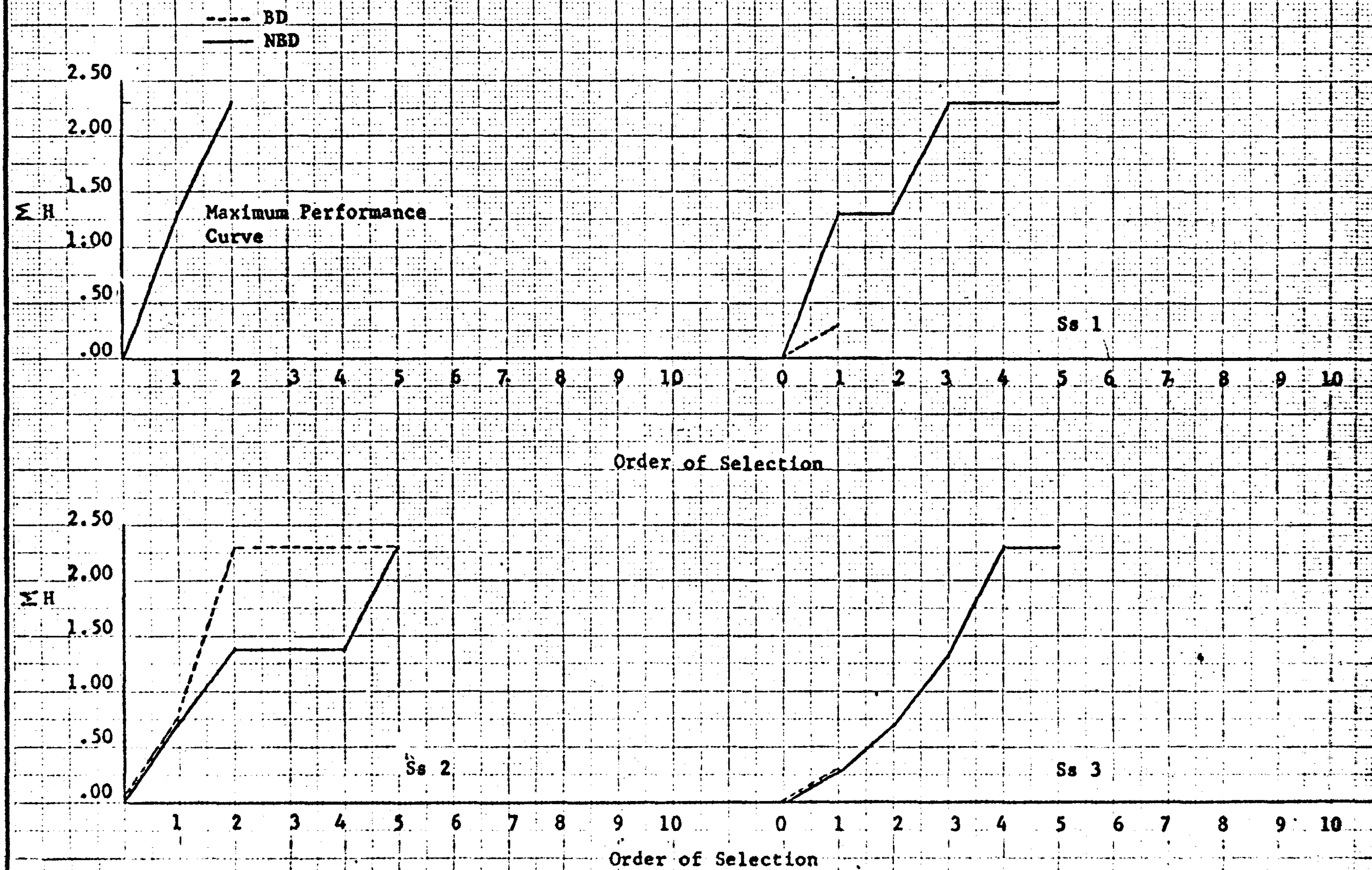
Individual Performance Curves According to Accumulated " Bits of Information " for Problem II.

APPENDIX XLVI



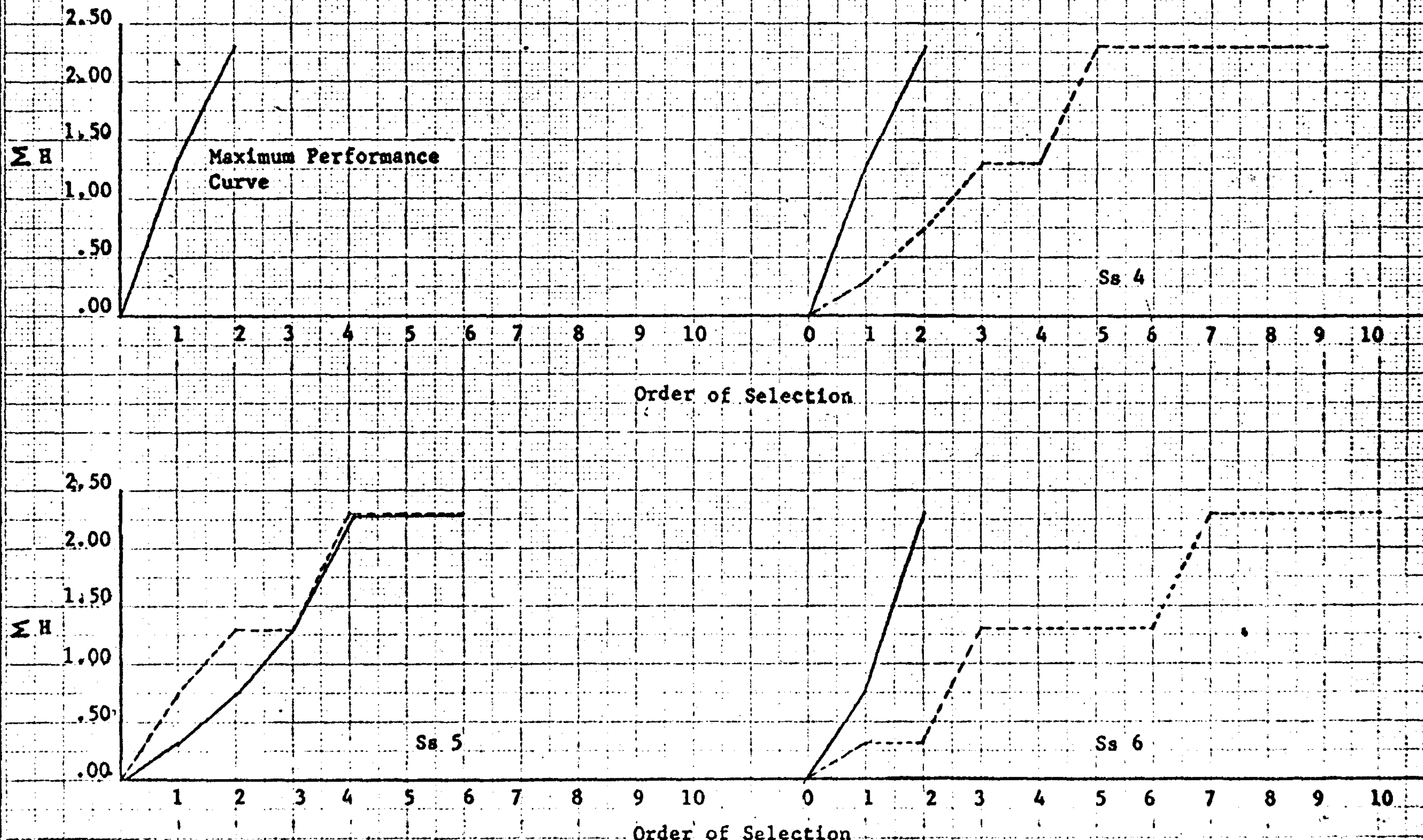
Individual Performance Curves According to Accumulated " Bits of Information " for Problem II.

APPENDIX XLVII



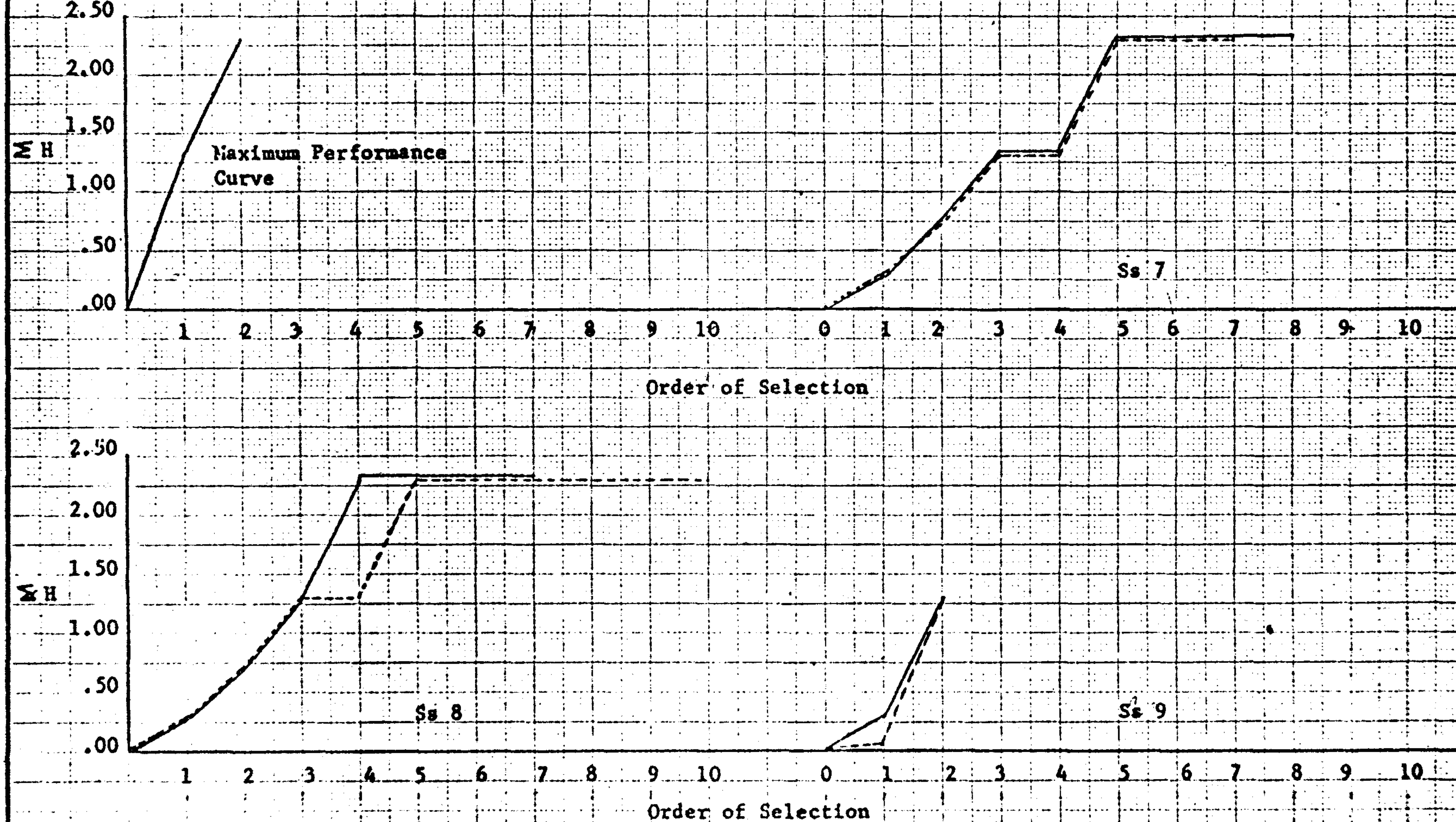
Individual Performance Curves According to Accumulated " Bits of INformation " for Problem III.

APPENDIX XLVIII



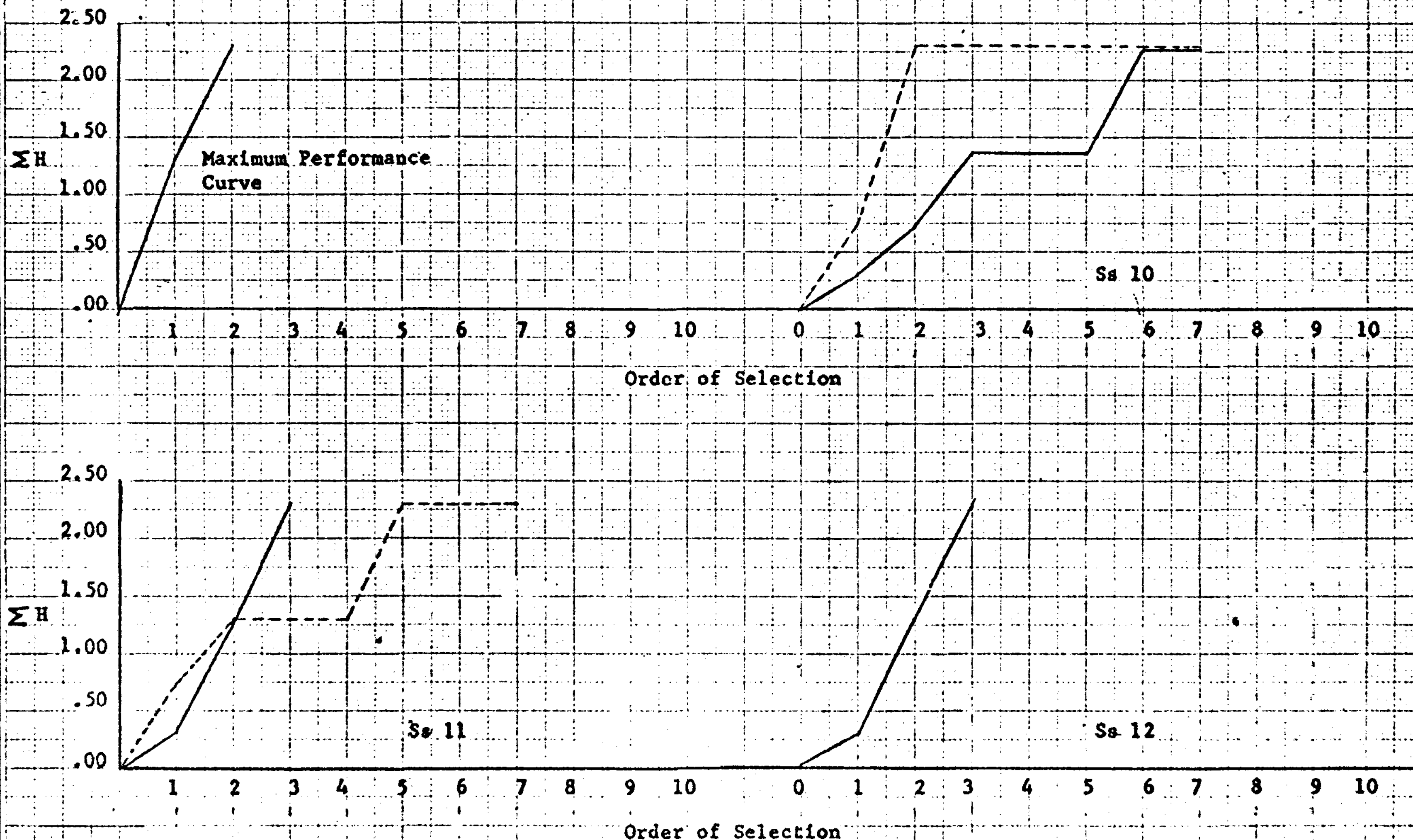
Individual Performance Curves According to Accumulated " Bits of Information " for Problem III.

APPENDIX XLIX



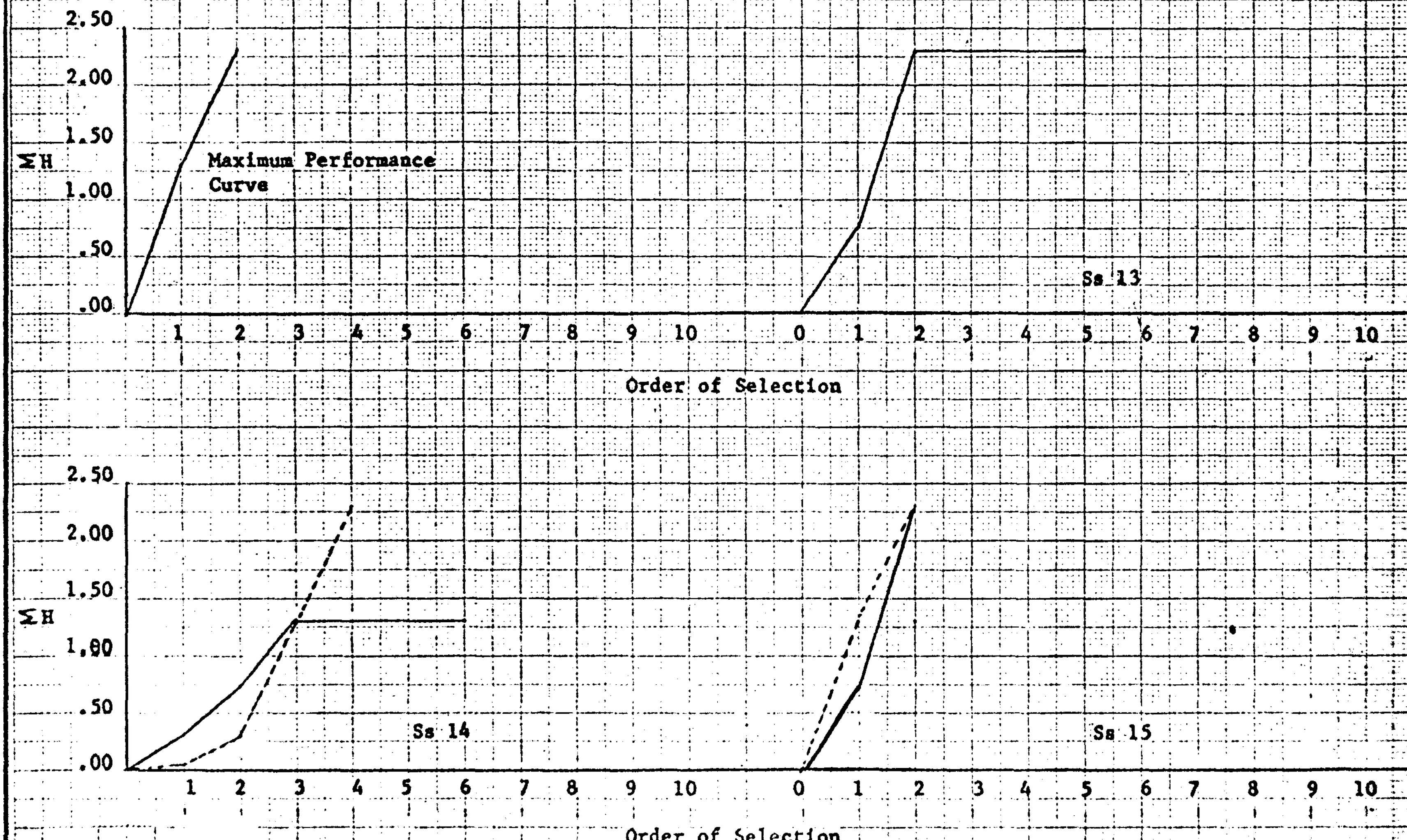
Individual Performance Curves According to Accumulated " Bits of Information " for Problem III.

APPENDIX L



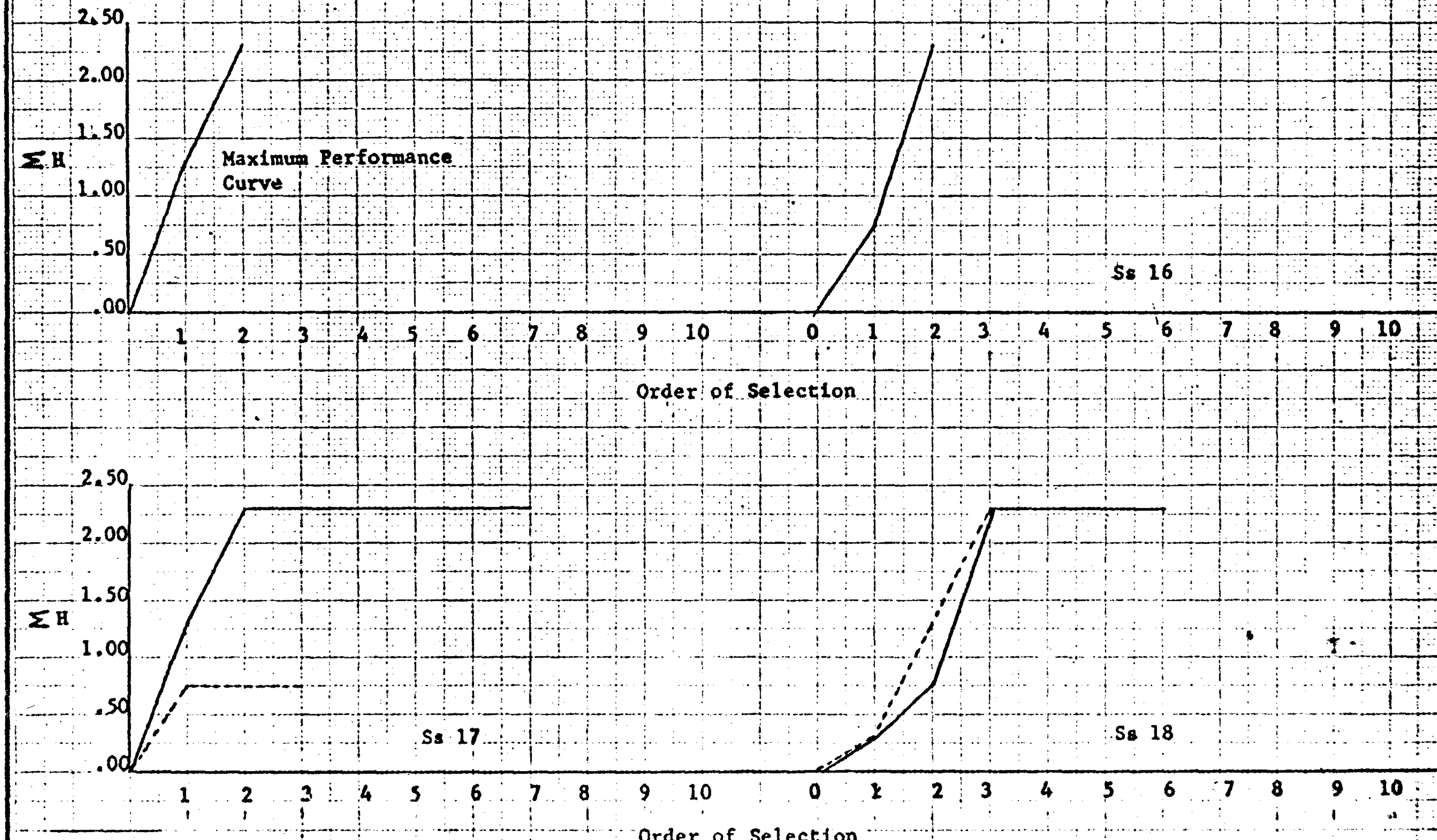
Individual Performance Curves According to Accumulated " Bits of Information " for Problem III.

APPENDIX LI



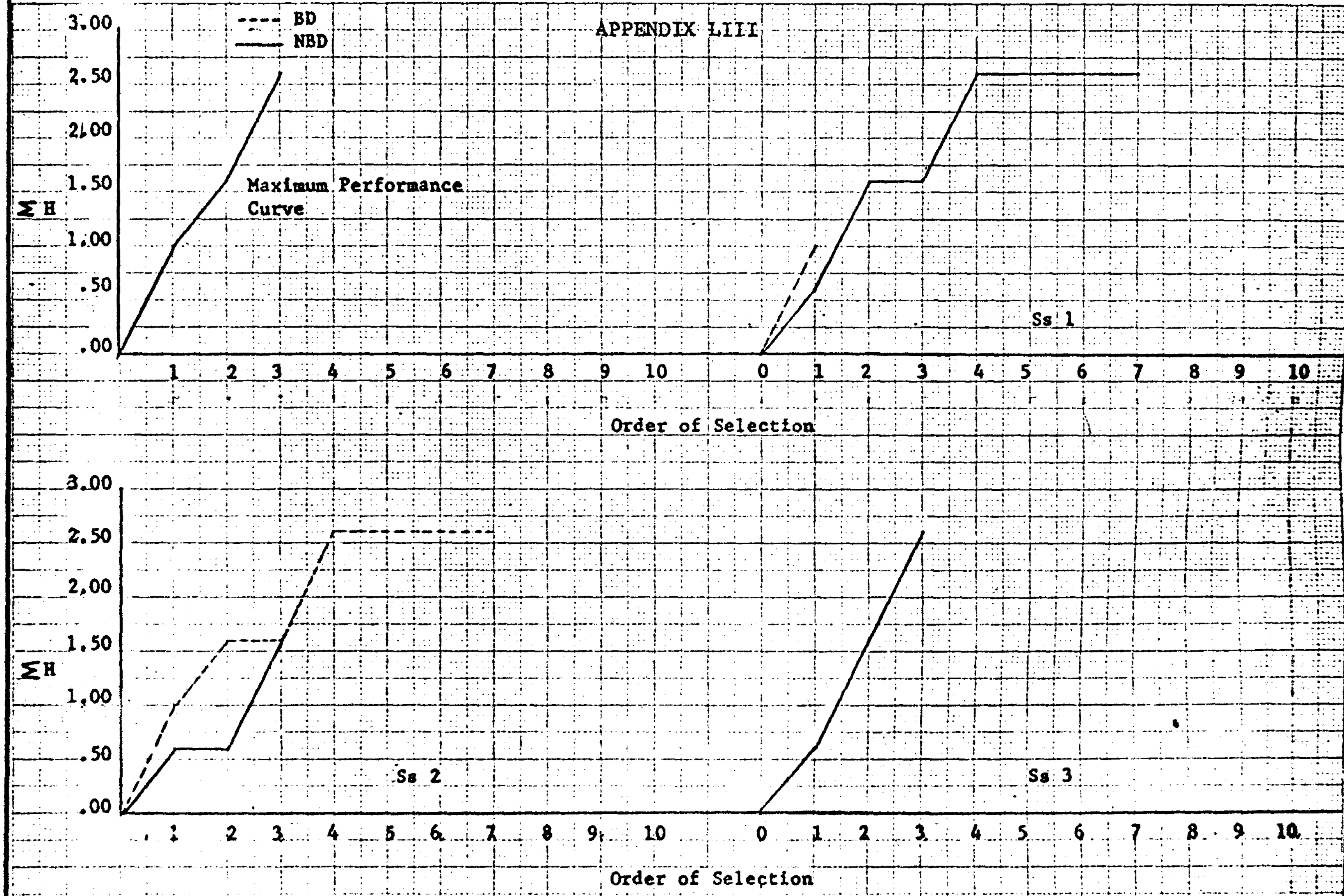
Individual Performance Curves According to Accumulated " Bits of Information " for Problem III.

APPENDIX LII



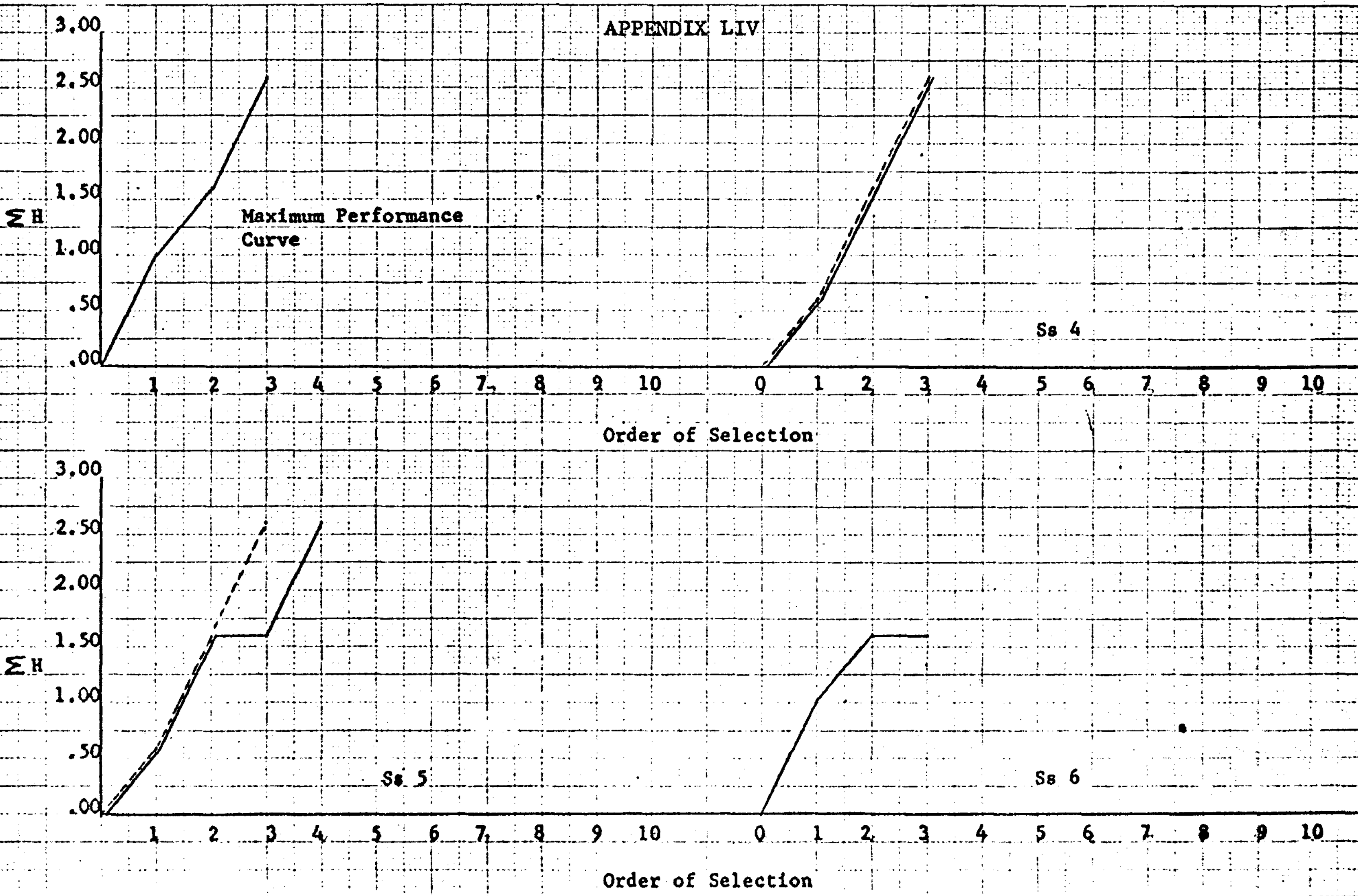
Individual Performance Curves According to Accumulated " Bits of Information " for Problem III.

APPENDIX LIII



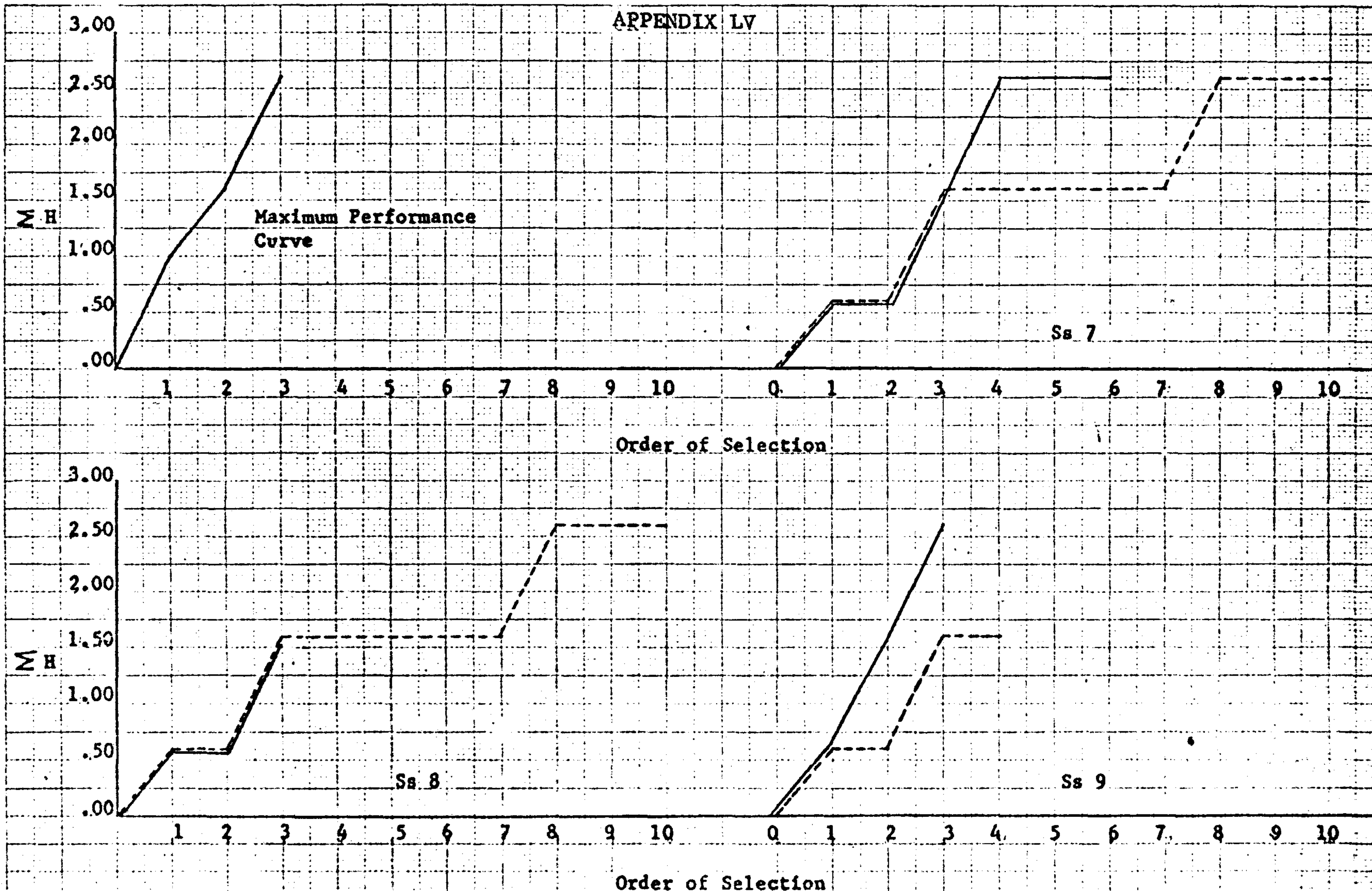
Individual Performance Curves According to Accumulated " Bits of Information " for Problem IV.

APPENDIX LIV



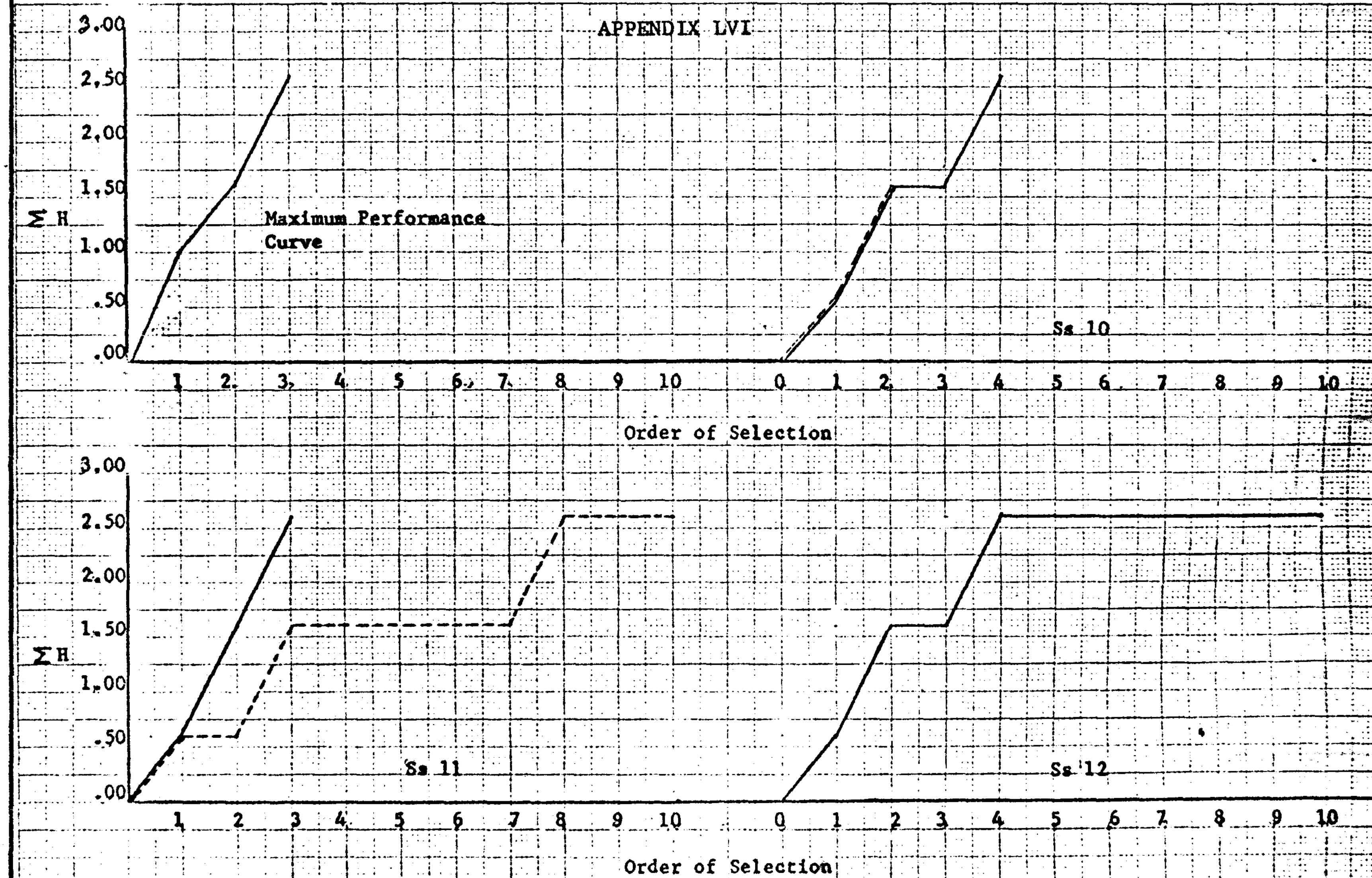
Individual Performance Curves According to Accumulated " Bits of Information " for Problem IV.

APPENDIX LV



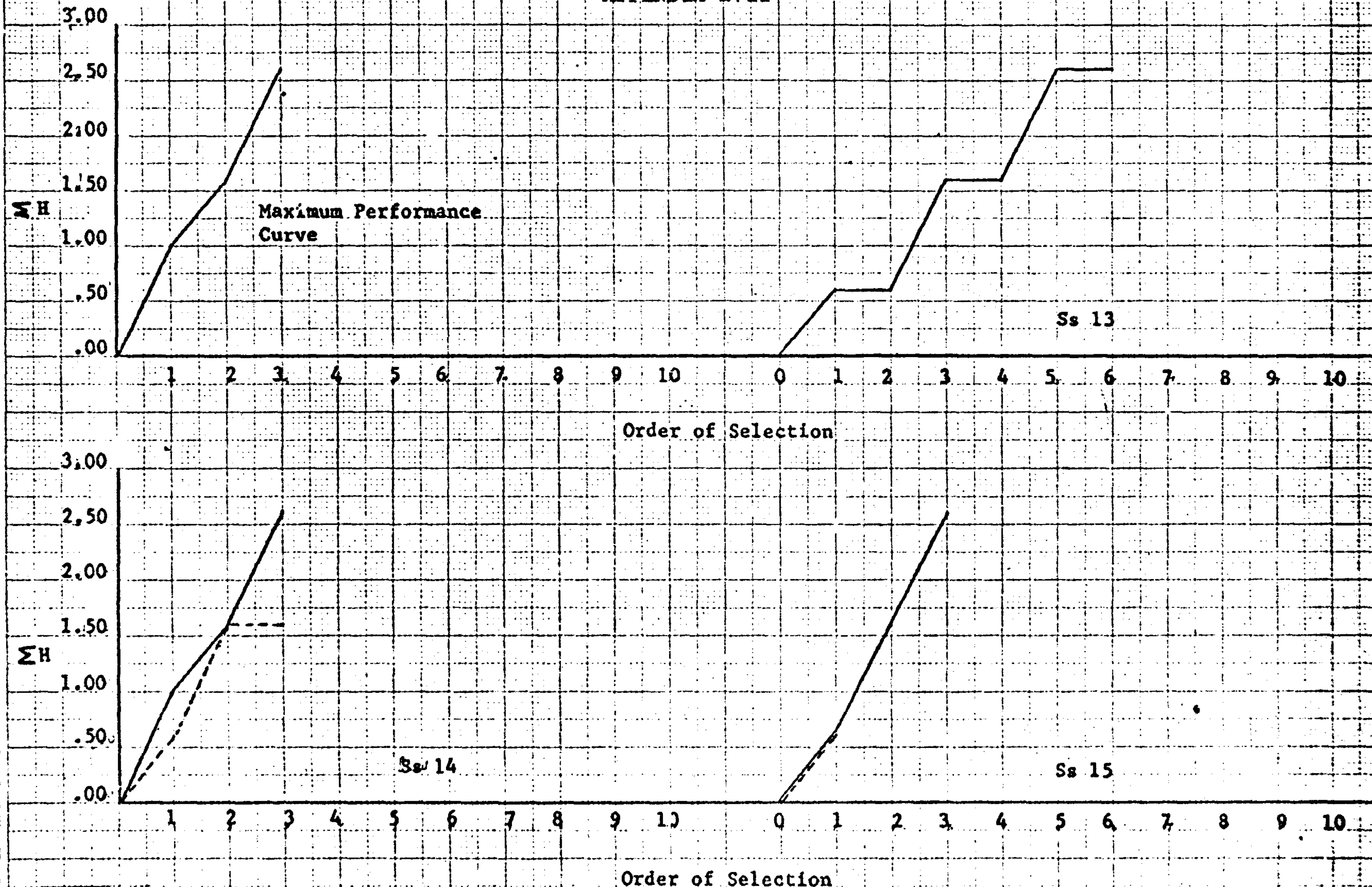
Individual Performance Curves According to Accumulated " Bits of Information " for Problem IV.

APPENDIX LVI



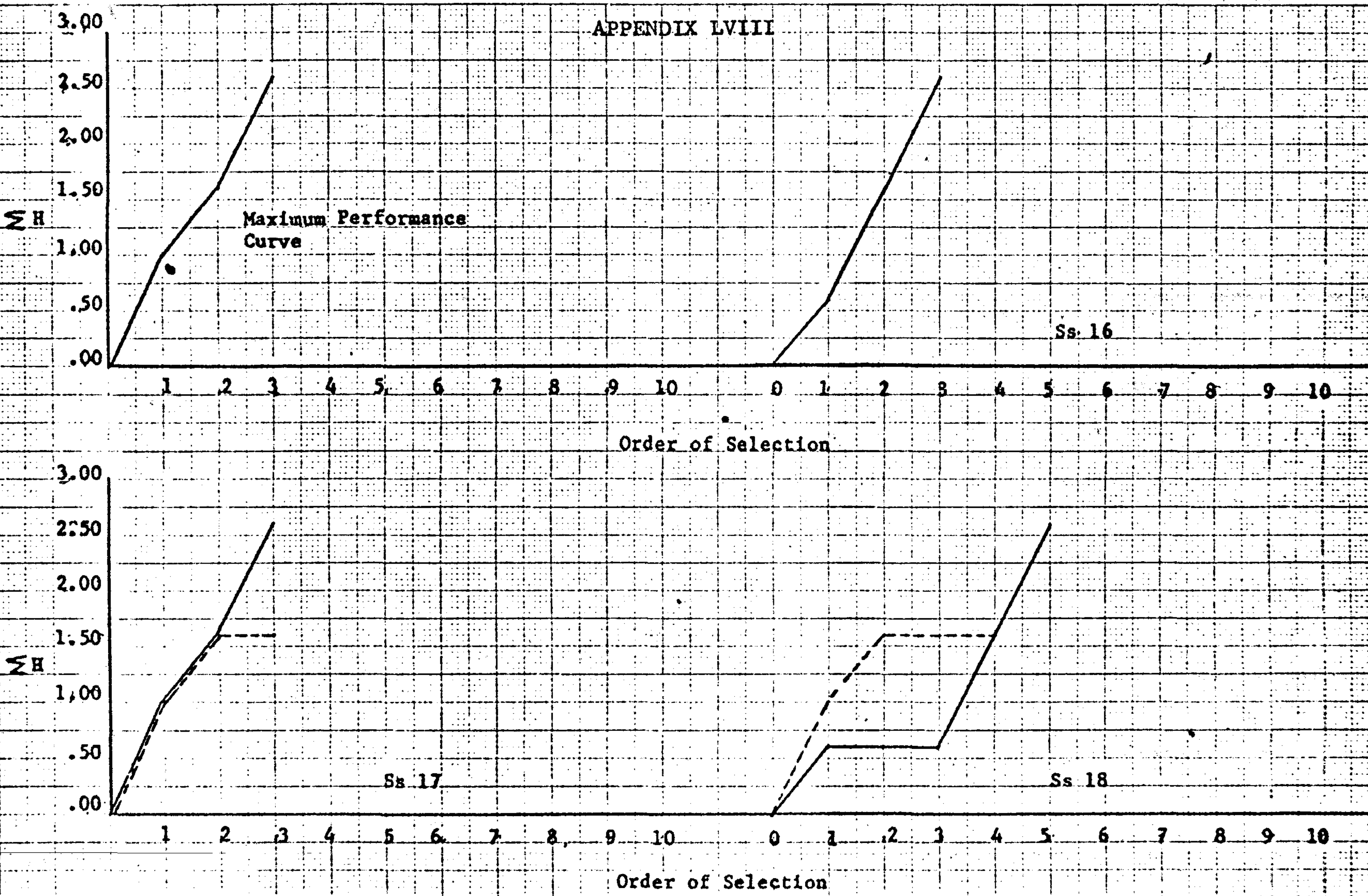
Individual Performance Curves According to Accumulated " Bits of Information " for Problem IV.

APPENDIX LVII



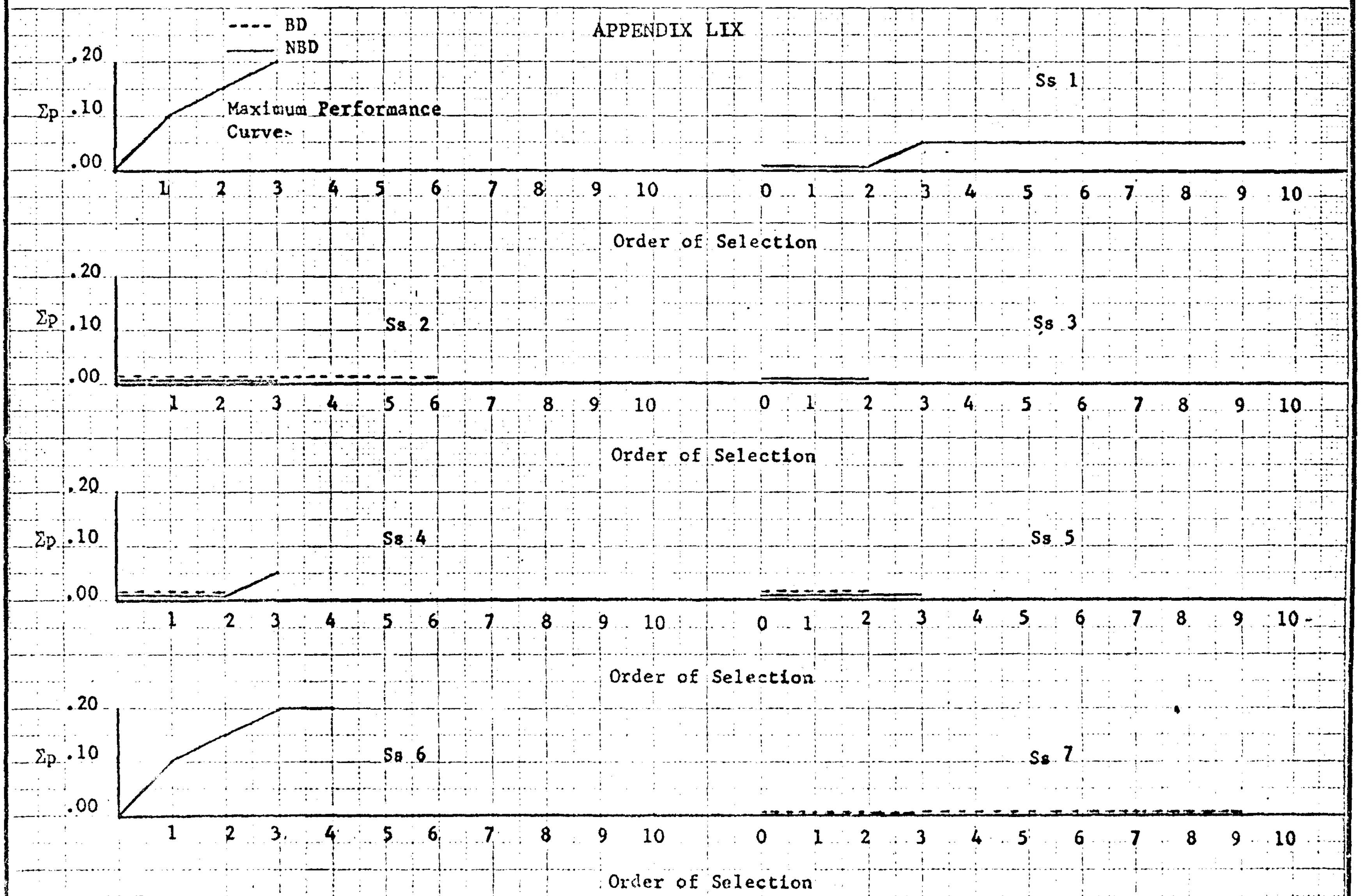
Individual Performance Curves According to Accumulated " Bits of Information " for Problem IV.

APPENDIX LVIII



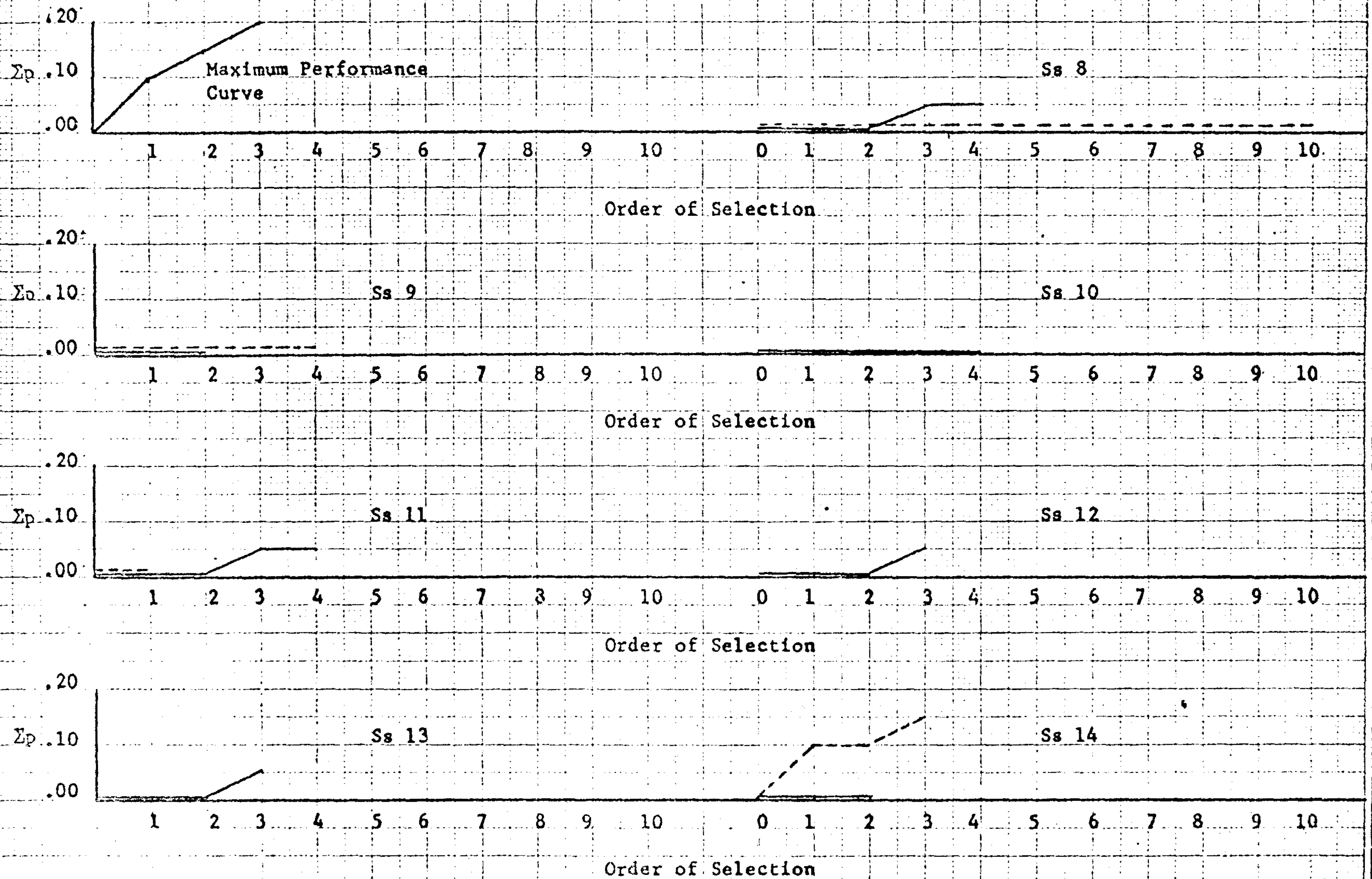
Individual Performance Curves According to Accumulated " Bit of Information " for Problem IV.

APPENDIX LIX



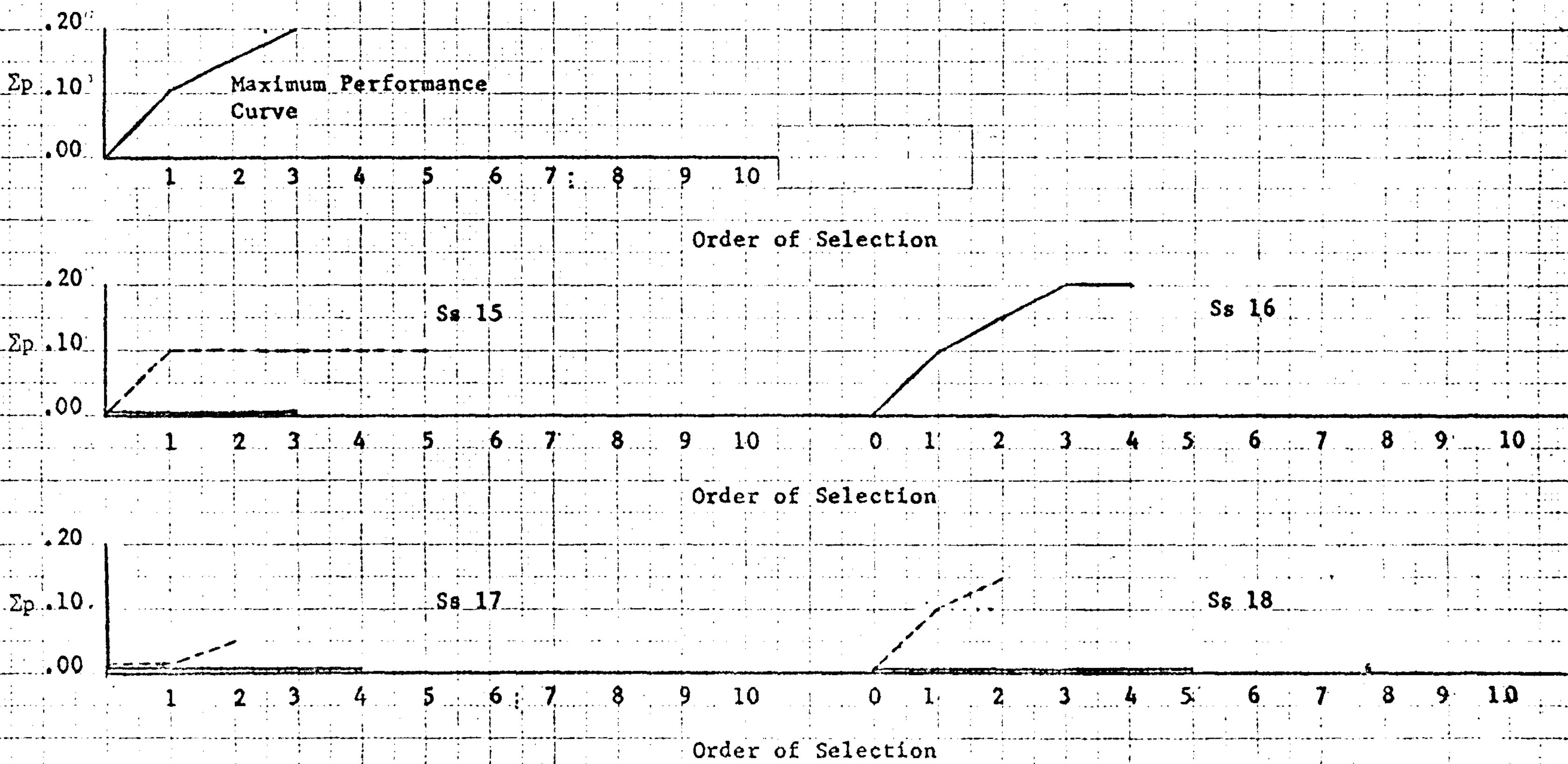
Individual Performance Curves According to Schema for Problem V.

APPENDIX LX



Individual Performance Curves According to Schema for Problem V.

APPENDIX LXI



Individual Performance Curves According to Schema for Problem V.

APPROVAL SHEET

The dissertation submitted by Michael A. Partipilo has been read and approved by five members of the Department of Psychology.

The final copies have been examined by the director of the dissertation and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the dissertation is now given final approval with reference to content, form, and mechanical accuracy.

The dissertation is therefore accepted in partial fulfillment of the requirements for the Degree of Doctor of Philosophy.

May 26, 1964
Date

Frank J. Kobler
Signature of Adviser