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Differential subtypes of sinistral learning disabled children: A neuropsychological, taxonomic approach.

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DIFFERENTIAL SUBTYPES OF SINISTRAL LEARNING DISABLED CHILDREN: A NEUROPSYCHOLOGICAL, TAXONOMIC APPROACH

by

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FAINT AND BROKEN LETTERING THROUGHOUT. WOULD NOT PRODUCE A GOOD MICROFICHE.

ABSTRACT

This study had a two-fold purpose. First an attempt was made to isolate systematically and report on the adaptive similarities and dissimilarities between subtypes of left- and right-handed learning disabled children. Toward this end multivariate quantitative taxonomic procedures were applied to the scores collected from a battery of neuropsychological measures. The typology of cognitive strengths and weaknesses associated with learning disabilities in these two particular groups of children originated from the burgeoning documented evidence suggesting that handedness and the organization of higher cognitive abilities are correlated to some extent with each other. A second aim of the investigation was to offer some evidence to show that similar subtypes could be generated in a reliable fashion through the application of different classification techniques.

The performance measurements collected on 161 sinistral and 161 dextral children referred to the neuropsychological service of an urban children's clinic because of learning, behavioural, or perceptual handicaps were classified statistically by several multivariate procedures. Hand dominance was determined initially on the basis of preferred name writing extremity. Children within these two target samples met the following criteria: they were between the chronological ages of 108 to 179 months, had obtained a WISC Full Scale IQ in the range of 85 to 115, and were free of sensory acuity defects, primary socio-emotional disturbance, or evidence of compromised environmental

influences.

Initial application of the Q technique of factor analysis to each handedness sample independently generated seven factors for each data set. Three factors from each target sample were found to be highly correlated with each other. For the left-handed sample, one other fairly meaningful factor emerged, while the remaining three factors exhibited membership assignments that were of small magnitudes. On the other hand, for the right-handers a sizeable number of children were classified into each of the remaining factors. Subsequent application of several cluster algorithms to the same data sets resulted in four-cluster classification solutions that were in perfect agreement with the Q factors for the left-handed sample, and seven-cluster classification solutions that were in fairly close agreement for the right-handed group of children. Subgroup compositions across such variables as intensity of left-handedness (including an analysis of hand preference vs hand proficiency), as well as familial handedness tendencies was also analyzed through the application of a series of Chi-Square analyses. Principal findings of this phase of the study revealed that there were no particular subgroups that exhibited either an unusually large or small number of *congruent*, *incongruent* or *mixed-proficient* left-handers (as defined by their performances on two skilled psychomotor tasks), *pure* or *mixed-preference* left-handers (as defined by their responses to seven hand questionnaire items), or subjects with mostly sinistral or dextral biological family members (i.e., *L+*, *L-*, *R+*, *R-*).

The profiles of test performance associated with the derived factors and clusters, correlation values computed between clusters and factors, and the results of a series of misclassification analyses were interpreted to define three highly similar and reliable subtypes of left- and right-handed learning disabled children. In addition, four other interpretable, but less well-defined subgroups emerged. Characteristics of the subgroups identified are described, and comparisons are made to other subtypes reported in the literature. The usefulness and suitability of multivariate classification instruments for providing a reliable taxonomy of learning disabilities is discussed. Finally, implications of the findings as they relate to the issue of handedness are addressed in some detail, including their obvious assessment and diagnostic considerations. Directions for future research are also provided.

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To you, Kathy, I owe what I have achieved today.

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CHAPTER I

INTRODUCTION

The problem of delineating the nature of the organization of the cerebral hemispheres in man has intrigued researchers for many years. A review of the literature reveals a voluminous number of reports that have been generated on the issue of cerebral specialization and functional asymmetry of higher cognitive abilities. At the most simplistic interpretive level, the research findings have posited the generally accepted view that the left cerebral hemisphere tends to process information sequentially and is specialized for more verbal and language-related functions. The right cerebral hemisphere, on the other hand, is seen as a parallel processor specialized for more visual-spatial perceptual organizational processes (Krashen, 1976; Milner, 1970; Sperry, Gazzaniga & Bogen, 1969; Warrington & Taylor, 1973).

While the above conceptualization of hemispheric organization is presumably thought to hold true for most right-handed individuals, the picture for left-handers is not as clear-cut. In the case of the lateralization of language functions, for example, some 98-99% of dextrals are thought to possess left hemispheric dominance for language functions. Figures for left-handed individuals, on the other hand, range somewhere from 65-70% (Gloning, 1977; Zangwill, 1964). The remainder of the sinistral population are considered to show evidence for either right hemispheric dominance for language functions or some degree of bilaterality language representation (Hardych & Petrinovich, 1977; Hecean & de Ajuriaguerra, 1964; Hicks & Kinsbourne, 1978). Furthermore, although the most compelling evidence concerning differences in brain lateralization as a function of preferred handedness has occurred in the area of language functions, a variety of other processes have been posited to differ in regards to cortical representation as well (Hardyck & Petrinovich, 1977; Hecean & de Ajuriaguerra, 1964; Levy & Reid, 1976; Varney & Benton, 1975). In general, it would seem that left-handers, as a group, constitute a much more heterogeneous population regarding patterns of cerebral functioning than do right-handers.

In the sections to follow, the relation between handedness and cognitive functioning is examined in more detail. Initially, this includes a brief account of some of the theories of the origin of hand preference. Next, research carried out primarily on adults utilizing a variety of experimental techniques is reviewed. An attempt is made to identify and describe more fully the host of variables felt to be important in regard to cerebral specialization of cognitive abilities. Following this, research conducted with children is examined, with a particular emphasis on delineating the importance of preferred handedness in children who are encountering learning or academic-related difficulties.

Finally, the multivariate statistical procedure as applied to the identification of subtypes of learning disabled children is described, and the purpose and design of the present study is discussed.

Models of Hand Preference

Estimates of the incidence of left-handedness in the general population have varied largely because of differences in the method of determination. One common means for determining an individual's hand preference has been by simple self-report. This has included an assessment of preferred handedness by self-proclamation or through means of a hand preference questionnaire (Hardyck & Petrinovich, 1977; Hecean & de Ajuriaguerra, 1964). Choice of writing hand has been equally utilized as a means of assessing preferred handedness as well. Over the years, however, an emphasis has been placed on viewing handedness in terms of performance measures. That is to say, it is thought that a more accurate account of *hand proficiency* could be ascertained by viewing an individual's performance on a variety of behavioural measures (e.g. manual speed, strength, and dexterity). The idea, of course, is that handedness not be viewed as a simple unitary construct (i.e. as a right versus left dichotomous variable), but rather that proficiency of hand usage may vary along a continuum (Barnsley & Rabinovitch, 1970; Johnstone, Galin & Herron, 1979; Palmer, 1974). In general, the incidence of left-sided hand preference in the general population (based on a compilation of the various methods of measuring preferred handedness) is reported by most researchers to be somewhere in the range of 5-10% (Hardyck & Petrinovich, 1977; Hecean & de Ajuriaguerra, 1964).

A review of the literature on the theories of hand preference reveals several different explanations for the origin of preferred handedness. Factors such as anatomical asymmetries (e.g. differences in organ size, hemispheric weight, and hemispheric blood supply), social and cultural influences, presence of a genetic or hereditary component (i.e., Mendelian recessive trait), and brain injury (i.e., 'pathological' sinistrality) have all been proposed as causative agents or explanations for left-handedness (Hardyck & Petrinovich, 1977; Harris, 1980; Hecean & de Ajuriaguerra, 1964). In regard to the first of these explanations, some rather convincing evidence has been documented recently to suggest that anatomical asymmetries exist between right-handed and left-handed individuals (Witelson, 1980). However, as Witelson (1980) points out, although the existence of an association between neuroanatomical asymmetry and hand preference appears fairly clear, the relationship between structural asymmetry and functional asymmetry (i.e., hemispheric cognitive specialization) is not as clearly defined. There are extensive accounts in the literature on the remaining explanations of handedness and a complete review of the theories is beyond the scope of the present discussion. Furthermore, since this study is not intended to be a treatise on the ontogeny of handedness, a detailed discussion of the various models is not warranted. Be that as it may, I will limit myself to a brief description of each of the theories.

Perhaps the most prolific writings concerning a genetic explanation of handedness have been generated by Annett (1964, 1967, 1970, 1972, 1973, 1975, 1978, 1979). In her original conceptualization of the inheritance of handedness and cerebral dominance, Annett (1964) argued that hand preference was determined by two alleles: D (which is usually dominant) that manifests right-handedness, and R (which is usually recessive) that manifests left-handedness. In her single gene, two allele model, dominant homozygotes (DD) were thought to be right-handed with language functions lateralized to the left cerebral hemisphere. Recessive homozygotic individuals (RR), on the other hand, were thought to be consistent left-handers with right hemispheric language specialization. To explain mixed handedness, there was postulated to be a partial penetrance of R in heterozygotes (DR). Consequently, such individuals could develop preference for either hand for skilled activities, and language may specialize in either hemisphere. However, Annett argued that with the exception of only a small number of heterozygotes who will develop ipsilateral hand and language lateralization (i.e., right handedness with right hemispheric language specialization), most heterozygotic individuals will develop as preferred right handers with contralateral left hemispheric language lateralization. In a series of subsequent articles, Annett (1972, 1973, 1975, 1978, 1979) studied the distribution of hand preferences in several samples of individuals, and concluded that the proportions of right, mixed, and left hand preference in the human population followed a binomial distribution with corresponding values of 66%, 30% and 4%, respectively. Since the mean of this distribution favoured a right hand preference, Annett suggested that most people inherit a "right-shift" factor (i.e., a bias toward right handedness and left hemispheric language specialization). Thus, the role of heredity in human handedness, according to Annett, involves essentially the hypothesized presence of a specific genetic factor that influences a shift toward dextrality. In the absence of this "right-shift" factor, the proportions of handedness (i.e., right, left, and mixed), would be expected to vary from that seen when hand preference was distributed binomially. That is to say, either hemisphere may serve speech and either hand develop greater skill.

A second, more comprehensive genetic model of preferred handedness is the one offerred by Levy & Nagylaki (1972, 1976, 1977). They proposed a two-gene, four allelle model whereby one gene was thought to determine hemispheric language dominance and the other determined whether hand preference was contralateral or ipsilateral to the controlling hemisphere. The pair of alleles determining hemispheric dominance were identified as L (dominant) and l (recessive), and those governing hand preference as C (dominant) and c (recessive). To account for the differences in degree of lateral specialization between sinistrals and dextrals (including differences concerning unilateral versus bilateral language representation, frequency of aphasia, and recovery from aphasia), the authors postulated that full expression of the alleles occurred only when a dominant allele was present, in homozygous or heterozygous conditions, at each of the two loci. The model was criticized by Hudson (1975) on the grounds that it was originally based on a single data set only (Rife, 1940), and subsequent testing of the model revealed that it was unable to fit additional data (i.e., account for the observed distributions of handedness in separate population samples).

In contrast to the genetic explanations for the causation of handedness are those that posit that hand preference is the result of social and cultural influences. Earlier proponents of a sociocultural theory of handeness have suggested that factors such as the handling practices of mother and nurses (i.e., "infant-holding" position), the holding of a soldier's shield in his left hand so as to better protect the heart (i.e., "warfare shield" theory), and the lack of clear hand differentiation at birth were important in the establishment of hand preference (Harris, 1980). More recently, Collins (1970, 1975) has argued that handedness is essentially a learned behaviour, the result of [illegible] conditioning and practice. In his latter study, Collins (1975) suggested that right sided hand preference could be attributed to cultural and environmental influences, largely on the basis that mice developed a right paw preference if exposed to an environment that favoured right-pawedness. The results of another recent study, conducted on the parents and offspring of forty-nine families, suggested that speech lateralization may, in large part, be determined by environmental factors as well (Bryden, 1975). In this study, two separate dichotic listening tasks (one employing pairs of consonant-vowel syllables, and the other employing lists of numbers) were administered to each subject. Based on the familial correlations computed on the laterality scores obtained from the tests, the results showed that the children's laterality scores could be predicted from those of the mother, but between-sibling correlations were negative. According to the author, the dissonance between the between-sibling and parent-child correlations suggested the absence of a genetic mechanism. The existence of the parent-child correlations, however, suggested the importance of environmental factors in the lateralization of language, at least as assessed by means of dichotic listening laterality.

Attempts to sort out the relation between genetic and nongenetic influences on preferred handedness have included a closer examination of Annett's conceptualization of heterozygosity (Satz, Fennell & Jones, 1974), studies of handedness in monozygotic and dizygotic twins (Corballis, 1980; Kovac & Ruisel, 1974; Springer & Searleman, 1978, 1980), an investigation of familial preferences for handedness, arm folding and arm clasping (Ferranato, Thomas & Sodava, 1974), comparisons between hand preferences in biological and adoptive families (Hicks & Kinbourne, 1976; Saltzman, 1980), and a rather intriguing examination of hand, eye and auditory dominance in several cultural groups (Dawson, 1977a, 1977b).

A final theory of the causation of handedness posits that sinistrality is a manifestation of brain pathology. Advocates of such a position suggest that, in some cases, left hemispheric brain damage sustained pre-, peri- or postnatally results in a lessened tendency to engage the right hand for skilled activities, and thus, a 'shift' to a left-sided hand preference (Annett, 1964; Bakan, 1971, 1977; Bakan, Dibb & Reed, 1973; Hecaen & de Ajuriaguerra, 1964; Satz, 1972, 1973). In support of the pathology view, researchers site the higher incidence of manifest left-handedness in certain clinical populations, including language disorders, reading difficulties, mental retardates, epileptics and even schizophrenics (Gordon, 1920; Gur, 1977; Harris, 1980; Hecean & de Ajuriaguerra, 1964; Hildreth, 1949; Silva & Satz, 1979). Figures for the incidence of sinistrality in these groups are generally double the estimate of left-sided hand preference within the normal population.

Perhaps the most detailed and comprehensive model of 'pathological' left-handedness is the one presented by Satz (1972, 1973, 1979). At its most elementary level, the model simply suggests that the frequency of left-handedness in presumably brain-injured populations increases as a function of early left brain injury occurring to natural right-handers. Using hypothetical data, Satz was able to demonstrate mathematically the twofold increase of sinistrality in retarded and epileptic groups. Furthermore the model generated several testable hypotheses. Some of these were logically derived from, while others were indirectly related to the model. Finally, the model suggested that the converse condition, 'pathological' right-handedness, is rarely seen because of the lower frequency of natural left-handedness in the general population. Additional support for a transfer of manual preference because of early left hemispheric insult has been reported in a more recent study by Satz and his colleagues in which the relationship between manifest left-handedness and unilateral brain injury or EEG abnormality was investigated in four cross-cultural studies of epileptic and mentally retarded subjects (Satz, Baymur, & Van Der Vlugt, 1979).

Related to a neuropathological view of left-handedness, Bakan (1971, 1973, 1977, 1978a, 1978b) has argued that the incidence of sinistrality may be correlated with birth trauma. More specifically, left-handedness was thought to be associated with birth order, and that it was the result of left hemisphere pyramidal motor dysfunction following perinatal hypoxia. In support of his claim, Bakan has demonstrated a raised incidence of manifest left-handedness in individuals who were either first born or born fourth or later in the familial order. He suggested that such individuals were more likely to experience birth complications as a result of primiparous births (longer labour and increased application of instruments), and births to older mothers. Furthermore, while a change in hand preference is typically the most overt residual symptom of hypoxia-induced pathology, Bakan has hypothesized that perhaps the increased incidence of right hemispheric or bilateral mediation of language functions, more often seen in left-handers, reflects hypoxia-induced deviations from the pattern of cerebral organization normally seen in the right-handed individual. Recently, Christian, Hunter, Evans & Standeford (1979) were able to demonstrate a significant relationship between birth order and handedness in monozygotic twins (i.e., there was an increased incidence of sinistrality among first born twins), but no such association was found in dizygotic twin pairs. While Bakan's explanation of 'pathological' left-handedness is certainly of heuristic value, most attempts to replicate his findings on independent samples have been unsuccessful (Annett & Ockwell, 1980; Hicks, Evans & Pellegrini, 1978; Hicks, Pellegrini & Evans, 1978; Hicks, Elliott, Garbesi, & Martin, 1979; Hubbard, 1971; Kocel, 1977; Teng, Lee, Yong & Chang, 1976). Critics of the model have suggested that perhaps the most parsimonious explanation for Bakan's birth order findings is that they simply reflect sampling error.

Handedness and Cerebral Organization in Adult Populations

As mentioned earlier, a burgeoning number of articles have appeared aimed at identifying different patterns of cortical organization and extent of cerebral specialization in relation to handedness. Historically, the earliest research on cerebral organization attempted to identify differences between left and right hemispheric participation in the area of language functions as inferred from unilateral brain damage (Hardyck & Petrinovich, 1977; Hecaen & de Ajuriaguerra, 1964; Hicks & Kinsbourne, 1978). In addition to the information gathered by lesion-produced deficits, the recent introduction of a number of methodological tactics (including dichotic listening techniques, visual half-field stimulation, application of electroconvulsive therapy, spectral analysis of visual and auditory evoked potentials, intracarotid injection and regional cerebral blood flow analyses) have enabled experimental investigation into other cognitive concomitants of handedness.

The earliest published reports on lesion-produced deficits in language functions can be traced back to the nineteenth century (Hardyck & Petrinovich, 1977; Broca, 1861 and Dax, 1865 as cited in Hecaen & de Ajuriaguerra, 1964). Since that time, the literature within the field has mushroomed. The last four decades, in particular, has witnessed the proliferation of a number of classical studies concerning cortical language representation in sinistrals, beginning with Brain's (1945) review of some of the more salient issues regarding the relation between language and handedness. A complete review of the studies concerning unilateral brain injury and language disturbance is an arduous task beyond the scope of this study. However, a look at several of the more contemporary reports on this issue should provide some understanding and appreciation for the extent and degree of language lateralization in sinistrals.

The results of several lesion studies have suggested that the mechanisms underlying language may be less lateralized in left-handed than in right-handed individuals. For example, Humphrey & Zangwill (1952) in their study of ten selected cases of sinistrals with unilateral brain insult (five left-sided, five right-sided) reported the presence of dysphasic symptoms in all cases of left hemispheric injury and in all but one individual who had sustained right hemispheric damage. Although there was marked individual variation in the severity of the dysphasic symptoms, the authors suggested that language dominance in sinistrals may be less well developed than in dextrals. Goodglass and Quadfasel (1954) reviewed a total of 123 left-handed individuals with unilateral lesions of either hemisphere. Based on the findings of the presence or absence of aphasia after left- or right-sided lesions, 53 and 47% of the sinistrals were posited to have left hemispheric and right hemispheric language specialization, respectively. From these findings, Goodglass and Quadfasel posited that language was represented bilaterally in sinistrals and language disturbance was more likely to accompany lesions of either hemisphere. A study of 10 cases of unilateral brain injury in left-handed individuals by Ettlinger, Jackson & Zangwill (1956) suggested that while a unilateral representation of language functions (most often left- but occasionally right-sided) is typically found in left-handed individuals, some degree of bilateral language representation may occur in a certain number of cases. Finally, Hecaen & Sauquet (1971) compared the frequencies of disturbances of language, gestures and perception in groups of left- and right-handed patients with unilateral lesions of both hemispheres. The results showed that there was less difference between frequency of symptoms when comparisons were made between left and right hemisphere syndromes in left-handers compared to the same comparisons in right-handers. Hecaen & Sanguet argued that the results supported a certain degree of cerebral ambilaterality in sinistrals.

Another area where the evidence supports the hypothesis that differences exist between sinistral and dextral concerning the cerebral organization of language functions is in the amelioration from aphasic deficits. Many authors have suggested that, in general, left-handers as a group are more likely to exhibit both language disturbances that are transitory in nature, as well as a more complete recovery from their aphasic symptomatology (Gloning, 1977; Gloning, Gloning, Haub & Quatember, 1969; Gloning & Quatember, 1966). Subirana (1964), in fact, suggested that 'the more basically right-handed an aphasic patient was, the less likely would be the regression of his aphasic losses' (p. 228). Both Subirana (1969) in his review on handedness and cerebral dominance, and Gloning (1977) in his report on the relationship between language disturbance and unilateral hemispheric damage in 57 right- and 57 left-handed patients, explained the increased incidence of aphasic-like symptoms, the transitory character of the language disturbance, and the rapid amelioration of the dysphasic symptoms in the left-handed (as compared to the right-handed individual) as reflecting some degree of bicerebrality or a lessened development of language lateralization in sinistrals. Related to this, Zangwill (1964) has suggested that sinistrals may differ from dextrals primarily in the rate, as well as in the completeness with which the lateralization of cerebral functions are established. That is to say, because the process of cerebral lateralization may be slower and less complete in the left-hander, the right cerebral hemisphere in particular, may retain a greater capacity to subserve language after unilateral brain damage. Besides positing differences between sinistrals and dextrals in regard to language lateralization, Gloning (1977) also has suggested that the fact that some left-handers suffered from severe and long-lasting aphasias following unilateral injury to either hemisphere meant that sinistrals were more likely to exhibit subgroups with respect to their aphasic symptomatology.

Not all lesion studies aimed at delineating the relation between language lateralization and handedness have been able to demonstrate unequivocally that differences exist between sinistrals and dextrals concerning cerebral organization. For example, Penfield and Roberts (1959) in their study of 522 patients operated upon for the treatment of intractable seizures found no difference in the frequency of aphasia between patients classified as left- or right-handed following a left-sided or right-sided operative procedure. Based on these findings, the authors suggested that the left hemisphere was dominant for language, regardless of handedness. In another detailed study of well lateralized brain wounds in left-handed patients, Russell and Espir (1961) reported that approximately 38 and 17% of those individuals with left-sided and right-sided cerebral damage, respectively, developed aphasic symptoms. Although Russell and Espir suggested that right hemispheric language dominance was apt to occur more often in sinistrals than dextrals, the failure to find both a higher incidence of aphasia and a more rapid recovery pattern amongst the left-handers was inconsistent with the notion of a bilateral representation of language functions in sinistrals.

Recently, Satz (1979, 1980) has formulated some hypothetical models of cerebral speech organization in the left-handed individual. According to Satz, while the unilateral lesion data to date certainly suggests that the pattern of language representation is different in left-handers than in right-handers, the *type* of hemispheric speech lateralization in the former group is yet to be clearly ascertained (i.e. is the pattern of language lateralization in sinistrals compatible with a variable unilateral representation (left- or right-sided) or a more complex form of bilateral and variable unilateral speech (left- or right-sided, and bilateral)). One way to delineate the type of organization, according to Satz, would be to determine the upper limit of aphasia that would be expected after unilateral brain damage (i.e., the maximum frequency of aphasia expected assuming that aphasia always occurred following random unilateral damage to the dominant language hemisphere). Satz argued that if these upper limits could be quantitatively established, then one could use the observed data on the incidence of aphasia after unilateral hemispheric damage in left-handers reported in the literature to ascertain the pattern of hemispheric language lateralization involved. When Satz computed the upper limit of aphasia that could be expected for each model and compared these values with the observed data for 12 published studies, a different model of hemispheric speech lateralization existed for left-handers and right-handers. Whereas a unilateral model represented the best estimate of brain lateralization in right-handers, the model that 'best fit' the observed incidence of aphasia in left-handers across studies was one that posited bilateral and variable unilateral speech representation. It would seem, according to Satz, that sinistrals constitute a much more heterogeneous group in regard to hemispheric brain lateralization than do right-handers.

Additional evidence that buttresses the notion that differences exist between left- and right-handers concerning patterns of language specialization comes from studies that have employed a variety of other experimental methods. For example, a number of studies utilizing an approach of dichotically presenting verbal information to normal, neurologically intact subjects have demonstrated smaller recall difference scores between the two ears for the left-handed individual as compared to the normal right ear advantage manifested by a right-handed person (Bryden, 1965; Curry & Rutherford, 1967; Geffen & Traub, 1979; Lishman & McMeekan, 1977; Satz, Achenbach, Pattisball & Fennell, 1965). Two studies have reported a left ear advantage for some left-handers; one utilizing a dichotic listening task (Knox & Boone, 1970), and the other employing a dichotic monitoring task (Geffen & Traub, 1980). The results of the above-mentioned studies have been interpreted by most authors as indicating that the mechanisms underlying language may be less lateralized in the left-handed.

Other studies of normal, neurologically intact individuals employing visual half-field preference measures have yielded findings that have been, for the most part, compatible with the concept of different types of functional brain lateralization in left-handers. Most dextrals are known to exhibit a right visual semi-field-left hemisphere advantage for verbal stimuli. Several studies with sinistrals, on the other hand, have shown a greater overall recognition in the left visual field, a right visual field superiority that is less marked, or have failed to show any consistent visual field differences in the perception of tachistoscopically presented verbal information (Beaumont & Dimond, 1973; Bradshaw, Gates & Nettleton, 1977; Bryden, 1965; Hines & Satz, 1974; McKeever & Gill, 1972; Orbach, 1967). Again, the evidence from these studies has been interpreted as relecting a language system that is more diffusely represented within the cerebral hemispheres of left-handers.

Recently, the growing adoption of several other methodological strategies for the study of handedness and language lateralization have been cited in support of the hypothesis that sinistrals may differ from dextrals concerning cerebral organization. Thus, a series of studies (Fleminger & Bruce, 1975; Pratt, Warrington & Halliday, 1971; Warrington & Pratt, 1973) have demonstrated that language functions were more likely to be disturbed following unilateral electroconvulsive therapy delivered to either hemisphere in left-handers as compared to right-handers, although left hemispheric language representation appeared to be the rule. Using an approach based on the spectral analysis of visual and auditory evoked potentials, Davis & Wada (1977) demonstrated that most right-handed epileptic patients (approximately 86%) exhibited left hemisphere speech dominance, while left- and mixed-handed patients were evenly divided between left and right hemispheric speech representation (approximately 50% in each group). Finally, hemispheric lateralization of language functions in sinistrals has been inferred through the inducement of hemispheric anesthesia secondary to intracarotid injection of sodium amytal or the faster acting barbiturate methohexital (Milner, Branch & Rasmussen, 1966; Willmore, Wilder, Mayersdorf & Sypert, 1978). All of these studies have provided another source of evidence to support the notion that the pattern of language lateralization in the left-handed individual is different from that typically observed in the right-handed person.

Much of the research on the cognitive concomitants of left-handedness has centered on identifying differences between left-handers and right-handers with regard to the direction and the degree of hemispheric specialization for language functions. It has also been demonstrated that, at least for some left-handers, the hemispheres may be organized differently for a variety of other cognitive capabilities. Several studies have reported a poorer performance for the left-handed on a variety of perceptual tasks (Flick, 1966; Nebes, 1971; Silverman, Adevai & McGough, 1966), and that left-handers as a group tend to be more 'field dependent' than right-handed individuals (Dawson, 1977a, 1977b; Oltman & Capobianco, 1967; Silverman, et al, 1966). However, some attempts to replicate the former studies have been unsuccessful (Hardyck, 1977; Kutas, McCarthy & Douchin, 1975). Levy (1969) posited that since left-handers were more likely to possess bilateral language centres or perhaps some degree of language competency in both hemispheres, they may be expected to perform relatively poorer than right-handers in tests of perceptual function. The hypothesis was simply that a bilateral language representation would tend to interfere with abilities normally thought to be subserved by the nondominant hemisphere. To test her hypothesis, Levy administered the Wechsler Adult Intelligence Scale to 10 left-handed and 15 right-handed postgraduate students and the results confirmed her expectations: dextrals were found to exhibit only an 8 point discrepancy while sinistrals were found to exhibit a 25 point difference between Verbal and Performance IQ scores (i.e., high Verbal IQ- low Performance IQ). These findings were interpreted by Levy as evidence to support the notion that right hemispheric participation in language processes interferes with the development of adequate right hemisphere visual perceptual and visual spatial abilities. Over the subsequent years, attempts at replicating the notion of a relative impairment of perceptual or spatial ability among left-handers has met with mixed success. Thus, several authors have demonstrated that verbal functions undertaken by the right hemisphere in left-handers can only occur at the expense of the spatial functions normally subserved by that hemisphere (Hicks & Beveridge, 1978; Johnson & Harley, 1980; McGlone & Davidson, 1973; Miller, 1971). At the same time, the hypothesized spatial impairment in the left-handed individual has not been able to endure the rigors of experimental replication by a number of other authors (Bryden, 1973; Carter-Saltzman, Scan-Slapatek, Barker & Katz, 1976; Fennel, Satz, Van Den Abell, Bowers

& Thomas, 1978; Heim & Watts, 1976; McKeever & Van Deventer, 1977; Yen, 1975). For the most part, these studies have reported the absence of any compelling evidence to support a superiority of spatial or verbal abilities for either right- or left-handers. One intriguing alternative hypothesis expounded upon by De Freitas & Dubrovsky (1976) suggests that perhaps in a left-handed population with language most likely lateralized to the right hemisphere, spatial analysis may be more effeciently performed in the left hemisphere. Evidence to support this possibility, however, is lacking. Generally speaking, it has been difficult to demonstrate without a doubt that hemispheric organization of spatial processing abilities may differ as a function of handedness. As Marshall (1974) has suggested, perhaps part of the problem may lie in our lack of understanding concerning the information processing skills required on tasks of a presumably linguistic and/or visuo-spatial nature. That is to say, little can be concluded in regard to differences in brain organization between dextrals and sinistrals until one knows more precisely what a particular behavioural task is intended to measure. Furthermore, the Levy model of 'intrahemispheric competition' suffers from a failure to provide more conclusive evidence that left-handers indeed possess bilateral language representation. Finally, since it is known that left-handers may constitute a more heterogeneous group concerning their hand preferences, an accurate identification of the "left-handers" becomes difficult. As Wang (1980) points out, there is a problem of defining dominance in regard to hand preference, since the dominant hand does not necessarily dominate every function. The hand superiority for a given performance seems to be determined by the degree of cerebral dominance for that particular function.

Other ability differences of various types have been postulated to exist as a function of preferred handedness. For example, left-handers have been found to exhibit reverse or smaller between ear difference scores when dichotically presented with auditory information of a nonverbal nature (Curry, 1967). Mixed left-handers, in particular, have been reported to exhibit faster reaction times to nonverbal auditory stimulation delivered to the right ear (Klisy & Parsons, 1975), and have been found to outperform other handedness groups in making pitch recognition judgements (Deutsch, 1980). When tested for differences in somatic pressure sensitivity after stimulating various body parts, a greater proportion of right-handers than left-handers were found to have greater sensitivity on the left side of the body (Weinstein & Sersen, 1961). In regard to motor skills, Kimura (1973) has demonstrated that left-handers tended to make more free hand movements during the act of speaking than right-handers, a finding she argued was indicative of bilateral representation of expressive language functions in sinistrals. More recently, Whilke & Sheeley (1979) studied the circular index finger movements in various handedness groups and concluded that strong right-handers tended to move both their left and right index fingers in the same directions. Finally, differences have also been reported concerning lateral eye movement directionality and saccadic eye movement latencies in response to various cognitive task demands as a function of preferred handedness (Gur & Gur, 1980; Pirozzola & Rayner, 1980).

It has been suggested by several authors that left-handers may not represent a single group, but may differ amongst themselves concerning patterns of hemispheric specialization. The most salient variables thought to differentiate between sinistrals have included hand posture during writing, degree of hand preference, and familial history of left-handedness. In regard to the first of these, Levy (1973) postulated that the position of the hand during writing may be an index of the lateral relationship between the dominant writing hand and the hemisphere specialized for language. That is to say, a normal posture (in which the hand lies below the line of writing) was thought to be indicative of a contralateral hemispheric language representation, and an inverted or "hooked" posture (in which the hand lies above the line of writing) indicated an ipsilateral language specialization. Subsequent studies conducted by Levy (Levy & Reid, 1976, 1978) in which comparisons were made between hand orientation during writing and performance on several tachistoscopic tests of cerebral lateralization have tended to confirm her expectations. In general, both dextrals and sinistrals that exhibited a normal writing posture manifested a strong lateral differentiation between the hemispheres, while 'inverted' left-handers exhibited a weak degree of lateral differentiation. In partial support of Levy's hand orientation theory, Gregory & Paul (1980) have recently demonstrated that normal and inverted left-handers differed in their performances on a battery of neuropsychologic tests in that the latter group performed more poorly on tasks involving oral vocabulary skills, alertness to visual detail and visual sequencing abilities. The mild performance decrements exhibited by left-handers with an inverted handwriting posture was interpreted by the authors as possibly reflecting some degree of neuropsychological skill deficiency as a result of a different pattern of cerebral organization in these individuals. On the other hand, two other studies employing dichotic and tachistoscopic indices of hemispheric language lateralization have failed to find a significant difference in level of performance between inverted and noninverted left-handers on these tasks (Herron, Galin, Johnstone & Ornstein, 1979; McKeever & Van Deventer, 1980).

Several studies have suggested that there is a relationship between the intensity of left-handedness and the type of organization of language representation. However, the studies of hemispheric specialization that have compared the consistency and degree of left-handedness have not been in agreement. On the one hand, there have been those who have suggested that strongly left-handed individuals possess left hemispheric language representation (weak left-handers are thought to possess right hemisphere language dominance)(Dee, 1971; Hecaen & Sauguet, 1971), whereas others believe that strong left-handers have reduced lateralization or bilateral representation of language (Knox & Boone, 1970; Lishman & McKeekan, 1977; Satz, Achenbach & Fennell, 1967; Sealeman, 1978; Shankweiler & Studdert-Kennedy, 1975). One study reported a tendency for less strongly left-handers to exhibit poorer performances on language-related tasks (e.g. spelling, object naming) compared to 'pure' left-handers (Newcombe & Ratcliff, 1973). Finally, two studies found strength of handedness to be a nonsignificant variable for differentiating between subgroups of left-handed individuals (Jackson, 1978; Schlichting, 1978). To summarize, it would appear that the relationship between the intensity of left-handedness and patterns of hemispheric specialization is an unresolved issue. It is unclear as to what extent differences in criteria for degree of hand preference as well as differences in selected brain lateralization measures can adequately account for the reported discrepancies. Perhaps, at best, the evidence indicates that the pattern of hemispheric specialization is different between strongly left-handed individuals and weak left-handers; however, the type or pattern of brain lateralization is yet to be defined.

The final factor thought to be important in elucidating subtypes of left-handedness is the presence or absence of a familial history or sinistrality. Over sixty years ago Kennedy (1916), in his study of six selected cases of lesion-produced deficits in language functions, suggested that the pattern of cerebral organization may be dictated more by 'the trend of an individual's stock rather than by his own peculiarities' (p. 859). Since that time, numerous studies of the language deficits in patients with brain injury, right-left perceptual asymmetries on dichotic stimulation and tachistoscopic tasks, and differences exhibited on tasks intended to measure various other cognitive abilities (e.g., simple motor and tactile-perceptual skills, visual perceptual abilities and intellectual functioning) have indicated that familial handedness may be a relevant factor in distinguishing between sinistrals with different patterns of hemispheric specialization. Of studies of unilateral brain damage, some have reported that it is the group of left-handers with a positive family history of sinistrality who have reduced lateralization or bilateral representation of language (Hecaen & Sauguet, 1971; Lishman & McMeekan, 1977), whereas another study has indicated that left-handers with a family history of left-handedness are more likely to have language represented predominantly in the left hemisphere (Newcombe & Ratcliff, 1973). Studies with hemiplegic children have also reported an association between familial handedness and cognitive functioning. Thus, Annett (1973) indicated that in a group of children with right-sided hemiplegia and a nonfamilial history of left-handedness, verbal and performance IQs were more highly correlated with the speed of peg moving by the affected hand than with that of the intact, better hand. Annett suggested that such a finding was consistent with the notion that there was a greater dependence on the left hemisphere in those individuals without familial sinistrality. In a related study, O'Malley & Griffith (1977) reported that hemiplegic children with a history of familial left-handedness had a higher incidence of language-related problems (including auditory language and speech delay difficulties). The authors suggested that the different pattern of deficits exhibited by children with a history of familial sinistrality may reflect an anomalous type of cerebral organization in such individuals.

Studies conducted with normal subjects have also reported differences on commonly used measures such as dichotic listening and tachistoscopic hemifield stimulation as a function of familial handedness. Of studies of right-left perceptual asymmetries with right-handers, several have reported that it is the dextral with no family history of left-handedness that exhibits the greatest superiority of the right visual field (Endress, 1974; Hannay & Malone, 1976; Hines & Satz, 1971; McKeever, et al, 1973). Another study (McKeever & Jackson, 1979) reported a clear familial sinistrality effect in colour-naming; subjects with a positive family history of left-handedness were significantly less right visual field superior for naming latencies than those lacking such a history. Studies conducted with left-handed individuals comparing familial sinistrals with those who have a negative history of left-handedness in the family have not been in agreement. On the one hand, there have been those who have reported that familial left-handers demonstrate the right visual field superiority indicative of relative left hemisphere dominance, while nonfamilial sinistrals exhibit reduced right-left perceptual asymmetry (Bradshaw & Taylor, 1979; McKeever, 1979; McKeever & Van Deventer, 1977; Satz, et al, 1967; Schlichting, 1978). On the other hand, several studies (Andrews, 1977; Bryden, 1965; Piazza, 1980; Schmuller & Goodman, 1979; Zurif & Bryden, 1969) have indicated that the left-handed with a family history of left-handedness tend to show a stronger left visual field superiority or a reduced right-left discrepancy. Some studies (Bryden, 1973;

Higenbottom, 1973; Jackson, 1978) have found that familial and nonfamilial sinistrals cannot be differentiated based on visual field preference scores.

Research relating dichotic recognition scores to brain organization has reported results similar to the visual hemifield findings. For example, several studies (Geffen & Traub, 1979, 1980; McKeever & Van Deventer, 1977; Satz et. al., 1967) have indicated that familial sinistrals were more likely to reveal left hemisphere language dichotically than nonfamilial left-handers. Other studies have reported that the left-hander with a positive history of sinistrality in the family tended to exhibit anomalous patterns of right-left ear difference scores (i.e. bilateral or atypical left ear superiorities) (Bryden, 1965; Lake & Bryden, 1976; Piazza, 1980; Zurif & Bryden, 1969). Finally, there have been those who have failed to uncover any clearcut relationship for family sinistrality and left-handedness (Briggs & Nebes, 1976; Schlichting, 1978).

Additional evidence to buttress the claim that there may be a relation between a family history of left-handedness and brain organization has been derived from studies that have examined a variety of other cognitive abilities. For example, within the tactile-perceptual realm, Fennell, Satz & Wise (1967) found that familial sinistrals exhibited a significantly greater incidence of lower pressure sensitivity thresholds on the right hand than did nonfamilial sinistrals, and Varney & Benton (1975) demonstrated that left-handers with a history of familial sinistrality showed a clear right hand superiority in detecting the direction of tactile stimulation applied to the palms of the hands; dextrals with a family history of left-handedness exhibited no lateral asymmetry in performance. In the area of motor functioning, McKeever & Van Deventer (1977) indicated that finger tapping scores were higher with the left hand for a group of familial left-handers compared to nonfamilial left-handers, whereas Annett (1974) reported an equal division between the two hands on measures of motor speed in a group of children having two sinistral parents. Also, Wolff & Cohen (1980) recently studied the interference effects from language-based tasks (reciting nursery rhymes or reading unfamiliar text) on manual performance (tapping in synchrony with a metronome) in a group of right-handers, and found that dextrals with a family history of sinistrality showed less overall and less lateralized dual task interference than dextrals with a negative familial sinistrality history. On auditory tasks of a nonverbal nature, Byrne & Sinclair (1979) demonstrated that familial left-handed subjects exhibited higher levels of performance on both subtests of the Seashore Rhythm Test than a group of nonfamilial sinistrals, and another study (Kellar & Bever, 1980) found that family handedness background significantly influenced ear preference scores on a task requiring the categorization of musical intervals (two-note chords) in a group of trained musicians. One study reported the presence of a diminished facial recognition ability in the familial left-handed (Gilbert, 1977). Finally, studies on intellectual functioning have reported both the occurrence of a lower Full Scale WAIS IQ in left-handers with a positive family history of sinistrality (Briggs & Nebes, 1976), and the presence of a complex interaction between handedness, familial sinistrality and sex on spatial and verbal abilities, while memory and perceptual speed abilities appeared not to be influenced by the interactions of these factors (Kocel, 1977, 1980).

In summary, a number of factors have been proposed as having some importance for delineating different patterns of organization and lateralization of cognitive functions, one of which is the presence or absence of a family history of left-handedness. It would appear that the effects of familial sinistrality on cortical organization are controversial, and the issue is far from being resolved. Be that as it may, there seems to be a trend in the literature that suggests that it may be the familial left-handed individual who is most likely to exhibit an anomalous type of cerebral organization. Taken together, the findings from a large number of studies of lesion-produced deficits, right-left perceptual asymmetries, and differences manifested on tasks intended to measure various other cognitive capabilities have been consonance with the notion that there is an association between the presence of sinistral tendencies within the family and the liklihood of a bicerebrality cortical representation. In this regard, Hardyck (1977) has proposed a model of hemispheric functioning that takes into account the familial handedness component. Essentially, Hardyck has argued that hemispheric specialization is organized along a continuum that ranges through two extremes. On one end of the continuum, representing the extreme lateralization position, are the right-handers with no family history of left-handedness. The other end of the continuum, representative of the bicerebrality point of view, are the left-handed individuals with a positive history of familial sinistrality. Finally, between these two groups, representing a lesser degree of bilaterality of cerebral functions, are the dextrals with a family history of left-handedness. While it would seem that researchers have made considerable progress in their attempts to identify how patterns vary for cerebral organization as a function of familial handedness, a great deal remains to be learned regarding this relationship. To complicate matters further, researchers have only begun to unravel the nature of the complex interrelationships that appear to exist between a variety of variables thought to be important for determining patterns of brain lateralization (e.g., familial handedness history, intensity of handedness, writing posture, task selection and sex) (Kocel, 1977, 1980; Searlemen, Tweedy & Springer, 1979).

Handedness and Learning Difficulties

Included in the literature postulating ability differences of various types for left-handed individuals is the claim that sinistrality is related to a variety of behavioural deficits. Most of the information pertaining to this issue has been generated from the performances of children in a number of clinical populations. Thus, some investigators have argued for an association between handedness and language problems (Barry & James, 1978; Boucher, 1977; Calnan & Richardson, 1976; Colbe & Parkison, 1977;

Gordon, 1921; Hecaen & de Ajuriaguerra, 1964; McBurney & Dunn, 1976), intellectual deficiency (Barry & James, 1978; Berman, 1971; Fagin-Dubin, 1974; Flick, 1966; Porac, Coren & Duncan, 1980; Richlin, Weinstein & Weisinger, 1976) and academic-related difficulties (Annett & Turner, 1974; Ayres, 1972; Bryden, 1970; Dean, 1981; Harris, 1957; Schevill, 1980; Shankweiler, 1964; Shearer, 1968; Stein, Gibbons & Meldman, 1980). Of studies of language disturbance, Gordon (1921) reported that the incidence of left-handedness was higher in 'mental defective' schools than in regular elementary schools (18.2% to 7.3%, respectively), and that sinistrality was more frequently associated with speech-related defects. Incidentally, Gordon further suggested that left-handedness was a manifestation of brain pathology, a view consonant with the 'pathological' left-handedness model. Hecaen & de Ajuriaguerra (1964) in their study of stammerers, dyslexics and normals demonstrated that the relative number of left-handed subjects was much greater in the stutterers than in the group of normal children. More recently, McBurney & Dunn (1976) reported that children whose handeness was other than strongly right or who exhibited a mixed laterality pattern (e.g. hand and foot preference different from eye) were more likely to be achieving below age-expectancy levels on various language skilled tasks. Studies of autistic children have also revealed marked differences concerning preferred handedness. Thus, Colby & Parkison (1977) reported that the incidence of left-handedness was 12% in normal children whereas it was

65% in autistic children. Boucher (1977) indicated that autistic children as a group exhibited a small increase in preferred left-handedness, and Barry & James (1978) reported a significant increase in the variance of dominant-hand usage from normals to autistics. Finally, in contrast to the studies cited above, Calman & Richardson (1976) were unable to find an increased incidence of speech disorders in children who were left- or mixed-handed.

Of studies of psychometric intellegence, some have reported the absence of any significant difference between left-handed and right-handed individuals (Fagin-Dubin, 1974; Hardyck, Petrinovich & Goldman, 1976; Keller, Crooke & Riesenman, 1973; Miller, 1971). On the other hand, Flick (1966) showed that left-handed-left-eyed dominant individuals exhibited poorer performances on intellectual measures than all other hand-eye dominant groups with the exception of left-handed-right-eyed subjects. Moreover, McBúrney & Dunn (1976), in their investigation of the association between language skills and laterality, reported that most sinistral groups obtained lower mean WISC Verbal and Performance IQs than dextrals. One study (Berman, 1971) indicated the need to examine a variety of body laterality measures (e.g. hand, foot, eye, ear) rather than attempting to correlate handedness alone with intellectual functioning. Furthermore, another more recent study (Swanson, Kinsbourne & Horn, 1980) emphasized the importance of age as a crucial variable in assessing the relationship between handedness and intellectual impairment. In their longitudinal study of elementary school children, Swanson and his colleagues found that a group of non-right-handed individuals could exhibit no difference in intellectual abilities from a group of dextrals at one stage in their life span (i.e., when assessed in 4th grade), yet when tested three years later (i.e., in 7th grade) were found to score lower than right-handers in overall intellegence. Finally, the relationship between lateral preference patterns and mental retardation has been studied as well. Again, it has been reported (Wilson & Bruce, 1955) that there is a twofold increase in the incidence of sinistrality amongst retardates as compared to normals. Also, a more systematic study of lateral preference patterns (hand, eye, foot, and ear) in a group of high-trainable and low-educable mental retardates revealed a significantly greater incidence of left-sided or mixed-sided behaviours on each of the preference dimensions when compared against two non-retarded groups (Porac, Coren & Duncan, 1981). Moreover, visual evoked potentials have been recorded from both hemispheres in a group of normal dextrals, dextral retardates and sinistral retardates (Richlin, Weinstein & Weisinger, 1976). The results of this study indicated that there existed an asymmetry between the hemispheres for the N_1-P_2 amplitude. For dextral retardates, the left hemisphere amplitude was greater than that of the right hemisphere; in sinistral retardates as well as normals the asymmetry was reversed-right hemisphere amplitude greater than left. The authors argued that handedness appeared to be one of several variables seemingly important in determining the kinds of electrical activity seen secondary to visual stimulation.

The notion that left-handedness may be related to learning deficits in general, and reading disability in particular, is certainly not a recent one. Ever since Orton (1937) suggested that the lack of consistent laterality preference reflected some degree of mixed cerebral dominance and, in turn, resulted in learning disability, researchers have been interested in the relationship between patterns of lateral preference, cerebral dominance and learning difficulties. However, as typically seen in so many areas of study concerning left-handedness, results have not been in agreement. On the one hand, some investigators have argued that there is no difference between dextrals and sinistrals in reading ability. Thus, Balow (1963) reported that mixed-handed children exhibited scores comparable with those obtained by children with consistent hand preference on a variety of reading achievement measures. Coleman & Deutsch (1964) indicated that there were no differences between a group of normal readers and a group of retarded readers on one standard measure of hand preference (e.g., Harris Tests of Lateral Dominance), and Hecaen & de Ajuriaguerra (1964) reported similar findings in their study of the index of laterality of children who have reading difficulties. At the same time, the latter authors did report that children who present with difficulties in learning to read were more often poorly lateralized (i.e., in terms of the relative proportions of the lateral dominances). In a study of good and poor readers (as assessed with four tests of reading ability), Belmont & Birch (1965) found that preferential hand usage did not differ between the two groups. One study (Clark, 1970) enlisted a population sample of over 1500 children and failed to find any evidence that reading achievement level could be predicted reliably on the basis of the presence of left-handedness. Wussler & Barclay (1970) indicated that a group of children with reading difficulties were not significantly different from one another in terms of patterns of psycholinguistic functioning when classified as either lateralized or mixed dominant, while another study (Ginsburg & Hartwick, 1971) rejected crossed hand-eye dominance as a sign of reading difficulties. Finally, one study of right-left perceptual asymmetry on visual hemifield stimulation (Olson, 1973) reported that both a group of right-handed children and a group of left-handed or ambidextrous children exhibited a right visual field preference for word recognition. Unfortunately, a second part of the study aimed at investigating visual field preferences in a group of poor readers did not report any handedness data.

On the other hand, there have been several reports that have indicated that an association exists between hand preference and specific reading disability. For example, Harris (1957) reported a much higher incidence of mixed-hand dominance and a trend towards greater left-handedness in a group of reading disabled children as compared against a group of normal readers, and this finding was confirmed by Shearer (1968) in his study of a group of 'backward' readers. Consonant with these findings, Ayres (1972) has reported a 16.9% incidence of sinistrality in a group of children having learning disorders, and Annett & Turner (1974) found an excess of children with sinistral tendencies among those with specific reading disabilities. At the same time, the findings of the latter study indicated that both left- or mixed-handed children and right-handed children exhibited similar levels of performance on several verbal and nonverbal tasks. On tests of right-left perceptual asymmetries, Bryden (1970) studied dichotic listening laterality in children at three grade levels (2, 4 and 6) and reported a developmental trend: for right-handers, the number of right ear dominant subjects increased with grade level, whereas the opposite finding was seen for a group of left-handed children. Moreover, good readers were found to exhibit an uncrossed dominance pattern (i.e., having a dominant hand ipsilateral to the dominant ear), and poor readers were much more likely to show crossed ear-hand dominance, although this finding was most evident in boys at all grade levels, but in younger girls only. Another dichotic listening study by Zurif & Carson (1970) demonstrated that poor readers exhibited a slight trend towards a left ear superiority in their recall for digits, and that the group of dyslexics, in relation to the good readers, were much less adept with either hand, and poorer with their preferred hand on one manual dexterity measure (i.e., circle-cutting task). Finally, Shankweiler (1964) has suggested that familial sinistrality may be a more important variable than the individual's handedness *per se* for determining the association between sinistrality and problems in learning to read. That is to say, of twelve cases of reading disability investigated by Shankweiler, only two cases were left-handed, however, six (50%) of the children reported left-handedness within the family history.

Recently, some studies have investigated lateral eye movement asymmetry and lateral preference patterns in heterogeneous populations of learning disabled children (Dean, Schwartz & Smith, 1981; Stein, et. al., 1980). Thus, in the latter study, Stein and his colleagues offerred some indirect support for Orton's (1937) contention that a relationship exists between inconsistent lateral preference and educational difficulties by demonstrating that a group of mostly right-handed disabled children exhibited left lateral eye movements, whereas normal readers showed a higher incidence of right eye movements. Incidentally, there was no significant difference between learning disabled and normal children concerning incidence of left-handedness. In the former study, Dean et. al. (1981) presented a detailed report of the lateral preference patterns for children with learning problems as inferred from a self-report instrument thought to predict reliably the actual preference for activities involving the eyes, ears, feet and hands. The hand preference schedule was composed of 49 items that represented six factors isolated on the basis of a multivariate classification procedure. Initially, the lateral preference patterns for a group of normal and a group of learning disabled children were studied. The results indicated that the children with specific learning problems exhibited more bilateral or mixed dominance than normal children on the following factors: visually-guided fine motor activities (Factor 2); auditory preference or ear use (Factor 4) and; fine motor tasks involving the feet (Factor 6). In the second part of the study, two groups of learning disabled children were identified who differed in their lateral preferences: one group exhibited a more consistent cerebral laterality, while the second group displayed a mixed preference pattern. The two groups were then compared on tasks intended to assess their verbal and spatial abilities. Comparisons between the two groups revealed that mixed dominant children diagnosed as learning disabled exhibited spatial processing deficits, whereas learning disabled children with consistent laterality preference showed a deficiency in verbal knowledge. Based on these findings, the authors suggested that there would appear to be at least two distinct types of learning disabled children who differ, as a function of lateral preference patterns, in their verbal and spatial ability structure.

Interest in evaluating the performances of left-and right-handed learning disabled children on tasks of a tactile-perceptual nature has provided another source of evidence for an association between lateral preference, hemispheric specialization and academic-related difficulties. For example, Bakker (1972) found that dextrals showed a left hand superiority in the ability to perceive a series of tactile sensations delivered to three fingers on each hand separately, whereas both sinistrals and reading disabled children exhibited a smaller between hand difference score. More recently, Schevill (1980) conducted a study intended to measure differences between left- and right-handed children in tactile letter decoding skills. More specifically, the study was aimed at investigating the transfer of learning that took place when children were trained in tactile letter discrimination on one body location (e.g., the chest area or the palm of the hand), and then were subsequently tested on both locations. Tactual-perceptual performances were evaluated in reading disabled dextrals and sinistrals (defined more precisely as 'slow and severely disabled' readers). The main purpose of the study was to examine the effect of handedness on bilateral transfer and learning within children who exhibit reading difficulties. It was thought that demonstrable differences between reading disabled dextrals and sinistrals in the ability to store and transfer tactile skin writing images bilaterally may reflect differences in brain organization between the two groups. In the first part of the study, bilateral transfer was studied following extended tactile instruction on the chest area, or on the preferred hand. In both cases, left-handers were found to be more accurate naming letters delivered tactually to the untrained left hand than in their identification of stimulations delivered to either the trained chest or the trained right hand. For Schevill, these findings suggested that sinistrals, at least those who have reading-related difficulties, possess a different type of cerebral organization from that for dextrals. That is to say, since dextrals were able to decode letters tactually on the chest and then transfer the learning bilaterally, they must possess better spatial and directional skills on that body location. On the other hand, since sinistrals exhibited poor decoding ability on the trained body area, but were still able to learn from the training, they must have been utilizing coding processes relating to the cerebral area subserving their left hands. In effect, sinistrals tend to use a greater degree of dominant hemisphere bias in processing tactile-verbal information. A second part of the study was intended to examine whether visual memory was important in interhemispheric transfer of information. More specifically, the interaction between handedness and visual memory in both the verbal and visual responses to the same tactile letters was investigated. A group of seventy-five reading disabled children (60 right- and 15 left-handed), and a group of forty normal readers (33 dextrals, 7 sinistrals) were given extended tactile training on the nonpreferred hand, and then were asked to identify stimulus letters written on both hands by oral response (tactile-verbal condition) or by visual selection (visual matching condition). The results showed that within the tactile-verbal condition reading disabled sinistrals were more accurate than dextrals on the untrained preferred hand, whereas normal sinistrals learned and stored the tactile-verbal images bilaterally. Within the tactile-visual matching condition, it was found that left-handed reading disabled children with an adequate visual memory were more accurate on the untrained preferred hand, whereas left-handed children with reading difficulties and a deficient visual memory system were poor in discriminating letters with both hands. On the other hand, dextrals with either good or poor visual memory skills were found to transfer the tactile-visual information bilaterally. In other words, left-handed children with reading problems who possess adequate visual memory abilities tend to use the same hemispheric bias for verbal and visual coding strategies, whereas reading disabled sinistrals with less than adequate visual memory skills tend to use a unilateral bias for verbal coding strategies, and display a diffuse tendency in selecting a visual code for a visual matching response (i.e., neither hand is accurate in responding). In Schevill's words 'left-handed children may be partially disregarding the nondominant spatial function and using a dominant bias for both spatial and verbal processing (p. 350).

To summarize, as in investigations of left-handers in general, studies attempting to link left-handedness to cognitive inefficiencies and, more specifically, to academic-related difficulties have not been in agreement. In order to make progress in understanding the relationship between handedness and learning problems, several issues have yet to be resolved. First, there is the problem of how to determine accurately the classification of sinistrality. In particular, the necessity for delineating more precisely different types of left-handers cannot be overemphasized. Several studies have illustrated that an individual classified as left-handed solely on the basis of preferred writing hand may be entirely different from one who has been identified as such by his/her performances on a number of other behavioural indices (Bannatype & Wichiarajote, 1969; Hardyck et. al, 1976; Johnstone, et. al., 1979; Satz et. al., 1967; Zurif & Carson, 1970). To complicate matters further, the establishment of hand preference is not only dictated by various criterion adopted for classifying manual dexterity, but is also prone to variation as a function of the age of the child (Belmont & Birch, 1963; Gesell & Ames, 1947). Moreover, developmental considerations become of crucial importance when attempting to interpret differences in cognitive performance between dextrals and sinistrals (Kaufman, Zalma & Kaufman, 1978; Kocel, 1977, 1980).

Secondly, there is the issue of discerning in more detail the importance of congruous and incongrous patterns of lateral preference. While acknowledging the significant advancement in describing the interrelationships between hand, foot, eye and ear dominance already made over the past several decades (see Hecaen & de Ajuriaguerra, 1964 for a review of this topic), recent research on this issue has stimulated new thoughts concerning the significance of 'mixed versus pure' laterality dominance as well as identifying the patterns of hemispheric organization that can be inferred from the discrepancy between preference patterns (Dean et. al., 1981; Kershner, 1975; Porac et. al., 1980).

Finally, most of the studies examining differences in learning patterns between left- and right-handers have dealt with a heterogeneous group of children. For the most part, research in the area has dealt almost exclusively with reading impairment *per se*, and information regarding the child's level of achievement in other academic-related areas (e.g., spelling, arithmetic) has not been reported. Moreover, the number and types of tasks used to assess reading impairment have been as diverse as the authors who have reported on them. The point is simply that children who have been classified as exhibiting a learning disability, or even more specifically a reading problem, may well be composed of a heterogeneous group of individuals who possess different learning styles or learning strategies.

Be that as it may, it would appear that there has been just enough evidence generated to buttress the claim that an association exists between hand preference and reading ability to warrant further investigation into the issue. Furthermore, the studies reviewed earlier of lesion-produced deficits, right-left perceptual asymmetries on dichotic listening and tachistoscopic stimulation tasks, and the differences exhibited in cognitive performance as a function of handedness provide rather convincing evidence that left- and right-handers may possess different adaptive ability structures which, in turn, may reflect different patterns of cerebral organization.

Multivariate Classification of Learning Problems

Over the past two decades, research into the nature of reading retardation has posited the view that children may encounter difficulties in learning to read for a variety of reasons. Thus, Shankweiler (1964), while stressing a visual-perceptual or visual organizational skill deficiency for reading disability, acknowledged three groups of reading impaired children ("pure" dyslexia, dyslexia secondary to spatial and constructional disability, and reading disability as an expression of language disturbance) Vernon (1971) has suggested that problems in reading acquisition may reflect deficiencies in visual-perceptual processes, auditory-linguistic deficits, inadequate intellectual processes (including poor problem solving or conceptual reasoning skills), or an inadequate motivational system. Moreover, both Benton (1975) and Vernon (1977) have stressed the necessity of identifying groups of reading disabled children who may exhibit different cognitive skill deficits rather than continuing to search for one unitary cause (i.e., some basic deficiency) for reading impairment, while Rourke, in a series of articles (1978a, 1978b, 1981a, 1981b, 1981c; but see also Rourke & Strang, 1981d and Rourke & Gates, 1981e), has argued quite adamently that retarded readers are not a homogeneous group in terms of their neuropsychological adaptive ability structure. In general, the main purpose of a 'subtyping' approach, of course, is to delineate with more precision the sorts of deficiencies that may account for a child's inability to acquire normal reading habits and, in turn, promote academic remedial programmes tailored to the individual's specific cognitive strengths and weaknesses.

The fact that reading disabled children may constitute a heterogeneous population in regard to their cognitive inefficiencies has been the focus of attention for several investigators who have employed both clinical inferential methods (Boder, 1973; Mattis, 1978; Mattis, French & Rapin, 1975), and multivariate classification procedures (Doehring, Hoshko & Bryans, 1979; Doehring & Hoshko, 1977; Fisk & Rourke, 1979; Petrauskas & Rourke, 1979). In the first of these methods, for example, Boder (1973) evaluated the performances of children referred to a clinic for learning problems on a diagnostic screening battery intended to determine a child's overall reading and spelling pattern (i.e., the number and kinds of errors exhibited by him/her on reading and spelling tasks). Included in the battery were a word recognition inventory, a written spelling task, recitation and writing of the alphabet, and a paragraph reading task. The screening procedure yielded three distinctive patterns of reading and spelling that were thought to reflect three subtypes of dyslexic children: dysphonetic dyslexia (children whose reading-spelling pattern reflected a primary deficit in symbol-sound integration), dyseidetic dyslexia (children whose reading-spelling pattern reflected a primary deficit in the ability to perceive letters and whole words as configurations), and mixed dysphonetic-dyseidetic (children who were both unable to integrate symbols with their sounds, and perceive letters and whole words as configurations). All children classified as severely retarded readers exhibited one or other of the patterns, whereas none of these patterns were found among children reading at an age-expectancy or above level. Moreover, it was found that even though improvement was seen in level of performance of reading and spelling over the course of several years, the patterns of reading and spelling remained fairly consistent. Finally, Boder suggested that since the patterns represented the reading disabled child's total performance in the reading and spelling tasks (i.e., his achievements as well as characteristic errors), the patterns had important prognostic and therapeutic implications.

In an attempt to isolate the clusters of cognitive deficiencies thought to limit the acquisition of reading skill, Mattis et. al. (1975)evaluated clinically the performances for three groups of children (brain damaged with no dyslexia; brain damaged with dyslexia; neurologically intact with dyslexia) on an extensive battery of neuropsychological tests. Based on the specific patterns of deficits exhibited on the testing, three different 'syndromes' or subgroups of reading disabled children were identified that accounted for 90% of the dyslexic children. These included a language disorder subtype (children who presented with an anomia and disorders of comprehension, imitative speech, and speech sound discrimination), an articulatory and graphomotor dysco-ordination group (children who exhibited an assortment of gross or fine motor coordination disorders, including a buccal-lingual dyspraxia with resultant poor speech and graphomotor dyscoordination), and a visuoperceptual deficit subtype (children who exhibited poor constructional ability and poor visual discrimination skills). The authors argued that the results of the study supported the view that dyslexia may be the result of multiple independent cognitive deficiencies rather than from a single causal defect. A cross validation study recently conducted by Mattis (1978) isolated the same three dyslexic syndromes, although the percentage of children presenting each syndrome and the total number of children accounted for by these syndromes differed from that found in the initial study. For the earlier study (Mattis et. al., 1975), 39% of the dyslexic children presented the language disorder syndrome, 37% the articulatory and graphomotor dysco-ordination syndrome, and 16% the visual-perceptual disorder. The comparable percentages in the more recent study (Mattis, 1978) were 63, 10 and 5% respectively.

The application of multivariate statistical classification techniques have provided another source for delineating subgroups of reading disabled children. Recently, for example, Doehring & Hoshko (1977) attempted to statistically classify reading problems by the use of the Q-technique of factor analysis. Thirty-one tests of reading-related skills were administered to two somewhat different groups of children with reading problems: Group R, composed of children in a summer programme for reading problems, and; Group M, composed of children in a summer programme for learning disorders, or in public school special classes for children with learning disorders, language disorders and mental retardation. Application of the statistical profile analysis method to each group revealed that children could be classified into subgroups which represented different patterns of reading deficits. For Group R, three subgroups were generated: one was characterized by slow oral word reading, a second by slow auditory-visual letter matching, and a third by slow auditory-visual association of words and syllables. For the Group M children, the statistical classification procedure identified two subgroups that were very similar to the last two subgroups generated for the Group R children, and a third subtype that was characterized by slow visual matching.

In another study employing the Q-technique of factor analysis, Petrauskas & Rourke (1979) attempted to identify subtypes of reading-disabled children based on their differential patterns of performance on a battery of neuropsychological measures. A total of 160 children (133 retarded readers, 27 normal readers) between the ages of 84 and 107 months were randomly divided into two subsamples with normal readers equally represented in each group. Both subsamples were then subjected to the factor analytic procedure (a total of twenty measures were selected for statistical treatment) separately as well as factor analysis of the total population. The results of the Q factor analyses revealed that six factors were generated for each of the data groups, and that three of the factors were quite reliable (based on high correlation coefficients calculated between the factors as well as a high degree of visual similarity observed between the plotted factor profiles). The profile for the first type revealed good performance on visual spatial, eye-hand coordination, tactile-perceptual and some problem-solving tasks, whereas deficiencies were exhibited on several auditory-verbal and language-related tasks. The profile for the second type was characterized by a combination of verbal and psycholinguistic, sequencing, and tactile finger localization deficits. Children in the third type exhibited deficiencies primarily on tasks involving the generating of verbal information and verbal coding. Finally, a fourth type, that failed to emerge reliably from the classification procedure, was composed mostly of normal readers.

In a related study, Fisk & Rourke (1979) analyzed the performances of learning disabled children at three different age levels (9-10 years, 11-12 years, 13-14 years) on a broad range of neuropsychological measures by means of the Q-type multivariate classification procedure. The main purposes of the study were to define subtypes of learning disabled children at each of the age levels, and to determine whether some of the subtypes would be replicated from one age level to another. Separate factor analyses were calculated for each age-based sample, and then the factor profiles generated at each age level were compared by correlational analyses and by visual inspection of the similarity of the plotted factor profiles to identify replicated subtypes. The results revealed three subtypes, two of which were replicated across three of the age levels and one that was replicated across two of the age levels (i.e., 11-12 years, 13-14 years). The first subtype exhibited deficiencies on some auditory-verbal and language-related tasks, some finger dysgraphesthesia, and pronounced finger agnosia. The second subtype exhibited deficiencies primarily on auditory-verbal and psycholinguistic tasks (involving mostly phoneme-grapheme matching and sound blending). The final subtype also exhibited deficits on some auditory-verbal tasks, and marked finger dysgraphesthesia. The authors concluded that learning disabled children indeed appear to constitute a heterogeneous group in terms of their neuropsychological adaptive ability structure, and that cognitive deficiencies seen at one age during the life span may persist across several developmental periods, although the cross-sectional nature of the study made interpretations regarding developmental trends somewhat guarded.

A final study illustrating the application of multivariate statistical classification procedures to determine subtypes of reading disabled children was conducted by Doehring et. al. (1979). The study had two parts: first, the Q-type factor analytic procedure was applied to a combined group of retarded and normal readers in an attempt to identify subtypes of reading problems, and secondly, the stability of the Q-technique was investigated by determining the subtypes that would be generated for the same children by means of another statistical classification procedure (cluster analysis). For the first part of the study, the results of the Q-technique revealed the same three subtypes of reading problems that were reported on in an earlier study by Doehring & Hoshko (1977). That is to say, the first subtype exhibited poor oral reading of syllables, words and sentences, the second subtype exhibited slow matching of spoken and written letters, and the third subtype exhibited poor matching of written syllables and words. For the second part of the study, several cluster analytic procedures were employed that represented the utilization of different types of distance-function indices (i.e., squared Euclidean distance coefficients or shape difference coefficients). In general, the results showed that the subtypes generated with the Q-type factor analytic procedure also emerged when the same data was treated to several cluster analytic classification procedures, with one particular cluster method (i.e., McQuitty's) demonstrating a remarkably high degree of congruity with the Q-technique in the sorts of subtypes identified. The authors emphasized that the results of the cluster analysis buttressed the application of statistical classification procedures in delineating different cognitive deficits associated with reading impairment.

Summary and Statement of Problem

Several perspectives on the origin of sinistrality and the relationship between handedness and cortical organization have been reviewed. To recapitulate, the studies of lesion-produced deficits, right-left perceptual asymmetries, and cognitive performance differences reported in the literature have implied that patterns of hemispheric specialization vary more among sinistrals that among dextrals. In the case of the lateralization of language functions, for example, nearly all right-handed individuals are thought to possess left hemispheric language dominance, whereas left-handers may exhibit left hemispheric, right hemispheric, or some degree of bilaterality language representation. Other cognitive abilities may be organized differently in the cerebral hemispheres of sinistrals as well, although the evidence to support such an assertion has been much less convincing.

It has also been suggested by several authors that left-handers may not constitute a homogeneous group, but may differ amongst themselves concerning patterns of hemispheric organization. Some of the variables thought to differentiate between sinistrals have included hand posture during writing, intensity of left-handedness, and familial history of sinistrality. Thus, it is the left-hander with a normal writing posture, or with an almost complete sinistral hand preference tendency, or with a family history of sinistrality who is most likely to exhibit an anomalous type of cerebral organization.

Emerging from the investigations into the types of ability differences for left-handed individuals is the claim that sinistrality is related to a variety of behavioural deficits. Several investigators have argued for an association between handedness and language problems, intellectual deficiency, and academic-related difficulties. The last of these has dealt mostly with the performances of children with reading impairment in particular. Most studies attempting to link sinistrality and reading disability have generated conflicting results. At the same time, studies dealing specifically with tactile discrimination skills in reading impaired children appear to offer some rather convincing evidence that left-handed children may be processing information in a manner different from their right-handed age-mates.

Finally, the application of multivariate statistical classification procedures appear to provide a precise method for identifying and describing subgroups of learning disabled children. In particular, both Q-type factor analysis as well as several cluster analytic procedures have been found to isolate subtypes of reading problems in a reliable fashion. It is clear that a reliable taxonomy of reading and other learning disabilities could offer potentially useful information regarding remedial management of such children. At the same time, most of the 'subtyping' resarch reported on in the literature has investigated adaptive skill deficiencies associated with adademic retardation in the *right-handed* learning disabled child. In turn, these adaptive skill deficits are thought to be related to specific patterns of cerebral organization and reflect areas of compromised brain functioning. A clarification and differentiation of the quality of cognitive impairment associated with learning disabilities in the *left-handed* child appears especially warranted, particularly in light of some rather convincing documented evidence to buttress the notion that left-handed individuals are more apt to exhibit an anomalous type of cerebral organization (i.e., one that is less clearly lateralized than that seen in the right-handed individual.

The purpose of the present study, therefore, was to isolate and define subgroups of left-handed learning disabled children. The performances of a group of sinistrals on a comprehensive battery of neuropsychological measures that included an assessment of hand preference patterns were analyzed by means of multivariate statistical classification methods. The measures chosen for study were essentially the same as those selected by Fisk & Rourke (1979) in their study of right-handed learning disabled children, and included tasks of a auditory-verbal, sequencing, visual-perceptual, tactile-perceptual, simple and more complex psychomotor, and conceptual reasoning nature. The rationale for selecting tasks within these neuropsychological skill areas was twofold: (1) there is documented evidence that the measures reflect behavioural functions that are thought to be subserved by various cortical systems and, in turn, are sinsitive to cerebral dysfunction (Reitan, 1966; Reitan & Davidson, 1974; Rourke, 1975), and (2) the measures are thought to reflect the nature of an individual's adaptive ability structure by providing information regarding areas of cognitive strength and weakness. Moreover, adopting tasks identical to those utilized by Fisk & Rourke (1979) enabled comparisons to be made of performance differences between left- and right-handed learning disabled children.

Expectations

The intended application of multivariate classification methods in the current study was viewed within an exploratory context. That is to say, the Q-technique of factor analysis as well as three cluster analytic procedures (i.e., average linkage, centroid sorting, iterative relocation) were used to analyze the performance measurements collected on a large number of children with the aim of discovering groups (or 'clusters') which would appear to belong together based on particular characteristics of the data set (Everitt, 1974; Maxwell, 1977; Wishart, 1978). The objective of the analysis was to see whether some underlying patterns of relationships exist within the data, with a view to the disclosure of subtypes of left-handed learning disabled children.

Although the generating of specific hypotheses was considered to be rather difficult, the evidence that has been reviewed concerning the relationship between preferred handedness and patterns of hemispheric specialization did suggest that certain predictions may be advanced regarding the identification of subgroups of left-handed disabled children. The following were a number of tentative expectations:

(1) First, if the brain of the sinistral is less clearly lateralized than that of the dextral, then it was expected that the number and type of cognitive deficits associated with learning disability in the left-handed individual would be different from that seen in the right-handed child (Hypothesis 1).

(2) Secondly, if the variable of familial handedness is indeed a relevant factor in distinguishing between sinistrals with different patterns of hemispheric specialization, then the subtypes generated from the left-handed learning disabled should reflect the presence or absence of left-handedness in the biological relatives of the group members (Hypothesis 2). Moreover, one may expect that cerebral laterality is affected by sinistral tendencies within the family of a right-handed person as well.

(3) Thirdly, if variation in cognitive organization in the sinistral were influenced by the intensity of left-handedness, then one might expect that the derived subgroups should manifest different measureable variations in the consistency and degree of left-handed preference (Hypothesis 3). In this regard, it has become increasingly clear that a distinction must be made between

hand preference and *hand proficiency*. Any attempt to identify subtypes of left-handers solely on the basis of preferred writing hand may be misleading. Discrete groups of sinistrals may only be uncovered by viewing the consistency of hand usage across a variety of behavioural tasks involving speed, strength, and manual dexterity.

Finally, in regard to the issue of the subtyping of learning disabled children, it was expected that the subgroups generated by means of one multivariate statistical procedure should be able to be detected through the application of several other classification methods as well. Indeed, this could only serve to buttress the claim that learning disabled children constitute a heterogeneous population in regard to the number and type of cognitive deficiencies they possess.

CHAPTER II

METHOD

Subjects

A total of 322 children were drawn from a population pool of over 3500 individuals who were referred to a large, urban children's clinic for a comprehensive neuropsychological evaluation. The complete battery of neuropsychologic measures were administered in a standardized manner by a trained psychometrist. The reasons for selecting the target population in this manner were twofold: (1) since the administration and scoring of the test battery required approximately eight hours per child, an unreasonable amount of time would have been needed in order to collect the necessary data on the rather large number of subjects utilized in the present study, and (2) it was felt that the monetary costs required to collect the data by any other means would have been substantial, and thus, would have posed severe limitations on the size of the target sample. Most of the children selected for study were referred to the clinic because they were thought to be suffering from some type of learning, behavioural, or "perceptual" handicap to which it was believed that cerebral dysfunction might be a contributing factor.

In drawing the sample for study, all subjects had to be between the chronological ages of 108 to 179 months, and must have exhibited an Intelligence Quotient in the range of 85 to 115 on one standard measure of psychometric intelligence, i.e., Wechsler Intelligence Scale for Children (Wechsler, 1949). Moreover, subjects were excluded if they failed to meet any one of the following selection criterion: (1) exhibited a greater than 25 decibel hearing loss with either ear within the frequency range of 500 to 4000 Hz. on a standardized Sweep Hearing Test, (2) medical evidence existed of a visual anomaly, (3) were judged by a professional to be in need of some form of psychotherapeutic intervention, or the interpretation of the neuropsychological test findings suggested the strong possibility of a socio-emotional disturbance, (4) spoke a primary language other than English in the home environment, or (5) there was rather convincing evidence of the presence of compromising environmental influences (e.g., inadequate food, shelter, clothing, and/or stimulation). Information pertaining to points (2), (3), and (5) above were obtained from past medical and social histories, while details regarding point (4) were derived from the results of a questionnaire the parents were requested to complete (see Appendix A).

As part of the assessment procedure, the subjects were administered the Harris Tests of Lateral Dominance

(Harris, 1947). Included on this inventory are a series of questions regarding preferred hand usage for the following seven manipulative tasks: throwing a ball, hammering a nail, cutting with a knife, turning a door knob, using a scissors, using an eraser, and name-writing. Initially, all subjects were classified as right- or left-handed on the basis of choice of writing hand. Thus, of the total 322 subjects, one-half (161) reported a left-handed name writing preference, whereas the remaining half (161) claimed to engage their right hand for the writing of their name. Moreover, of the total 161 left-handed writers, 86 were found to use their left hand on all seven of the Harris Inventory items, whereas the remaining 75 reported a tendency to use their right hand on one or more of the remaining questionnaire items. A more detailed account of the various hand preference patterns for the group of left-handed children is provided in Table 1. Right-handed writers, on the other hand, were composed almost entirely (n=151) of individuals who reported the use of their right hand solely for the inventory items.

One of the main reasons for the inclusion of a group of right-handed children in this study, apart from identifying differences that may exist between sinistral and dextral subtype profiles, was to act as a control for the effects of a positive and negative familial sinistrality history. That is to say, it was felt that if the variable of familial handedness *per se* was an important component in being

TABLE 1

Harris Inventory Hand Preference Patterns
for the Group of Left-Handed Children

L-R Pattern	*n*	% Sample
7-0	86	53%
6-1	24	15%
5-2	17	11%
4-3	8	5%
3-4	6	4%
2-5	8	5%
1-6	12	7%
TOTALS	161	100%

N.B. L = Left Hand
R = Right Hand

able to distinguish between individuals with different patterns of hemispheric specialization, then it might be expected that the subtypes generated for the sample of learning disabled children should reflect the presence or absence of sinistral tendencies within an individual's biological family members, irrespective of the individual's preferred handedness. The left- and right-handed groups were matched with regard to age distributions (i.e., there were 75 9-10 year olds, 56 11-12 year olds, and 30 13-14 year olds in each group), and a breakdown of the familial handedness component revealed that 65 left- and 64 right-handed children reported the presence of left handedness within the family, whereas 75 sinistrals and 92 dextrals reported the absence of sinistrality tendencies among family members. Data was missing on the remaining 21 left- and 5 right-handers. A more precise count of which family members were reported to exhibit sinistral tendencies is provided in Table 2. Information pertaining to the handedness of family members was derived from the same parent questionnaire referred to earlier (see Appendix A). Thus, children who reported the presence of at least one immediate family member (i.e., mother, father, sibling) as being left-handed constituted the positive familial sinistrality condition, whereas children who reported no immediate biological family members as being left-handed constituted the negative familial sinistrality condition.

TABLE 2

Classification of Sinistral Family Members for the Left- and Right-Handed Samples

	Sample			
	Left-Handers		Right-Handers	
Family Member	*n*	% Sample	*n*	% Sample
Sibling Only	39	60%	42	65%
Father Only	9	14%	8	13%
Mother Only	6	9%	7	11%
Father and Mother	4	6%	0	0%
Mother and Sibling	4	6%	4	6%
Father and Sibling	3	5%	3	5%
Total N	65	100%	64	100%

Table 3 presents the composition of subjects as well as the descriptive statistics for age, sex, and WISC Full Scale IQ. As can be see from Table 3, left-handers were comprised of 136 males and 25 females, whereas there were 134 male and 27 female right-handers. Moreover, it was clear that the groups were closely matched with regard to mean age and mean WISC Full Scale IQ.

One final note. Also listed on Table 3 are the mean Wide Range Achievement Test (WRAT; Jastak & Jastak, 1965) Reading, Spelling, and Arithmetic centile scores for each handedness sample. Even though no specific WRAT "cutoffs" were utilized in the selection of subjects, it was clear that the groups were closely equated on this basis as well. Moreover, Table 4 presents a more detailed account of the various WRAT subtest performance patterns for each handedness sample. Briefly, left-handers were composed of 147 subjects who had obtained at least one WRAT centile score of 30 or below, and 14 individuals with Reading, Spelling, and Arithmetic scores all above the 30th centile. Of the right-handed sample, there were 148 and 13 who met the above criterion, respectively.

Test Measures

Included among the tests that compile the comprehensive neuropsychological test battery were forty-two measures presumably thought to represent various adaptive skill areas as outlined by Reitan (1974). These skill areas

TABLE 3

Chronological Age, Sex, WISC Full Scale IQ and
WRAT Reading, Spelling, and Arithmetic Centile Specifications
for Left-Handed and Right-Handed Samples

	Left-Handers	Right-Handers
Sex Composition		
Males	136	134
Females	25	27
Total	161	161
Age (in years)		
Mean	11.45	11.28
SD	1.60	1.48
Range	9.03 - 14.98	9.06 - 14.06
WISC Full Scale IQ		
Mean	97.81	98.73
SD	7.47	7.76
Range	85.00 - 115.00	85.00 - 115.00
WRAT Centile		
Reading	27.09	25.13
SD	26.20	23.40
Spelling	17.63	16.33
SD	19.10	11.72
Arithmetic	16.33	20.01
SD	11.72	12.95

TABLE 4

WRAT Subtest Performance Patterns for

Left-Handed and Right-Handed Samples

Pattern	Samples Left-Handed	Samples Right-Handed
R, S, A $\leq$ 30	99	99
R, S $\leq$ 30	13	7
S, A $\leq$ 30	16	15
R, A $\leq$ 30	0	2
R $\leq$ 30	2	1
S $\leq$ 30	4	3
A $\leq$ 30	13	21
R, S, A $>$ 30	14	13
Total N	161	161

N.B. R, S, and A refer to the Reading, Spelling and Arithmetic Subtests of the WRAT, respectively. The 30 represents the 30th centile.

included: (1) tactile-perceptual and tactile-kinesthetic abilities, (2) visual-motor, visual-perceptual and visual-spatial skills, (3) sequential processing abilities, (4) auditory-perceptual and language-related abilities, (5) simple motor and psychomotor skills, and (6) conceptual reasoning and non-verbal problem-solving capabilities. A listing of the test measures categorized into their respective skill areas is provided in Table 5. The sorting of tests into these particular areas of neuropsychological functioning was based primarily on face validity. At the same time, these classifications were found to exhibit a reasonably high degree of congruity with the categorization of performance measures generated by a preliminary R-type factor analysis conducted on the test battery (Gates, Note 1). By way of comparison, the R-type factor analytic classification procedure (conducted on children in the age range of 9 to 12 years) isolated seven interpretable factors: a perceptual organizational and non-verbal problem-solving factor, a verbal comprehension factor, a sequential processing or code-guided behaviour factor, a speech-sounds factor, an immediate verbal memory factor, a simple motor factor, and a complex motor factor.

Included within each of the six adaptive skill areas outlined by Reitan were the following performance measures:

TABLE 5

List of Dependent Test Measures Grouped Into Adaptive Skill Areas

	Test Measures	Skill Area
1.	Tactile Imperception and Suppression-Right Hand (TACR)	Tactile-Perceptual
2.	Tactile Imperception and Suppression-Left Hand (TACL)	Tactile-Perceptual
* 3.	Tactile Finger Recognition-Right Hand (FAGNR)	Tactile Perceptual
4.	Tactile Finger Recognition-Left Hand (FAGNL)	Tactile-Perceptual
* 5.	Fingertip Number Writing-Right Hand (FTWR)	Tactile-Perceptual
6.	Fingertip Number Writing-Left Hand (FTWL)	Tactile-Perceptual
7.	Tactile Coin Recognition-Right Hand (ASTR)	Tactile-Perceptual
8.	Tactile Coin Recognition-Left Hand (ASTL)	Tactile-Perceptual
* 9.	Tactual Performance Test-Right Hand (TPTDT)	Tactile-Perceptual
*10.	Tactual Performance Test-Left Hand (TPTNDT)	Tactile-Perceptual
11.	Tactual Performance Test-Both Hands (TPTBT)	Tactile-Perceptual
*12.	WISC Picture Completion Subtest (PICCOM)	Visual-Perceptual
13.	WISC Picture Arrangement Subtest (PICARR)	Vidual-Perceptual
*14.	WISC Block Design Subtest (BLKDES)	Visual-Perceptual
*15.	WISC Object Assembly Subtest (OBJASS)	Visual-Perceptual
16.	Visual Imperception and Suppression-Right Hand (VISR)	Visual-Perceptual
17.	Visual Imperception and Suppression-Left Hand (VISL)	Visual-Perceptual
*18.	Target Test (TARGET)	Visual-Perceptual

TABLE 5 (cont'd)

Test Measures	Skill Area
*19. WISC Arithmetic Subtest (ARITH)	Sequential Processing
*20. WISC Digit Span Subtest (DIGITS)	Sequential Processing
*21. WISC Coding Subtest (CODING)	Sequential Processing
*22. WISC Information Subtest (INFO)	Auditory-Perceptual
*23. WISC Comprehension Subtest (COMP)	Auditory-Perceptual
24. WISC Similarities Subtest (SIMIL)	Auditory-Perceptual
25. WISC Vocabulary Subtest (VOCAB)	Auditory-Perceptual
26. Peabody Picture Vocabulary Test (PPVTIQ)	Auditory-Perceptual
27. Auditory Imperception and Suppression-Right Hand (AUDR)	Auditory-Perceptual
28. Auditory Imperception and Suppression-Left Hand (AUDL)	Auditory-Perceptual
*29. Speech-Sounds Perception (SSPER)	Auditory Perceptual
*30. Auditory Closure (AUDCLO)	Auditory-Perceptual
31. Sentence Memory (SENMEM)	Auditory-Perceptual
32. Verbal Fluency (VFLU)	Auditory-Perceptual
*33. Finger Oscillation-Right Hand (TAPR)	Motor
*34. Finger Oscillation-Left Hand (TAPL)	Motor
35. Foot Tapping-Right Foot (FTAPR)	Motor
36. Foot Tapping-Left Foot (FTAPL)	Motor

TABLE 5 (cont'd)

	Test Measures	Skill Area
37.	Grip Strength-Right Hand (GRIPR)	Motor
38.	Grip Strength-Left Hand (GRIPL)	Motor
*39.	Grooved Pegboard-Right Hand (PEGSRT)	Motor
*40.	Grooved Pegboard-Left Hand (PEGSLT)	Motor
*41.	Category Test (CATTOT)	Conceptual Reasoning
*42.	Trails B Test (TRSBT)	Conceptual Reasoning

* Denotes dependent measures used in data analyses treatment.

(1) Tactile-perceptual and tactile-kinesthetic skills

Tactile Imperception and Suppression Test; Tactile Finger Recognition Test; Fingertip Number-Writing Perception Test; Coin Recognition Test; Tactual Performance Test (Reitan & Davidson, 1974).

(2) Visual-motor, visual-perceptual, and visual-spatial abilities

The Picture Completion, Picture Arrangement, Block Design and Object Assembly subtests of the WISC (Wechsler, 1949); Visual Imperception and Suppression Test; Target Test (Reitan, 1969).

(3) Sequential processing abilities

The arithmetic, Digit Span, and Coding subtests of the WISC (Wechsler, 1949).

(4) Auditory-perceptual, auditory-verbal and language-related abilities

The Information, Comprehension, Similarities and Vocabulary subtests of the WISC (Wechsler, 1949); Peabody Picture Vocabulary Test (Dunn, 1965); Auditory Imperception and Suppression Test; Halstead Speech-Sounds Perception Test as modified for use with younger children by Reitan (Reitan & Davidson, 1974); Auditory Closure Test (Kass, 1964); Sentence Memory Test (Benton, 1965); Verbal Fluency Test (Strong).

(5) Simple motor and psychomotor skills

The Finger Oscillation Test; Foot-Tapping Test; Grip Strength Test; Grooved Pegboard Test (Reitan & Davidson, 1974).

(6) Conceptual reasoning and non-verbal problem-solving capabilities

The Category Test; Trails B Test (Reitan & Davidson, 1974).

A more comprehensive description of each of these measures is provided in Appendix B.

Procedure

Of the forty-two dependent measures listed in Table 5, twenty-one (those denoted by an asterisk next to the variable name) were selected for data analyses treatment. As mentioned previously, these test measures comprise the same ones used by Fisk & Rourke (1979) in their study of right-handed learning disabled children. The main purpose for selecting identical dependent measurements was to enable more direct comparisons to be made of performance differences between left- and right-handed learning disabled children (i.e., do the same 'subtypes' of cognitive deficiencies exist for learning disabled children irrespective of handedness?). At the same time, these twenty-one variables were compared against those selected by means of a Pearson product moment correlational analysis (SAS Procedure CORR; Helwig & Council, 1979) conducted on the pool of forty-two test measures. The criteria for selecting variables by a correlational analysis technique have been outlined in Fisk & Rourke (1979) and included the following: (a) selected variables were to represent the lowest possible intercorrelations between test measures within each adaptive skill area, (b) the number of test measures selected were to be approximately the same within each adaptive skill area, and (c) selected variables were to reflect a reasonably high degree of clinical explanatory potential.

Discussion on the statistical treatment of the data is conducted in three phases. The first phase includes a description of the steps involved in the application of the Q technique of factor analysis to the left-handed and right-handed groups of children independently. In the second phase, the steps involved in the application of different cluster analytic classification procedures to the two target samples is outlined. Briefly, two hierarchical agglomerative algorithms (i.e., average linkage, centroid sorting) combined with a iterative relocation procedure were utilized in the treatment of the data. Finally, phase III describes the statistical analyses used to compare the composition of subgroups generated by the multivariate quantitative taxonomic procedures across such variables as intensity of sinistral preference or proficiency, and history of familial handedness.

Q Technique of Factor Analysis

For the purpose of enabling comparisons to be made between the many different test measures, raw scores collected on each of the dependent measures were converted to T scores based on a fund of normative data supplied by Wechsler (1949), Knights & Moule (1967) and Knights (1970). The transformed T score distribution was based on a mean of 50 and a standard deviation of 10.

Briefly, the Q type factor analytic procedure involves the following computational format: preparation of the correlation matrix, extraction of the initial factors, and rotation to a terminal solution (Nie, Bent, & Hull, 1970; Lawlis & Chatfield, 1974). As a basic input to the factor analysis, T scores were transposed and product moment correlation coefficients were calculated between each pair of subjects in the target sample. Next, factor analysis was applied to the correlational matrix using an iterated principal axis solution (communality estimates based on 1.00 in the diagonals initially). The purpose of this stage was to explain the inter-relationships existing in the data by means of a minimum number of common factors or components. To achieve simpler, and hopefully, theoretically more meaningful factor patterns, the initial extracted factors that yielded eigenvalues greater than or equal to the ratio of number of subjects/number of variables were then retained and rotated orthogonally to varimax criterion (SAS PROC FACTOR, Method = Prinit; Helwig & Council, 1979).

The decision was made to retain subjects who exhibited a single factor loading of .50 or greater, mainly because this criterion was adopted both by Fisk & Rourke (1979) and by Doehring and his associates (1979). At the same time, since the factor loading is indicative of the correlation coefficient between subject and factor (Lawlis & Chatfield, 1974), a value of .50 would seem to represent a moderately strong degree of association between the two. Thus, children were assigned to each subtype in terms of the factor for which they showed the highest factor loading above .50. For each group of individuals who constituted a subtype, $\underline{T}$ score means for the twenty-one variables used in the factor analysis were calculated. These values were then plotted to enable graphical presentation of the factors or 'subtypes' determined by the factor analytic procedure.

This computational format was applied in a similar manner to the left- and right-handed children independently. Analyses of the similarities and differences between factor solutions generated for the left- and right-handed samples were conducted in the following two ways: (1) through visual inspection of the factor profiles, and (2) by means of Pearson product moment correlational analysis between each plot separately.

At this point it would be worthwhile to review the expectations outlined in Chapter I. Perhaps this may be best accomplished by viewing a pictorial representation of the subtypes expected to be generated through the application of the Q type multivariate classification technique. In Figure 1, you can see that initially the total population (N = 322) has been partitioned into two handedness samples (based on choice of name-writing hand), with 161 subjects within each group. For the left-handers, the boxes labelled *pure* and *mixed-preference* are intended to illustrate two expected subtypes that manifest different measurable variations in the consistency and degree to which they report the use of their left hand on a series of hand preference questionnaire items. Thus, the former subgroup is composed of members who report a tendency to engage the left hand for all seven of the manipulative tasks listed on the Harris inventory, whereas the latter subgroup is made up of individuals who demonstrate deviations from a consistent sinistral tendency for the preference items (e.g., a person who writes his name with the left hand but throws a ball with the right). Moreover, it was pointed out earlier that a distinction should be

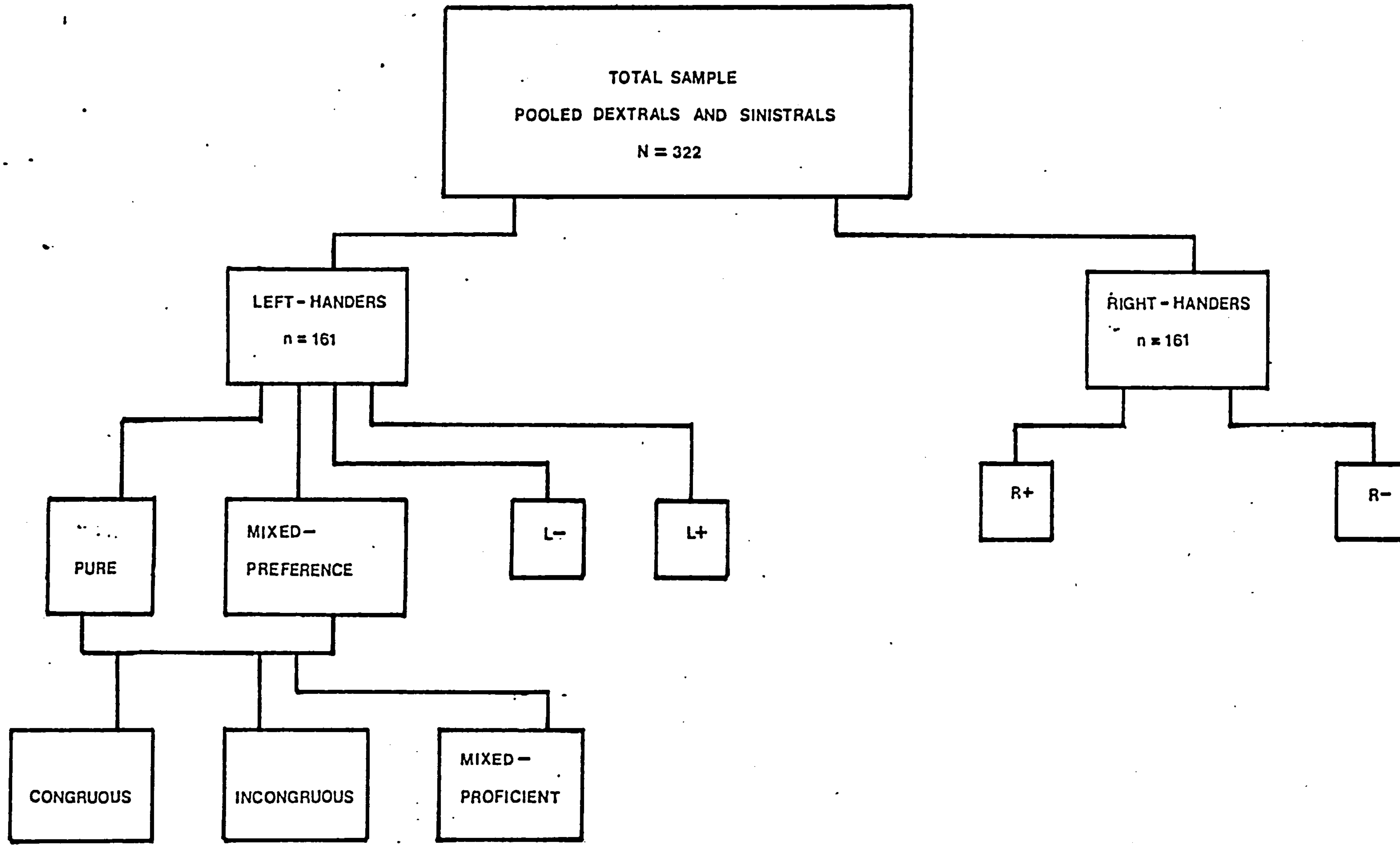

Figure 1. Illustration of subtypes expected to be generated by multivariate statistical classification analyses (see text for explanation of partitions and notations).

made between *hand preference* and *hand proficiency*. The three boxes located directly beneath the *pure* and *mixed-preference* partitions are intended to represent three expected subtypes of left-handed writers who manifest variations in consistency of hand usage across two behavioural tasks: one involving gross motor speed, and a second involving fine manipulative dexterity. As part of the neuropsychological assessment proceedings all subjects were also administered both a speeded fine eye-hand coordination task involving the placement of small steel pegs into slots or holes varying in directional orientation (i.e., Grooved Pegboard Test), and a simple motor speed task involving the rapid tapping of a key with the index finger (i.e., Finger Oscillation Task). On the basis of an individual's performances on these two behavioural measures, it was thought that the following three subtypes may emerge: (1) *congruous left-handers*, those individuals who write with the left hand, and who also exhibit a higher level of performance with the left hand as compared to the right hand on both the Grooved Pegboard and Finger Oscillation Tasks, (2) *incongruous left-handers*, those individuals who write with the left hand, but who demonstrate a higher level of performance with the right hand on both behavioural measures, and (3) *mixed-proficient left-handers*, those individuals who prefer to write with the left hand, but who exhibit a mixed proficiency pattern on the two behavioural tasks (i.e., left-handed performance superior to right-handed performance on one task, and vice versa). Initial accounts of these hand proficiency patterns within the total sinistral sample (N = 161) revealed 64, 36 and 61 *congruous*, *incongruous*, and *mixed-proficient* left-handers, respectively.

One final note on this issue. It was thought that the emergence of discrete *hand preference* and *hand proficient* subtypes would hopefully aid in detecting differences that may exist between the classification of sinistrality by means of a hand preference inventory as compared against demonstrated left-handed performance proficiency on behavioural tasks involving simple motor speed and fine manipulative dexterity. As well, it was felt that it would permit an investigation into the importance of 'degree or intensity' of sinistrality as measured by two separate methods.. Finally, it should be pointed out that even if hand proficiency is found to be a more important consideration in delineating subtypes of left-handers, the location of the *congruous* , *incongruous* and *mixed-proficient* partitions on Figure 1 (i.e., beneath both *hand preference* markers) is intended to illustrate the fact that each of these three categories could well include both *pure* and *mixed preference* individuals as subtype members.

The remaining boxes, labelled *L+* on Figure 1, are intended to reflect detected subtypes of sinistral learning disabled children who manifest variations in hand preference tendencies within the child's biological family members. Thus, the *L+* (positive familial sinistrality) partition consists of those children who report the presence of at least one immediate family member (e.g., mother, father, sibling) as being left-handed, whereas left-handed writers who report no immediate biological relatives as exhibiting sinistral tendencies constitute a separate (negative familial sinistrality) subtype identified as *L-*. To control for the effects of a positive and negative familial sinistrality history, a comparable group of right-handed writers (N = 161) was factor analyzed as well. From such an analysis it was felt that a similar classification for right-handed learning disabled children should emerge (i.e., a subtype composed of members with familial left-handed tendencies (R+), and a separate subgroup whose members report a nonfamilial sinistrality history (R-)). In each case, the reporting of familial left-handedness was accomplished by having the two parents document, by means of a Parent Questionnaire, their own hand preferences as well as those of their offspring (see Appendix A).

Cluster Analytic Classification Procedures

To reiterate, the main reason for utilizing multivariate cluster analytic techniques in the present study was to confirm the existence of subtypes that had been identified by the Q type factor analytic procedure. That is to say, it was expected that the subgroups generated by means of one multivariate statistical procedure should be able to be detected through the application of several other classification methods as well. As Doehring et. al. (1979) so aptly stated, (at least in regard to reading impairment), '. . . subtypes which had previously been identified by the Q technique (and continue to) remain well-defined when the data were re-examined using the technique of cluster analysis . . . confirms the usefulness of statistical classification procedures in identifying the patterns of reading problems' (p. 1, Italics added). Stated another way, the occurrence of consonant subtypes isolated by means of several different classification methods will serve to buttress the claim that learning disabled children constitute a heterogeneous population in regard to the number and type of cognitive deficiencies they possess.

The number and variety of cluster analytic techniques is overwhelming. Even Everitt (1974) in his detailed comprehensive review of cluster analysis admitted to the fact that attempts to list and describe clustering techniques currently available cannot keep pace with the mushrooming literature on the development of new classification techniques. To complicate matters further, numerous methodological considerations surround the use of cluster analysis. Thus, Blashfield (1980) points out that the choice of clustering method, the similarity measure, the computer programme, and the procedure for estimating the number of clusters must be clearly defined. Moreover, adequate evidence of a cluster solutions validity should be provided as well (e.g., replicating a solution across different cluster analytic methods or across a different collection of variables). Morris, Blashfield and Satz (1981) add to this list the fact that most cluster methods cannot be formulated in precise mathematical terms. Because the technique demands some familiarity with a number of complicated parameters, both Morris et al. (1981) and Doehring et al. (1979) have cautioned against the selection and application of cluster analysis without first consulting an expert in the field.

Be that as it may, some of the bewilderment surrounding the selection of an 'appropriate' clustering method can be alleviated somewhat by the fact that most cluster analysis techniques can be organized or arranged into categories. Thus, Everitt (1974) suggests the following five part classification scheme: hierarchical techniques; optimization-partitioning techniques; density or mode-seeking techniques; clumping techniques; and others (the reader is referred to Everitt (1974) for a detailed discussion on the particulars that distinguish between these classes of clustering methods). Morris, Blashfield and Satz (1981) report a similar classification arrangement but define 'others' more clearly to include 'factor analysis variants' and 'graphic techniques'. In general, in most clustering procedures, measurements collected on a number of individuals (or objects) are examined through the use of ad-hoc algorithms, with a view to the disclosure of subgroups or 'clusters' that would appear to belong or 'hold' together based on particular characteristics of the data set (Everitt, 1974; Lawlis & Chatfield, 1974; Maxwell, 1977). Members (individuals or objects) of a group or cluster share a high degree of association between each other while, at the same time, demonstrate low associative values with members of a different cluster. In general, the aim is to discover clusters or categories that exist in the data rather than allocate individuals to known groups, which is the purpose of an 'assignment or identification' procedure such as discriminant function analysis (Maxwell, 1977; Morris et al., 1981).

The advent of computer software programmes dealing specifically with a variety of cluster analytic methods has enabled the application of multiple techniques (Wishart, 1978). The Clustan 1C User Manual provides a comprehensive compilation of the clustering programmes available. In approaching the problem of the application of cluster analytic procedures, a certain amount of care needs to be exercised in regard to subject and variable selection, choice of similarity measure, determination of the number of clusters existing in the data, and validation of the solution (Morris et al., 1981). For the first of these issues, some authors (Everitt, 1974; Wishart, 1978) have suggested that when dealing with a large number of dependent measures, one may want to perform a principle components analysis on the data, and use the first few principle component scores as input variables to the clustering procedure. This is a useful way of reducing the number of variables. However, since one objective of this study was to compare classifications derived from different taxonomic procedures, a decision was made to apply cluster analyses to the same twenty-one T score measures collected on the same target populations used in the factor analytic procedure. Besides, these measures have already been shown to load highly on factors found in a factor analysis of the test battery. Moreover, following the recommendation of Morris and his colleagues (1981) T score were chosen over factor score matrices as inputs to the clustering procedures. According to these authors, since factor scores are normally distributed, they are thought to be limiting in a clustering problem. The remaining issues, similarity measure and cluster method selection, criterion for termination of the clustering procedure, and validation of the cluster solution are discussed in more detail below.

For many clustering methods, the first stage in the computational format involves a conversion of a matrix of data into a matrix of interindividual similarities or dissimilarities (Everitt, 1974;

Maxwell, 1977; Morris et al., 1981). Basically, this refers to a measure of the relationships or associations between pairs of individuals, given the value of a set of variables common to both. Two measures of interindividual similarity are typically considered in cluster analysis. The first of these is correlation, a measure usually adopted when one is particularly interested in the similarity of profile shapes or patterns. The most commonly used correlation measure is the product moment correlation coefficient. The second measure, distance, is thought to be more appropriate when elevation across variables is of particular interest. The best known distance measure is, of course, Euclidean. The choice between correlations and distances measures in clustering is difficult to make, and a case can be made for the selection of either one. In the present study, it was felt that the similarity of profile shapes, rather than how far apart the profiles were, was more important in identifying different subtypes of left-handed learning disabled children. Thus, the product moment correlation coefficient was selected as the measure of similarity between subjects.

The next stage in the cluster analysis is to select the clustering technique(s). Most researchers agree that there is no one technique that can be judged to be "best" in all circimstances. A single set of scores analyzed by two different techniques can result in entirely different solutions or groupings of the data (Everitt, 1974). At best, Everitt suggests that several techniques should be used to lessen the possibility of accepting misleading solutions. It is for this reason primarily that two clustering methods were chosen to analyze the data in the present study. Because the hierarchical agglomerative techniques are accepted as the clustering methods of choice in a number of investigations, a decision was made to adopt two hierarchical techniques, group average or average linkage (CLUSTAN, version 1C2, procedure HIERARCHY, method GROUP AVERAGE, Wishart, 1978). and centroid sorting (CLUSTAN, version 1C2, procedure CENTROID, Wishart, 1978). Moreover, the results of another recent cluster analysis study of learning disabled children (Joschko, Note 2) suggested the use of these two particular techniques following a systematic analysis of a variety of clustering methods.

The basic procedure with hierarchical agglomerative methods is as follows: beginning with the computation of a interindividual similarity matrix members are grouped together by a series of successive 'fusions' which culminate at the point where all individuals are in one group (Everitt, 1974; Maxwell, 1977). The clustering methods unite individuals or groups of individuals which are most similar. Differences between the various agglomerative methods arise because of the differing ways of defining similarity between an individual and a group containing several individuals or between two groups of individuals. For the group average method, similarity between clusters is defined as the average similarity of all pairs of individuals in the two clusters. For the centroid sorting analysis, the similarity between two clusters is computed using the two centroid vectors representing the clusters.

To clarify further the cluster solutions derived by means of the two hierarchical methods, a iterative relocation procedure was applied to both (CLUSTAN, version 1C2, procedure RELOCATE, Wishart, 1978). The initial clustering solution was reexamined to see if any of the classified subjects should be reallocated to another group. The technique simply removes each subject from its assigned group and compares its similarity to each other cluster with the objective of determining the one to which it is most similar (Everitt, 1974; Morris et al., 1981). Statistically, the technique attempts to minimize within-cluster variance and maximize between-cluster variance. Moreover, as Morris et al. state, '. . .(the relocation method) also allows the investigator to examine the number of 'relocated' subjects which could give some idea of the stability of the solution. If many subjects are changing clusters during each iteration, one must wonder about the adequacy of the results'. (p. 89, Italics added). One final note on the relocation procedure. Some authors (Wishart, 1978) have suggested that it is often difficult to find a 'global optimum' solution when clustering very large populations (e.g., N 150). To help circumvent this problem, Wishart (1978) has suggested that different 'starting configurations' (e.g., shape difference, size difference, or random classification arrays) should be utilized in the RELOCATE step. If the same cluster solution is replicated from say a random start as from a shape difference classification array, then a 'global optimum' solution is likely to have been achieved. In the current study, iterative relocation analyses was performed utilizing the shape difference classification array, and a random initial configuration.

A persistent problem in cluster analysis is the difficulty of deciding as to the correct nember of groups to consider for a given set of data. Two commonly used methods or indicators for the number of cluster present in the data include an examination of the dendrogram or mapping of the data, and an analysis of the clustering coefficients (Everitt, 1974; Morris et al., 1981). In the first of these methods, hierarchical tree-like plots of the clustering solutions enable detection of a phenomenon known as "chaining" in the data (i.e., a tendency to cluster together entities linked by chains of intermediates), as well as detecting multilevel clustering solutions (Everitt, 1974; Morris et al., 1981). With the second of these methods, clustering coefficients (i.e., measures of variance) are computed during the course of the clustering process. A precipitous change observable in a plot of these values from one grouping to the next suggests that two clusters were combined to form a heterogeneous cluster (i.e., one with a high degree of within-cluster variability). Both criterion were employed in the present study, although some indication of the correct number of clusters was presumably provided by the _Q_ type factor analytic solution.

Validation is the last step in the clustering procedure. Several methods for determining the stability and usefulness of the clustering solutions are reported on the literature. Some of these procedures include the following: (1) randomly dividing the sample into two and performing separate analyses on each (clearly structured data should produce similar solutions for the partitioned samples as that found for the entire population), (2) removal of a few variables from the analysis ('real' clusters should be altered little in the process), (3) demonstrating that clusters have predictive value with respect to variables not included in the original clustering procedure, and (4) analyzing the same data set by several different clustering techniques (widely divergent solutions call into question the existence of well-defined clusters) (Everitt, 1974; Maxwell, 1977; Morris et al., 1981). Criterion (4) was partially satisfied in the present study by the utilization of two different clustering methods. In addition, a split-sample design was employed which randomly divided the 161 children into two subsamples and each half was clustered independently. Membership assignment in the partitioned samples was checked against the cluster solutions derived for the standard.

Finally, the solutions derived from the cluster analyses were compared against the subtypes generated by the Q-technique or factor analysis. This was accomplished in three ways. First, for each group of individuals who constituted a cluster, T score means for the variables used to define the cluster were calculated. These values were then plotted graphically to enable visual inspection of the similarity between intercluster profiles, and between Q type and cluster analysis profiles. Secondly, Pearson product moment correlational analyses were conducted between each plot separately. Finally, following the criterion outlined in Doehring et al. (1979) the results of the cluster analyses were evaluated and interpreted with reference to the classification obtained in the Q type analysis, (i.e., the number of subjects from each of the Q technique subtypes who were not classified together by a given method of cluster analysis).

Figure 2 presents an illustration of the steps involved in the Q type factor analytic and cluster analysis procedures.

Subtype Analyses

Subgroup composition across such variables as intensity of left-handedness (including analyses of hand preferences and hand proficiency), as well as familial handedness tendencies was analyzed through the application of a series of Chi-Square (χ^2) Goodness-of-Fit tests (Yamane, 1967). The distribution of scores for the hand preference, hand proficiency and familial handedness variables for each Q type factor and cluster analytic group were compared against their respective hypothetical distributions, and a measure of agreement or conformity (χ^2) was generated for each.

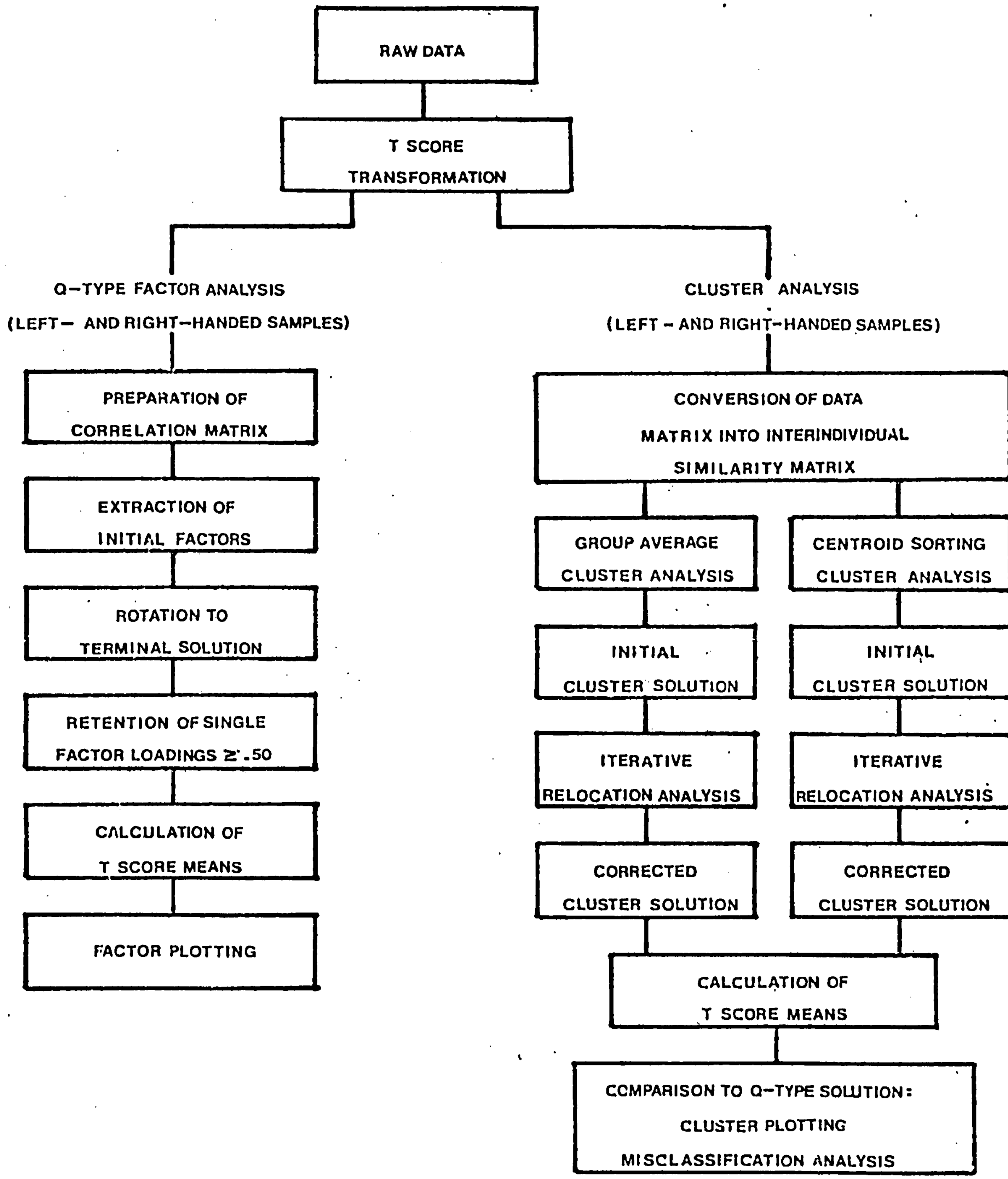

Figure 2. Illustration of the steps involved in the Q type and cluster analytic classification procedures.

CHAPTER III

RESULTS

The results of this study are presented in three phases. The first phase reports on the selection of appropriate variables on which to factor and cluster analyze the target samples. The second phase describes the *Q* type factor analyses solutions. Finally, the last phase discusses the cluster analyses results and includes a report on the validation procedures used to assess the adequacy and stability of the clustering solutions. It also gives an account of the degree of conformity or agreement between the subtypes derived from the different multivariate taxonomic procedures.

Variable Selection

In any multivariate taxonomic procedure the choice of variables will obviously determine the classification found, and it is important that the measures selected are relevant to the type of classification being sought. For example, in their attempts at describing the adaptive ability makeup of children who were encountering learning problems, both Petrauskas and Rourke (1979) and Fisk and Rourke (1979) utilized a broad range of neuropsychologic measures aimed at delineating areas of normal and compromised brain functioning. For reasons already noted, the twenty-one dependent measures employed by the latter authors in their *Q* typing of right-handed learning disabled children were also utilized in the present study.

At the same time, following the procedure outlined in the Fisk and Rourke (1979) investigation, product moment correlations were computed between the forty-two test measures listed in Table 5. The results of these analyses are presented in Tables 6 to 11. An asterisk next to the variable name denotes those test measures selected by Fisk and Rourke (1979) and utilized in the present study as input variables to the multivariate classification procedures.[1] Moreover, by way of comparison, Table 12 presents the results of an R type factor analysis of the test battery conducted on a group of children within the age range of 9-12 years. It is clear from Table 12 that those variables selected as dependent measures on the basis of a 'rational grouping procedure' so employed in the present study follows fairly closely the factor solutions generated by a formalized R type analysis.

Q Type Factor Analyses Solutions

The results of the factor analyses by the Q technique applied to the scores of the 161 left- and 161 right-handed children independently are presented in Table 13. The eigenvalue limitation used to

[1]Applying the criterion that selected variables were to represent the lowest possible intercorrelations between test measures within each adaptive skill area, an argument could perhaps have been made for the selection or inclusion of certain other variables as dependent measures (e.g., VFLU, SENMEM, and VOCAB within the Auditory-Perceptual realm; FAGNL and FTWL within the Tactile-Perceptual area; and GRIPR and GRIPL among the Motor measures). However, as stated earlier, one intention of this study was to compare directly the subtypes generated for a sample of left-handed children to those already reported on for a similar group of right-handed agemates (i.e., Fisk & Rourke, 1979). Thus, dependent measures were duplicated.

TABLE 6

Pearson Product Moment Correlation Coefficients

for Auditory-Perceptual Measures.

	INFO	COMP	SIMIL	VOCAB	PPVTIQ	AUDR	AUDL	SSPER	AUDCLO	SENMEM	VFLU
* INFO	1.00	.34	.33	.50	.41	.17	-.07	.30	.35	.41	.15
* COMP		1.00	.23	.32	.33	.05	-.08	.14	.12	.23	.13
SIMIL			1.00	.43	.37	.13	.03	.13	.13	.28	.15
VOCAB				1.00	.56	.09	.01	.22	.38	.46	.16
PPVTIQ					1.00	.01	.01	.18	.25	.38	.10
AUDR						1.00	.05	-.07	.01	.06	-.08
AUDL							1.00	.02	-.05	.04	-.08
* SSPER								1.00	.15	.34	.34
* AUDCLO									1.00	.29	.18
SENMEM										1.00	.33
VFLU											1.00

TABLE 7

Pearson Product Moment Correlation Coefficients

for Sequential Processing Measures

	ARITH	DIGITS	CODING
* ARITH	1.00	.24	.04
* DIGITS		1.00	.07
* CODING			1.00

TABLE 8

Pearson Product Moment Correlation Coefficients

for Visual-Perceptual Measures

	PICCOM	PICARR	BLKDES	OBJASS	VISR	VISL	TARGET
* PICCOM	1.00	-.01	.27	.18	-.07	-.11	.16
PICARR		1.00	.20	.19	.01	-.01	.23
* BLKDES			1.00	.39	.09	-.02	.27
* OBJASS				1.00	-.03	-.04	.18
VISR					1.00	.19	-.03
VISL						1.00	.01
* TARGET							1.00

TABLE 9

Pearson Product Moment Correlation Coefficients

for Tactile-Perceptual Measures

	TACR	TACL	FAGNR	FAGNL	FTWR	FTWL	ASTR	ASTL	TPTDT	TPTNDT	TPTBT
TACR	1.00	.48	-.16	-.12	-.04	-.06	-.02	-.13	-.21	-.12	-.11
TACL		1.00	-.19	-.08	-.09	-.13	-.14	-.16	-.36	-.19	-.12
* FAGNR			1.00	.56	.21	.19	.06	.10	.23	.16	.10
FAGNL				1.00	.16	.13	-.01	.04	.12	.17	.05
* FTWR					1.00	.83	.06	.16	.13	.27	.11
FTWL						1.00	.06	.14	.16	.23	.12
ASTR							1.00	.58	.07	.12	.02
ASTL								1.00	.15	.28	.06
* TPTDT									1.00	.46	.35
* TPTNDT										1.00	.33
TPTBT											1.00

TABLE 10

Pearson Product Moment Correlation Coefficients

for Motor Measures

	TAPR	TAPL	FTAPR	FTAPL	GRIPR	FRIPL	PEGSRT	PEGSLT
* TAPR	1.00	.76	.39	.33	.43	.46	.27	.24
* TAPL		1.00	.37	.39	.35	.41	.26	.34
FTAPR			1.00	.87	.24	.30	.23	.20
FTAPL				1.00	.21	.28	.19	.20
FRIPR					1.00	.88	.23	.18
FTAPL						1.00	.24	.23
* PEGSRT							1.00	.76
* PEGSLT								1.00

TABLE 11

Pearson Product Moment Correlation Coefficients

for Conceptual Reasoning Measures

	CATTOT	TRSBT
* CATTOT	1.00	.16
* TRSBT		1.00

TABLE 12

R Type Factor Analysis Solutions

Factor 1		Factor 2		Factor 3		Factor 4		Factor 5		Factor 6		Factor 7		Factor 8	
*OBJASS	.74	VOCAB	.78	TRSAT	.61	MAZCM	.83	VFLU	.52	*DIGITS	.62	GRIPM	.58	PEGSM	.32
*BLKDES	.66	SIMIL	.67	*TRSBT	.57	MAZSM	-.38	*AUDCLO	.49	SENMEM	.44	TAPM	.57	CATTOT	-.30
PEGSM	.51	*INFO	.66	*CODING	.52	HOLCM	.37	FAGM	.38	*ARITH	.39				
*PICCOM	.48	PPVTIQ	.66	*SSPER	.39			*SSPER	.31	ASTM	.38				
TPTM	.45	*COMP	.59	*TARGET	.36					*CATTOT	.31				
PICARR	.45	SENMEM	.56												
*TARGET	.34	*ARITH	.44												
TPTMEM	.33	*PICCOM	.33												
*CATTOT	.32	PICARR	.29												

* Denotes variables used in the current study.

N.B. Some of the variable abbreviations listed on this Table differ from those listed on Table 5. The meaning of these abbreviations are not particularly important for the purposes of the present study. However, if the reader is interested, the signification of these labels can be ascertained elsewhere (Gates, personal communication).

TABLE 13

Factor Analysis Solutions for Left-Handed and Right-Handed Samples

	Factors						
Data	1	2	3	4	5	6	7
Sinistrals							
Eigenvalues	33.399	22.619	16.102	15.471	11.361	9.052	8.273
Variance	0.276	0.187	0.133	0.128	0.094	0.075	0.068
Cum Variance	0.276	0.462	0.595	0.723	0.816	0.891	0.959
Dextrals							
Eigenvalues	34.926	24.756	17.648	12.538	11.010	10.232	8.386
Variance	0.285	0.202	0.144	0.102	0.090	0.083	0.068
Cum Variance	0.285	0.487	0.631	0.733	0.083	0.906	0.975

terminate factoring was 7.66 for both handedness samples. This value yielded seven factors for each of the factor analyses that accounted for 95.9% and 97.5% of the common variance for the left- and right-handed samples, respectively.

The number of children in each handedness sample exhibiting factor loadings of .50 or more on only one of the factors, high loadings on more than one factor, and factor loadings less than .50 on all of the factors is shown in Table 14. For the left-handed sample, 110 (68%) of the 161 children demonstrated single factor loadings of .50 or more, 15 (9%) of the children exhibited multiple factor loadings, and the remaining 36 (23%) children (i.e., unclassified subjects) were found to have low factor loadings on all seven factors. For the right-handed group of children, the corresponding values were 116 (72%), 20 (12%) and 25 (16%), respectively. Only individuals with a high factor loading on only one factor were considered in the determination of subtypes, and only those with a high positive loading. A sizeable number of subjects exhibited negative factor loadings, and 12 of the left- and 3 of the right-handed individuals were found to have single factor loadings below -.50. However, these children were excluded from subtype classification. Likewise, when a person has a sizeable factor loading on more than one factor, classification is difficult. Thus, subjects exhibiting multiple factor loadings were excluded from subtype determination as well. A complete listing of all of the individual factor loadings is provided in Appendix C for the left-handed sample, and Appendix D for the right-handed sample.

TABLE 14

Number of Classified (Single Factor Loadings $\geq .50$), Multiple Loadings, and Unclassified Subjects for Sinistral and Dextral Samples

Loadings	Sample	
	Sinistrals	Dextrals
Single Loadings		
1	41	20
2	26	26
3	19	18
4	9	11
5	6	18
6	4	8
7	5	15
Total	110	116
% Sample	68%	72%
Multiple Loadings		
Total	15	20
% Sample	9%	12%
Unclassified		
Total	36	25
% Sample	23%	16%

The T score means and standard deviations of variables used in the factor analyses procedure for each sinistral and dextral Q type factor are shown in Tables 15 and 16. An asterisk next to the variable name denotes those measures used in the factor analytic procedure. The other measures listed on the Tables include the T score means and standard deviations of variables not utilized in the Q technique, as well as descriptive information on the mean age (CAGE), mean WISC VIQ, PIQ and FSIQ, and mean WRAT Reading (RPERC), Spelling (SPERC), and Arithmetic (ARPERC) centile scores for each factor. Briefly, for the left-handed sample, Factors 1, 2, 4, 5 and 6 exhibited fairly similar mean age values (11.09, 10.73, 10.94, 10.34 and 11.46, respectively). The mean age for Factor 7 was slightly higher (12.66), while Factor 3 exhibited the highest mean age value (13.46). It was also clear from Table 15 that the mean WISC FSIQs were fairly uniform across the seven factors. When the discrepancies between mean WISC VIQs and PIQs were examined, all of the factors showed a similar lower VIQ-higher PIQ pattern, with the exception of Factor 4. The magnitude of this discrepancy was the least for Factor 6, whereas the greatest mean difference occurred within the group of children who constituted Factor 2. A reverse pattern was seen for Factor 4 where the mean VIQ value exceeded the mean PIQ. Finally, on the WRAT, the mean Reading, Spelling and Arithmetic subtest scores were all below the 30th centile for Factors 1, 2, 3 and 7. For Factors 4 and 6, the mean subtest scores for Reading and Spelling exceeded the 30th centile, while Arithmetic was below this value. Finally, Factor 5 exhibited a mean Reading

TABLE 15

T Score Means and Standard Deviations

of Variables for Each Sinistral Q Type Factor

Factor 1

VARIABLE	N	MEAN	STANDARD DEVIATION
* INFO	41	44.30894309	6.20232494
* COMP	41	46.58536585	9.38342117
SIMIL	41	52.52032520	7.70210966
VOCAB	41	47.72357724	6.96973714
PPVTIQ	41	49.44715447	8.31451534
AUDR	41	0.09756098	0.43616958
AUDL	41	0.19512195	0.95445042
* SSPER	41	37.38569845	16.44433710
* AUDCLO	41	49.03963415	17.63727673
SENMEM	40	34.00652174	10.11740278
VFLU	41	40.48432056	9.51448795
* ARITH	41	42.92682927	7.07872878
* DIGITS	41	42.68292683	7.273219[illegible]
* CODING	41	48.53658537	9.69102622
* PICCOM	41	54.71544715	8.65947169
PICARR	41	50.65040650	7.60916714
* BLKDES	41	50.97560976	8.30809185
* OBJASS	41	51.78861789	9.13167750
VISR	41	0.21951220	0.68964466
VISL	41	0.41463415	0.86532103
* TARGET	41	41.59555507	11.07545325
TACR	41	0.78048780	1.23515576
TACL	41	0.63414634	1.08986461
* FAGNR	41	-21.75609756	48.64194717
FAGNL	41	21.62601626	41.87893896
* FTWR	41	35.67595471	15.62089187
FTWL	41	29.71467200	24.93665061
ASTR	41	40.89505941	14.25169547
ASTL	41	42.55232174	15.12276740
* TPTDT	41	46.03010239	13.27857761
* TPTNDT	41	46.40719228	13.95470713
TPTBT	41	33.30016914	39.06033897
TPTMEM	40	49.87500000	12.21593175
TPTLOC	40	45.42781385	12.27774582
* TAPR	41	48.33367496	11.49845517
* TAPL	41	44.9[illegible]09707	13.81291342
FTAPR	41	30.43512195	7.13624310
FTAPL	41	30.32073171	7.12563309
GRIPR	38	41.22428571	14.16064621
GRIPL	38	36.41652878	13.20838729
* PEGSRT	41	43.97748458	12.00586420
* PEGSLT	41	43.44579946	11.55124778
* CATTOT	41	50.93172388	9.04529362
* TRSBT	41	39.96918783	22.03056747
CAGE	41	11.09568293	1.28881169
VIQ	41	45.08943089	5.85900275
PIQ	41	51.82113821	6.11014528
FSIQ	41	48.11382114	4.99756038
RPERC	41	24.21951220	22.03237640
SPERC	41	18.19512195	19.84719062
ARPERC	41	18.65853659	12.08223853

TABLE 15 (cont'd)

Factor 2

VARIABLE	N	MEAN	STANDARD DEVIATION
* INFO	26	39.61538462	6.62164284
* COMP	26	47.05128205	9.15675455
SIMIL	26	50.76923077	8.39617332
VOCAB	26	49.10256410	6.22237485
PPVTIQ	26	47.94871795	9.95978237
AUDR	26	0.03846154	0.19611614
AUDL	26	0.07692308	0.27174649
* SSPER	26	12.39842657	17.50811193
* AUDCLU	26	47.05480769	11.93124264
SENMEM	26	31.01003344	14.21024050
VFLU	26	36.31593407	8.71520307
* ARITH	26	41.66666667	7.19567771
* DIGITS	26	43.46153846	6.07221499
* CODING	26	49.87179487	9.21258893
* PICCOM	26	56.79487179	10.26237006
PICARR	26	52.43589744	9.50123699
* BLKDES	26	52.43589744	7.51636391
* OBJASS	26	56.41025641	8.37578929
VISR	26	0.03846154	0.19611614
VISL	26	0.23076923	0.51440780
* TARGET	26	41.21040913	10.54563626
TACR	26	0.42307692	0.94543437
TACL	26	0.30769231	0.97032905
* FAGNR	26	54.00000000	12.84990272
FAGNL	26	44.87179487	15.74888410
* FTWR	26	54.10144603	11.92520810
FTWL	26	50.42948718	13.90163789
ASTR	26	44.59814032	12.57462718
ASTL	26	44.82385262	11.82159792
* TPTDT	26	52.92908828	9.60354652
* TPTNDT	26	52.27880561	8.79268092
TPTBT	26	41.17596782	31.61257324
TPTMEM	26	52.48076923	6.38249810
TPTLOC	26	47.60556111	10.20961326
* TAPR	26	52.66444632	11.07760998
* TAPL	26	48.77432012	11.13751547
FTAPR	25	31.11880000	5.28624813
FTAPL	25	31.00800000	6.27387507
GRIPR	26	49.06882591	10.33379771
GRIPL	26	44.07279867	11.48576299
* PEGSRT	26	43.62267450	10.32361544
* PEGSLT	26	46.03846154	9.22489263
* CATTOT	26	51.72642502	8.60404608
* TRSBT	26	38.48806909	16.80503211
CAGE	26	10.73684615	1.29345075
VIQ	26	44.15384615	5.22322231
PIQ	26	54.76923077	7.08473742
FSIQ	26	49.07692308	5.41299481
RPERC	26	11.19230769	11.45781561
SPERC	26	8.38461538	9.94012846
ARPERC	26	15.65384615	12.71201733

TABLE 15 (cont'd)

Factor 3

VARIABLE	N	MEAN	STANDARD DEVIATION
* INFO	19	42.28070175	4.97557386
* COMP	19	50.00000000	10.71516751
SIMIL	19	53.50877193	6.71038298
VOCAB	19	46.84210526	5.49676495
PPVTIQ	19	51.64912281	9.59003707
AUDR	19	0.05263158	0.22941573
AUDL	19	0.10526316	0.45883147
* SSPER	19	-38.38421053	16.73934199
* AUDCLO	19	42.75526316	11.40512366
SENMEM	19	36.47139588	12.89354457
VFLU	19	41.50751880	10.72998571
* ARITH	19	42.28070175	5.21780328
* DIGITS	19	45.96491228	9.91189256
* CODING	19	46.14035088	9.37972320
* PICCUM	19	53.50877193	9.45905303
PICARR	19	50.35087719	7.27711930
* BLKDES	19	53.68421053	7.76941907
* OBJASS	19	54.56140351	10.0129[illegible]702
VISR	19	0.10526316	0.31530177
VISL	19	0.05263158	0.22941573
* TARGET	19	29.89050558	18.93364813
TACR	19	0.05263158	0.22941573
TACL	19	0.05263158	0.22941573
* FAGNR	19	42.52631579	24.38434931
FAGNL	19	37.96491228	31.82162762
* FTWR	19	-17.42536839	51.86792394
FTWL	19	-24.98053059	97.64918761
ASTR	19	41.63855793	19.15578985
ASTL	19	46.57157600	17.70836122
* TPTDT	19	51.15303828	5.94909441
* TPTNDT	19	42.12121212	24.22481479
TPTBT	19	37.04815068	20.03214895
TPTMEM	19	47.50877193	12.13205041
TPTLOC	19	42.25199362	9.63464320
* TAPR	19	50.69266506	12.16741297
* TAPL	19	47.15555556	16.61348057
FTAPR	19	35.40105263	5.05484794
FTAPL	19	36.72210526	4.88309963
GRIPR	7	48.32244898	12.48156970
GRIPL	7	41.36874209	14.49811564
* PEGSRT	19	49.0248497	19.12501191
* PEGSLT	19	45.56483897	11.93378064
* CATTDT	19	43.65036707	9.48553022
* TRSBT	19	31.04655579	20.28930296
CAGE	19	13.26426316	1.31961425
VIQ	19	45.92982456	6.06505773
PIQ	19	52.38596491	8.44536776
FSIQ	19	48.91228070	5.24091466
RPERC	19	27.63157895	21.35730561
SPERC	19	13.68421053	15.28271584
ARPERC	19	11.47368421	8.81519157

TABLE 15 (cont'd)

Factor 4

VARIABLE	N	MEAN	STANDARD DEVIATION
* INFO	9	50.37037037	8.73124091
* COMP	9	54.44444444	11.66666667
SIMIL	9	53.33333333	8.49836586
VOCAB	9	51.85185185	6.68977477
PPVTIQ	9	50.22222222	8.25967446
AUDR	9	0.00000000	0.00000000
AUDL	9	0.00000000	0.00000000
* SSPER	9	45.92222222	7.13895619
* AUDCLO	9	65.29444444	5.09588509
SENMEM	9	38.99516908	3.91046927
VFLU	9	42.14285714	0.50236854
* ARITH	9	50.00000000	6.87184271
* DIGITS	9	45.55555556	7.63762616
* CODING	9	43.33333333	8.33333333
* PICCOM	9	52.59259259	6.62020849
PICARR	9	48.51851852	7.63707554
* BLKDES	9	48.14814815	5.29966223
* OBJASS	9	47.03703704	6.54990340
VISR	9	0.00000000	0.00000000
VISL	9	0.22222222	0.66666667
* TARGET	9	45.07914180	7.13676971
TACR	9	0.00000000	0.00000000
TACL	9	0.00000000	0.00000000
* FAGNR	9	46.44444444	17.28518955
FAGNL	9	50.51851852	7.40703703
* FTWR	9	55.08951643	7.55741336
FTWL	9	49.09259259	8.48941789
ASTR	9	41.56239316	14.03079266
ASTL	9	50.18051665	7.95732838
* TPTDT	9	55.04920448	8.64849910
* TPTNDT	9	51.53209877	10.25604660
TPTBT	9	49.64462081	11.88281759
TPTMEM	9	50.42592593	11.09902120
TPTLOC	9	47.12457912	13.16574642
* TAPR	9	49.88867199	11.34052386
* TAPL	9	42.96543210	12.13470236
FTAPR	9	32.98555556	7.46095689
FTAPL	9	33.21888889	8.65265630
GRIPR	9	40.63492063	17.38555451
GRIPL	9	33.06760542	17.00745537
* PEGSRT	9	16.36196079	23.07954275
* PEGSLT	9	12.23148148	29.98893829
* CATTOT	9	52.09685464	5.93395853
* TRSBT	9	46.22523504	8.90403073
CAGE	9	10.94322222	0.70437557
VIQ	9	51.18518519	7.02991843
PIQ	9	46.88888889	4.70224533
FSIQ	9	49.33333333	4.70224533
RPERC	9	61.00000000	38.67815921
SPERC	9	34.66666667	28.87040007
ARPERC	9	20.55555556	11.25956384

TABLE 15 (cont'd)

Factor 5

VARIABLE	N	MEAN	STANDARD DEVIATION
* INFO	6	43.88888889	3.89681731
* COMP	6	49.44444444	6.46930072
SIMIL	6	50.00000000	9.66091783
VOCAB	6	52.22222222	5.44331054
PPVTIQ	6	52.66666667	10.86482602
AUDR	6	0.00000000	0.00000000
AUDL	6	0.00000000	0.00000000
* SSPER	6	52.26666667	16.93123347
* AUDCLO	6	74.33333333	7.52772653
SENMEM	6	40.14492754	10.53095775
VFLU	6	40.47619048	14.09093403
* ARITH	6	42.22222222	5.01848435
* DIGITS	6	46.11111111	8.27759135
* CODING	6	45.55555556	10.68054653
* PICCOM	6	51.11111111	8.34443705
PICARR	6	52.22222222	6.88530373
* BLKDES	6	56.66666667	6.66666667
* OBJASS	6	50.55555556	8.00462829
VISR	6	0.00000000	0.00000000
VISL	6	0.00000000	0.00000000
* TARGET	6	49.27536232	5.77895711
TACR	6	0.166666[illegible]	0.40824829
TACL	6	0.00000000	0.00000000
* FAGNR	6	52.66666667	8.16496581
FAGNL	6	48.88888889	5.44331054
* FTWR	6	48.06201550	11.20082641
FTWL	6	45.27777778	8.27759135
ASTR	6	41.53846154	10.60311442
ASTL	6	50.58823529	6.16946381
* TPTDT	6	54.81818182	6.26521289
* TPTNDT	6	56.73333333	3.21039977
TPTBT	6	55.50000000	10.52193476
TPTMEM	6	49.44444444	10.09216785
TPTLOC	6	45.55555556	12.54621088
* TAPR	6	44.40666667	3.29706941
* TAPL	6	36.32592593	5.30672374
FTAPR	6	30.03333333	2.56722938
FTAPL	6	29.40000000	3.46467692
GRIPR	6	39.75333333	11.28313195
GRIPL	6	29.16666667	11.24555846
* PEGSRT	6	53.36083104	4.58905795
* PEGSLT	6	45.50000000	5.82237065
* CATTOT	6	54.05340963	8.77106983
* TRSBT	6	28.66458333	29.88432560
CAGE	6	10.34983333	0.15217413
VIQ	6	46.77777778	3.94217462
PIQ	6	51.77777778	6.24914809
FSIQ	6	49.11111111	5.07134287
RPERC	6	42.00000000	31.79937106
SPERC	6	27.00000000	20.46460359
ARPERC	6	22.33333333	21.86930878

TABLE 15 (cont'd)

Factor 6

VARIASLE	N	MEAN	STANCARD DEVIATION
*INFO	4	47.50000000	7.87635938
*COMP	4	57.50000000	11.97992147
SIMIL	4	48.33333333	6.38284739
VOCAB	4	55.00000000	7.93492048
PPVTIQ	4	56.83333333	12.04159458
AUDR	4	0.00000000	0.00000000
AUDL	4	0.50000000	1.00000000
*SSPER	4	58.58409091	14.87639824
*AUDCLO	4	52.43750000	14.91660847
SENMEM	4	35.65217391	12.46545321
VFLU	4	37.68750000	4.20533503
*ARITH	4	40.83333333	7.39118594
*DIGITS	4	45.00000000	10.36375450
*CODING	4	52.50000000	11.34476548
*PICCOM	4	52.50000000	13.70995853
PICARR	4	50.00000000	7.20082300
*BLKDES	4	45.00000000	6.38284739
*OBJASS	4	54.16666667	10.67187373
VISR	4	0.25000000	0.50000000
VISL	4	0.50000000	0.57735027
*TARGET	4	25.48076923	21.93312422
TACR	4	0.00000000	0.00000000
TACL	4	0.00000000	0.00000000
*FAGNR	4	28.00000000	43.01937548
FAGNL	4	19.50000000	45.85120864
*FTWR	4	46.95857383	12.58634720
FTWL	4	43.77309682	27.07704333
ASTR	4	51.19505495	7.57131095
ASTL	4	42.12301587	12.53723354
* TPTDT	4	55.83773011	4.67818124
* TPTNDT	4	40.95569829	17.87514844
TPTBT	4	48.10516934	6.31489294
TPTMEM	4	46.20833333	10.48047126
TPTLOC	4	45.26298701	11.45140073
* TAPR	4	69.67195531	11.10875230
* TAPL	4	66.95871212	7.42067899
FTAPR	4	40.70000000	1.64519502
FTAPL	4	41.[illegible]5000000	4.34012289
GRIPR	3	40.55639098	10.12365182
GRIPL	3	43.76299376	14.33946377
* PEGSRT	4	55.79248836	15.94161894
* PEGSLT	4	55.03472222	10.43447552
* CATTOT	4	43.15025812	15.32573871
* TRSBT	4	-4.95745098	55.88956681
CAGE	4	11.46325000	1.84437458
VIQ	4	48.83333333	9.01644588
PIQ	4	51.16666667	5.39890249
FSIQ	4	49.83333333	5.82141640
RPERC	4	52.75000000	51.23394057
SPERC	4	32.50000000	34.31714829
ARPERC	4	16.50000000	20.72840241

TABLE 15 (cont'd)

Factor 7

VARIABLE	N	MEAN	STANDARD DEVIATION
* INFO	5	38.00000000	6.05530071
* COMP	5	39.33333333	5.47722558
SIMIL	5	54.00000000	4.34613494
VOCAB	5	44.00000000	5.47722558
PPVTIQ	5	48.53333333	10.00444346
AUDR	5	0.00000000	0.00000000
AUDL	5	0.00000000	0.00000000
* SSPER	5	50.80000000	7.52163546
* AUDCLU	5	38.04000000	9.60692459
SENMEM	5	30.57391304	14.71372699
VFLU	5	51.38571429	13.68492020
* ARITH	5	44.00000000	6.83130051
* DIGITS	5	46.66666667	6.66666667
* CODING	5	44.00000000	8.29993307
* PICCOM	5	49.33333333	6.41179469
PICARR	5	56.00000000	9.83192080
* BLKDES	5	56.00000000	12.33783702
* OBJASS	5	58.00000000	6.49786290
VISR	5	0.20000000	0.44721360
VISL	5	0.00000000	0.00000000
* TARGET	5	55.83865546	3.53120778
TACR	5	0.20000000	0.44721360
TACL	5	0.00000000	0.00000000
* FAGNR	5	50.00000000	8.94427191
* FAGNL	5	52.00000000	8.94427191
* FTWR	5	58.00000000	12.70127214
FTWL	5	56.84146341	20.36463959
ASTR	5	60.33142857	1.00154982
ASTL	5	60.00000000	4.56435465
* TPTOT	5	55.83419689	5.20223768
* TPTNDT	5	62.23333333	4.90282106
TPTBT	5	55.84675325	2.69911875
TPTMEM	5	57.90000000	8.64146978
TPTLOC	5	65.94545455	12.11678707
* TAPR	5	50.76363636	5.16949092
* TAPL	5	44.39111111	6.28621066
FTAPR	5	39.52000000	1.98796378
FTAPL	5	37.24600000	3.34276532
GRIPR	3	43.04761905	7.73190228
GRIPL	3	38.62745098	2.39544936
* PEGSRT	5	52.24580018	11.38256799
* PEGSLT	5	49.7[illegible]66667	5.91326193
* CATTOT	5	54.89574793	5.80560398
* TRSBT	5	43.84615385	7.73067355
CAGE	5	12.66300000	0.56153718
VIQ	5	42.80000000	3.10555059
PIQ	5	53.73333333	5.15536398
FSIQ	5	47.86666667	4.03870166
RPERC	5	23.00000000	10.79351657
SPERC	5	14.40000000	14.39791652
ARPERC	5	13.20000000	8.37854403

*Denotes dependent measures used in statistical treatment of data.

TABLE 16

T Score Means and Standard Deviations

of Variables for Each Dextral Q Type Factor

Factor 1

VARIABLE	N	MEAN	STANDARD DEVIATION
* INFO	20	43.33333333	5.51446795
* COMP	20	48.33333333	6.69074599
SIMIL	20	51.66666667	5.24265010
VOCAB	20	48.50000000	6.16299084
PPVTIQ	20	47.06666667	8.81890579
AUDR	20	0.10000000	0.30779351
AUDL	20	0.05000000	0.22360680
* SSPER	20	13.72568182	27.15913859
* AUDCLO	20	45.00375000	15.97558638
SENMEM	20	70.38260870	9.90687511
VFLU	20	35.43214286	8.76841242
* ARITH	20	42.00000000	6.15587011
* DIGITS	20	45.33333333	8.12187862
* CODING	20	47.16666667	8.93609541
* PICCOM	20	47.00000000	11.18164745
PICARR	20	47.83333333	7.66819207
* BLKDES	20	49.33333333	7.14101898
* OBJASS	20	50.16666667	9.82150642
VISR	20	0.15000000	0.48936048
VISL	20	0.15000000	0.67082039
* TARGET	20	43.46688717	9.20390573
TACR	20	0.45000000	0.99868334
TACL	20	0.65000000	1.26802789
* FAGNR	20	52.80000000	18.05721900
FAGNL	20	47.73333333	14.00651477
* FTWR	20	50.26038970	11.45659421
FTWL	20	46.51287879	18.40164903
ASTR	20	46.25208791	13.29007813
ASTL	20	37.27450980	13.76492625
* TPTOT	20	53.29160419	13.14624816
* TPTNDT	20	51.76316864	9.12993414
TPTBT	20	51.13888889	9.54295853
TPTMEM	20	49.70833333	11.42313173
TPTLOC	20	47.50346320	13.67065615
* TAPR	20	60.57231281	11.70733447
* TAPL	20	46.21500000	8.72899207
FTAPR	20	31.19500000	5.90729834
FTAPL	20	28.24500000	5.26681418
GRIPR	20	48.72919549	12.10223225
GRIPL	20	41.38659742	12.41450641
* PEGSRT	20	52.99870665	12.03680070
* PEGSLT	20	22.81666667	17.71956249
* CATTOT	20	51.55739987	8.21425326
* TRSBT	20	45.43736237	9.34851802
CAGE	20	10.72100000	1.01609148
VIQ	20	46.03333333	4.54978953
PIQ	20	47.73333333	7.56847880
FSIQ	20	46.53333333	3.91488388
RPERC	20	15.60000000	12.89389901
SPERC	20	9.70000000	8.77856240
ARPERC	20	16.05000000	10.21595759

TABLE 16 (cont'd)

Factor 2

VARIABLE	N	MEAN	STANDARD DEVIATION
* INFO	26	45.38461538	5.66289467
* COMP	26	49.10256410	9.40721672
SIMIL	26	54.10256410	7.19924023
VOCAB	26	47.30769231	5.65836496
PPVTIQ	26	47.48717949	7.93374272
AUDR	26	0.11538462	0.32581259
AUDL	26	0.23076923	0.42966892
* SSPER	26	28.57534965	16.82874195
* AUDCLO	26	43.54134615	15.11689608
SENMEM	26	37.28428094	13.06685154
VFLU	26	35.81131319	8.73786948
* ARITH	26	46.66666667	7.18021974
* DIGITS	26	45.76923077	7.02741883
* CODING	26	50.00000000	10.54092553
* PICCOM	26	53.84615385	8.77837280
PICARR	26	50.89743590	8.08607540
* BLKDES	26	52.69230769	9.14180778
* OBJASS	26	54.61538462	10.33126530
VISR	26	0.53846154	0.85933785
VISL	26	0.92307692	2.24362344
* TARGET	26	45.63638410	10.07476456
TACR	26	0.96153846	1.58696614
TACL	26	0.92307692	1.29377206
* FAGNR	26	-7.00000000	39.89586704
FAGNL	26	16.41025641	28.68872139
* FTWR	26	43.48665708	12.02518822
FTWL	26	41.90818125	18.61669829
ASTR	26	35.72772612	15.85790547
ASTL	26	40.94124829	13.86624828
* TPTOT	26	53.66485398	6.13308695
* TPTNOT	26	50.49873484	8.66593409
TPTBT	26	46.84055813	12.69360074
TPTMEM	26	52.19230769	10.08592995
TPTLOC	26	48.75324675	11.23415796
* TAPR	26	54.00772841	9.17922365
* TAPL	26	42.24689200	8.33870767
FTAPR	26	30.53076923	4.81003528
FTAPL	26	28.03115385	6.09741409
GRIPR	24	50.95929198	14.21530675
GRIPL	24	44.56565490	13.58703702
* PECSPT	26	52.14376109	11.87292790
* PECSLT	26	78.99786325	14.25336634
* CATTOT	26	50.97420728	8.85268230
* TRSBT	26	40.46360838	12.69468352
CAGE	26	10.73011539	1.27663628
VIQ	26	47.61538462	5.21254240
PIQ	26	53.33333333	8.22786593
FSIQ	26	50.35897436	4.75247124
RPERC	26	17.11538462	20.50429599
SPERC	26	12.80769231	15.85438546
ARPERC	26	23.38461538	14.00021978

TABLE 16 (cont'd)

Factor 3

	VARIABLE	N	MEAN	STANDARD DEVIATION
*	INFO	18	40.92592593	5.69434481
*	COMP	18	45.18518519	7.34065786
	SIMIL	18	51.85185185	9.30403119
	VOCAB	18	46.66666667	8.24462590
	PPVTIQ	18	50.22222222	8.08452083
	AUDR	18	0.05555556	0.23570226
	AUDL	18	0.05555556	0.23570226
*	SSPER	18	40.05505051	18.08345504
*	AUDCLO	17	40.87647059	10.19371157
	SENMEM	17	33.64143223	12.15068573
	VFLU	17	36.02521008	8.40535510
*	ARITH	18	44.07407407	7.54555278
*	DIGITS	18	46.11111111	8.94792487
*	CODING	18	48.33333333	7.94178163
*	PICCOM	18	50.18518519	7.18315224
	PICARR	18	51.11111111	11.26043452
*	BLKDES	18	50.00000000	7.04792186
*	OBJASS	18	54.44444444	8.55585264
	VISR	18	0.44444444	0.85558526
	VISL	18	0.77777778	1.92576369
*	TARGET	18	40.60516771	12.86263608
	TACR	18	0.55555556	0.78382338
	TACL	18	0.22222222	0.54831888
*	FAGNR	18	46.88888889	14.55573013
	FAGNL	18	37.00000000	33.21410048
*	FTWR	18	-3.91240447	34.68426834
	FTWL	18	10.05561460	50.30599270
	ASTR	18	35.36681319	13.88143778
	ASTL	18	41.42857143	16.24115574
*	TPTOT	18	50.50836107	5.98715195
*	TPTNOT	18	46.45319133	11.75120333
	TPTET	18	42.02423865	16.02686856
	TPTMEM	18	52.28703704	9.31174070
	TPTLOC	18	51.81818182	13.65052631
*	TAPR	18	52.69273833	12.96921611
*	TAPL	18	35.07025614	8.70770145
	FTAPR	18	34.35000000	7.34936972
	FTAPL	18	31.88333333	7.33919774
	GRIPR	7	39.93563480	12.75659805
	GRIPL	7	[illegible].75998882	11.34419413
*	PECSRT	17	49.27428032	14.75607597
*	PEGSLT	17	22.07843137	50.92887503
*	CATTOT	18	49.98567607	7.35919171
*	TRSBT	18	44.37511983	8.17211353
	CACE	18	12.81700000	1.40148858
	VIQ	18	44.88888889	6.26641635
	PIQ	18	51.14814815	8.06770551
	FSIQ	18	48.00000000	5.95407259
	RPERC	18	16.94444444	11.80962829
	SPERC	18	12.16666667	15.20545569
	ARPERC	18	14.55555556	10.45563300

TABLE 16 (cont'd)

Factor 4				
	VARIABLE	N	MEAN	STANDARD DEVIATION
*	INFO	11	44.84848485	7.65413996
*	COMP	11	46.66666667	6.32455532
	SIMIL	11	54.24242424	5.97976385
	VOCAB	11	45.75757576	6.34050630
	PPVTIQ	11	50.72727273	7.54515029
	AUDR	11	0.27272727	0.64666979
	AUDL	11	0.09090909	0.30151134
*	SSPER	11	50.49495868	8.74017357
*	AUDCLO	11	45.51136364	10.97603277
	SENMEM	11	41.57628458	9.09592575
	VFLU	11	38.67857143	6.99936222
*	ARITH	11	47.57575758	7.16331846
*	DIGITS	11	49.39393939	6.96310524
*	CODING	11	44.54545455	9.34198733
*	PICCOM	11	50.30303030	8.75018037
	PICARR	10	52.66666667	11.63222429
*	BLKDES	11	50.00000000	5.16397779
*	OBJASS	11	47.57575758	11.16451911
	VISR	11	0.00000000	0.00000000
	VISL	11	0.18181818	0.40451992
*	TARGET	11	27.21842288	13.20295939
	TACR	11	0.54545455	1.29333958
	TACL	11	0.09090909	0.30151134
*	FAGNR	11	52.00000000	6.13158389
	FAGNL	11	38.84848485	20.99331303
*	FTWR	11	54.33300207	10.03670547
	FTWL	11	52.15667097	16.92707073
	ASTR	11	53.05194805	7.15048092
	ASTL	11	52.38434768	7.17204696
*	TPTDT	11	52.25225352	6.75728114
*	TPTNDT	11	51.87945662	5.70563980
	TPTET	11	47.24015557	8.61984523
	TPTMEM	11	52.95454545	10.01556369
	TPTLOC	11	50.98622590	10.78187919
*	TAPR	11	55.68258989	6.89079799
*	TAPL	11	39.84788797	9.22131699
	FTAPR	11	34.16636364	6.78715297
	FTAPL	11	32.44545455	5.09555955
	GRIPR	9	51.19181287	11.23585071
	GRIPL	9	42.52040227	12.65823453
*	PEGSRT	11	52.96139049	14.78401347
*	PEGSLT	11	39.64393939	10.05357422
*	CATTOT	11	52.75007821	8.07667465
*	TRSET	11	50.49625446	7.34060170
	CACE	11	11.79063636	1.24283356
	VIQ	11	47.75757576	5.13179828
	PIQ	11	41.42424242	7.40734007
	FSIQ	11	47.87878788	6.35832390
	RPERC	11	60.45454545	32.82183309
	SPERC	11	41.54545455	33.01624944
	ARPERC	11	24.90909091	21.96567570

TABLE 16 (cont'd)

Factor 5

	VARIABLE	N	MEAN	STANDARD DEVIATION
*	INFO	18	43.51851852	7.45112372
*	COMP	18	49.07407407	8.54098581
	SIMIL	18	52.77777778	7.85905248
	VOCAB	18	50.18518519	7.09157857
	PPVTIQ	18	50.48148148	8.45072006
	AUDR	18	0.00000000	0.00000000
	AUDL	18	0.00000000	0.00000000
*	SSPER	18	35.92601010	16.29797878
*	AUDCLO	18	45.29305556	13.73112021
	SENMEM	18	35.68115942	11.43100401
	VFLU	18	40.92857143	6.89176310
*	ARITH	18	40.92592593	6.02885822
*	DIGITS	18	43.33333333	7.14005547
*	CODING	18	42.96296296	6.14518132
*	PICCOM	18	53.70370370	9.48951185
	PICARR	18	50.00000000	8.55585264
*	BLKDES	18	56.48148148	9.10879932
*	OBJASS	18	56.48148148	9.73318799
	VISR	18	0.33333333	0.97014250
	VISL	18	0.16666667	0.51449576
*	TARGET	18	38.07238609	10.77068719
	TACR	18	0.27777778	0.82644209
	TACL	18	0.05555556	0.23570226
*	FAGNR	18	53.44444444	12.38225591
	FAGNL	18	50.14814815	3.87082640
*	FTWR	18	41.32272569	21.38398626
	FTWL	18	37.56040076	15.04846936
	ASTR	18	43.76695157	15.68648259
	ASTL	18	42.18202096	14.22270629
*	TPTDT	18	50.97060489	9.39179253
*	TPTNDT	18	49.27090836	7.23734950
	TPTOT	18	46.05652227	13.60979400
	TPTMEM	18	45.02777778	9.57533767
	TPTLOC	18	42.96156806	10.52438828
*	TAPR	18	60.52645244	8.77362397
*	TAPL	18	44.59051627	8.92412900
	FTAPR	18	34.12388889	4.98244228
	FTAPL	18	31.75388889	6.52438245
	GRIPR	14	48.70805585	11.08910872
	GRIPL	14	41.60930360	9.69676834
*	PEGSRT	18	52.11043315	10.35536944
*	PEGSLT	18	37.66975309	13.19538142
*	CATTOT	18	45.46017232	6.61319440
*	TRSBT	18	9.14988216	29.98773492
	CAGE	18	11.13627778	1.49849096
	VIQ	18	45.77777778	6.36164980
	PIQ	18	52.62962963	6.58567359
	FSIQ	18	48.92592593	5.87067104
	RPERC	18	23.27777778	18.59729758
	SPERC	18	13.50000000	14.95188361
	ARPERC	18	16.55555556	12.13270845

TABLE 16 (cont'd)

	Factor 6			
	VARIABLE	N	MEAN	STANDARD DEVIATION
*	INFO	8	44.58333333	3.05375127
*	COMP	8	50.41666667	8.62581949
	SIMIL	8	51.66666667	4.71404521
	VOCAB	8	49.16666667	4.62910050
	PPVTIQ	8	50.66666667	8.97969491
	AUDR	8	0.00000000	0.00000000
	AUDL	8	0.00000000	0.00000000
*	SSPER	8	42.59375000	9.26456731
*	AUDCLO	8	52.26562500	15.63927027
	SENMEM	8	38.20652174	11.02972073
	VFLU	8	41.66303571	10.05702468
*	ARITH	8	45.83333333	6.60687473
*	DIGITS	8	47.50000000	8.11621931
*	CODING	8	52.08333333	12.20688070
*	PICCOM	8	54.16666667	12.81739889
	PICARR	8	58.75000000	11.67516697
*	BLKDES	8	56.66666667	9.92031746
*	OBJASS	8	58.75000000	7.54615428
	VISR	8	0.00000000	0.00000000
	VISL	8	0.25000000	0.70710678
*	TARGET	8	52.41126672	7.36911229
	TACR	8	0.12500000	0.35355339
	TACL	8	0.25000000	0.70710678
*	FAGNR	8	60.50000000	7.91021040
	FAGNL	8	53.08333333	7.69198717
*	FTWR	8	53.62447321	5.36737093
	FTWL	8	50.20075758	11.96172881
	ASTR	8	40.86598901	9.42301113
	ASTL	8	44.62418301	10.91673069
*	TPTDT	8	57.49386548	3.95984768
*	TPINDT	8	55.00927811	4.87897679
	TPTBT	8	53.54575163	7.87916813
	TPTMEM	8	52.02083333	12.94170001
	TPTLOC	8	46.64502165	11.20376692
*	TAPR	8	44.00496857	8.67834446
*	TAPL	8	34.41792929	7.26459086
	FTAPR	8	30.82125000	4.54097673
	FTAPL	8	27.72875000	2.46374533
	GRIPR	8	44.12556391	10.24017939
	GRIPL	8	34.77247921	11.13413635
*	PEGSRT	8	57.77600063	7.21391921
*	PEGSLT	8	47.31250000	13.80136510
*	CATTOT	8	51.65553448	8.19781483
*	TRSBT	8	50.23568015	10.42916526
	CAGE	8	10.70725000	0.93891210
	VIQ	8	47.58333333	1.70666295
	PIQ	8	56.50000000	8.17079585
	FSIQ	8	53.00000000	3.93599587
	RPERC	8	27.87500000	31.96175170
	SPERC	8	22.25000000	27.51493101
	ARPERC	8	22.62500000	7.85470741

TABLE 16 (cont'd)

Factor 7

VARIABLE	N	MEAN	STANDARD DEVIATION
* INFO	15	42.22222222	5.95823607
* COMP	15	39.77777778	6.83904136
SIMIL	15	52.66666667	6.57073840
VOCAB	15	46.22222222	7.11210311
PPVTIQ	15	86.44444444	155.93948087
AUDR	15	0.00000000	0.00000000
AUDL	15	0.00000000	0.00000000
* SSPER	15	49.93969697	7.37638856
* AUDCLO	15	45.13500000	8.50045537
SENMEM	15	33.57101449	14.39684706
VFLU	15	40.72380952	7.81146820
* ARITH	15	42.66666667	6.92361957
* DIGITS	15	44.00000000	8.37608084
* CODING	15	57.33333333	7.59025840
* PICCOM	15	54.66666667	9.57841489
PICARR	15	49.77777778	9.71553058
* BLKDES	15	54.00000000	6.44832172
* OBJASS	15	55.77777778	8.49525233
VISR	15	0.06666667	0.25819889
VISL	15	0.00000000	0.00000000
* TARGET	15	51.19692954	7.40846114
TACR	15	0.13333333	0.35186578
TACL	15	0.13333333	0.35186578
* FAGNR	15	57.73333333	7.77756848
FAGNL	15	53.60000000	8.65360431
* FTWR	15	57.97158089	9.85591460
FTWL	15	53.64087214	18.46090372
ASTR	15	51.41899878	12.04884098
ASTL	15	49.21693122	10.75631576
* TPTDT	15	51.08910780	7.49769735
* TPTNDT	15	51.53355292	7.09880906
TPTBT	15	50.36526045	12.13097635
TPTMEM	15	52.41111111	9.44320253
TPTLOC	15	48.83462203	9.66794736
* TAPR	15	63.52507630	9.51356361
* TAPL	15	50.52181818	7.91030147
FTAPR	15	34.19733333	5.39989215
FTAPL	15	33.07333333	5.69314835
GRIPR	10	45.44406011	8.05763901
GRIPL	10	38.68323746	11.79518201
* PEGSRT	15	55.80551025	11.06145421
* PEGSLT	15	45.55740741	15.93302167
* CATTOT	15	53.93962881	7.45417402
* TRGBT	15	50.77251483	7.03480431
CACE	15	11.72646667	1.69719600
VIQ	15	43.68888889	4.76672772
PIQ	15	55.95555556	5.71529092
FSIQ	15	49.42222222	4.82629482
RPERC	15	22.33333333	14.22104410
SPERC	15	14.13333333	12.99377140
ARPERC	15	19.26666667	10.06739196

*Denotes dependent measures used in statistical treatment of data.

subtest score that was above the 30th centile, whereas both the Spelling and Arithmetic mean subtest scores were below this centile level.

For the right-handed sample, Table 16 indicates that the mean ages, save one (Factor 3), were quite similar across factors. The corresponding values for Factors 1, 2, 4, 5, 6 and 7 were 10.72, 10.73, 11.79, 11.13, 10.70 and 11.72, respectively. Factor 3 exhibited the oldest mean age value at 12.81. On the WISC, Factor 1 exhibited the lowest mean FSIQ, Factors 2, 3, 4, 5 and 7 were fairly similar and exhibited slightly higher mean FSIQs, and Factor 6 showed the highest mean FSIQ. In all cases, mean PIQ exceeded mean VIQ, although by varying amounts. For example, the smallest difference between the two was found for Factors 1 and 4. Factors 2, 3 and 5 exhibited very similar and slightly larger VIQ-PIQ discrepancies. Finally, the largest VIQ-PIQ differences were seen for the group of children who constituted Factor 6, and for those individuals who madeup Factor 7. On the WRAT, with the exception of Factor 4, all of the factors exhibited Reading, Spelling, and Arithmetic subtest scores that were all below the 30th centile ranking. For Factor 4, Reading and Spelling subtest scores were above the 30th centile, while Arithmetic was below this value.

Plots of the $\underline{T}$ score means of the variables used in the factor analyses procedures for each left- and right-handed Q factor are shown in Figures 3 to 16. Visual inspection of the factor profiles suggested that Factors 1, 2, and 3 of the sinistral sample exhibited almost identical characteristics to Factors 2, 1, and 3 of the dextral sample, respectively. Table 17 contains the Pearson

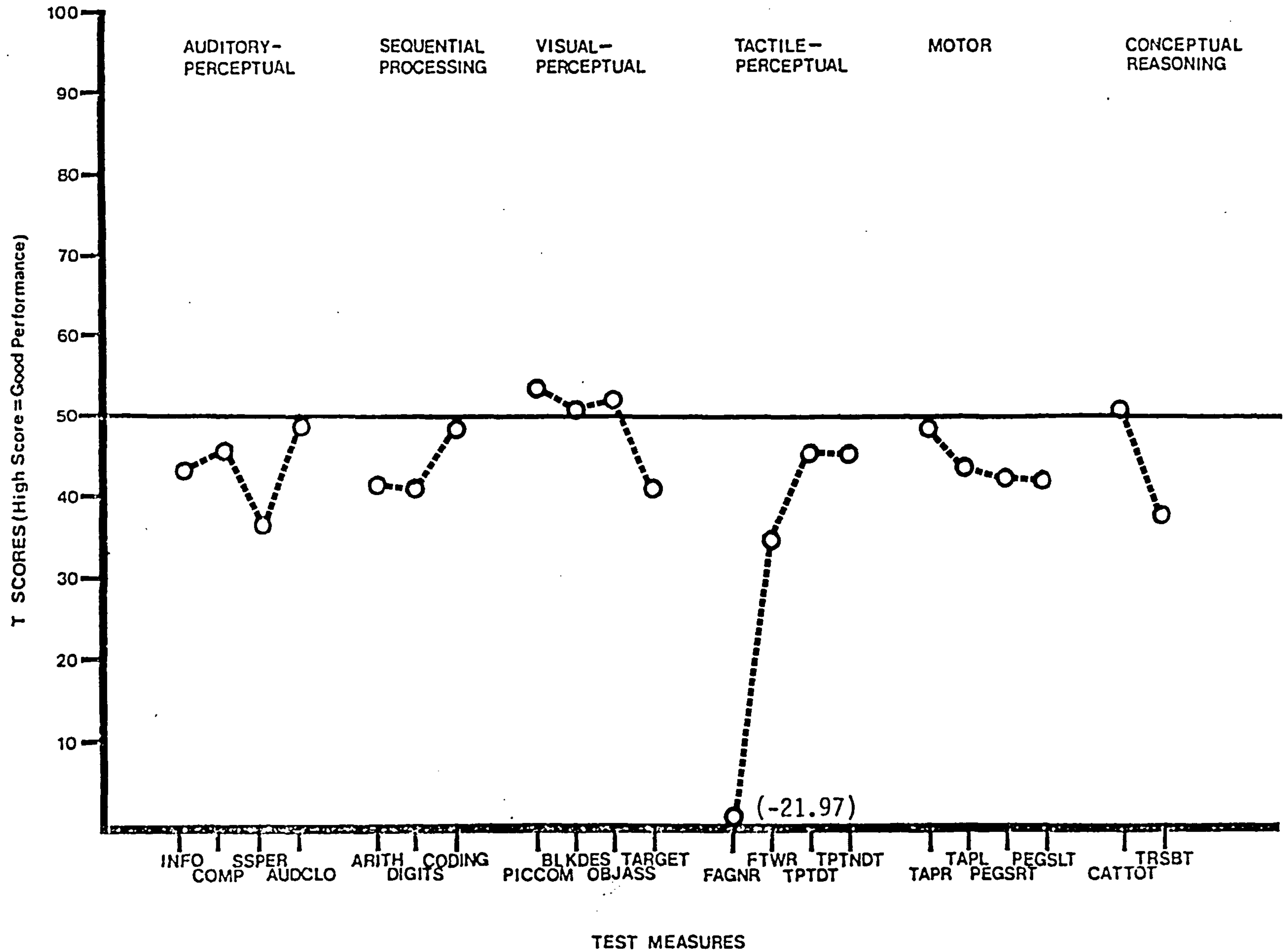

Figure 3. Plot of T score means for Factor 1 of sinistral sample.

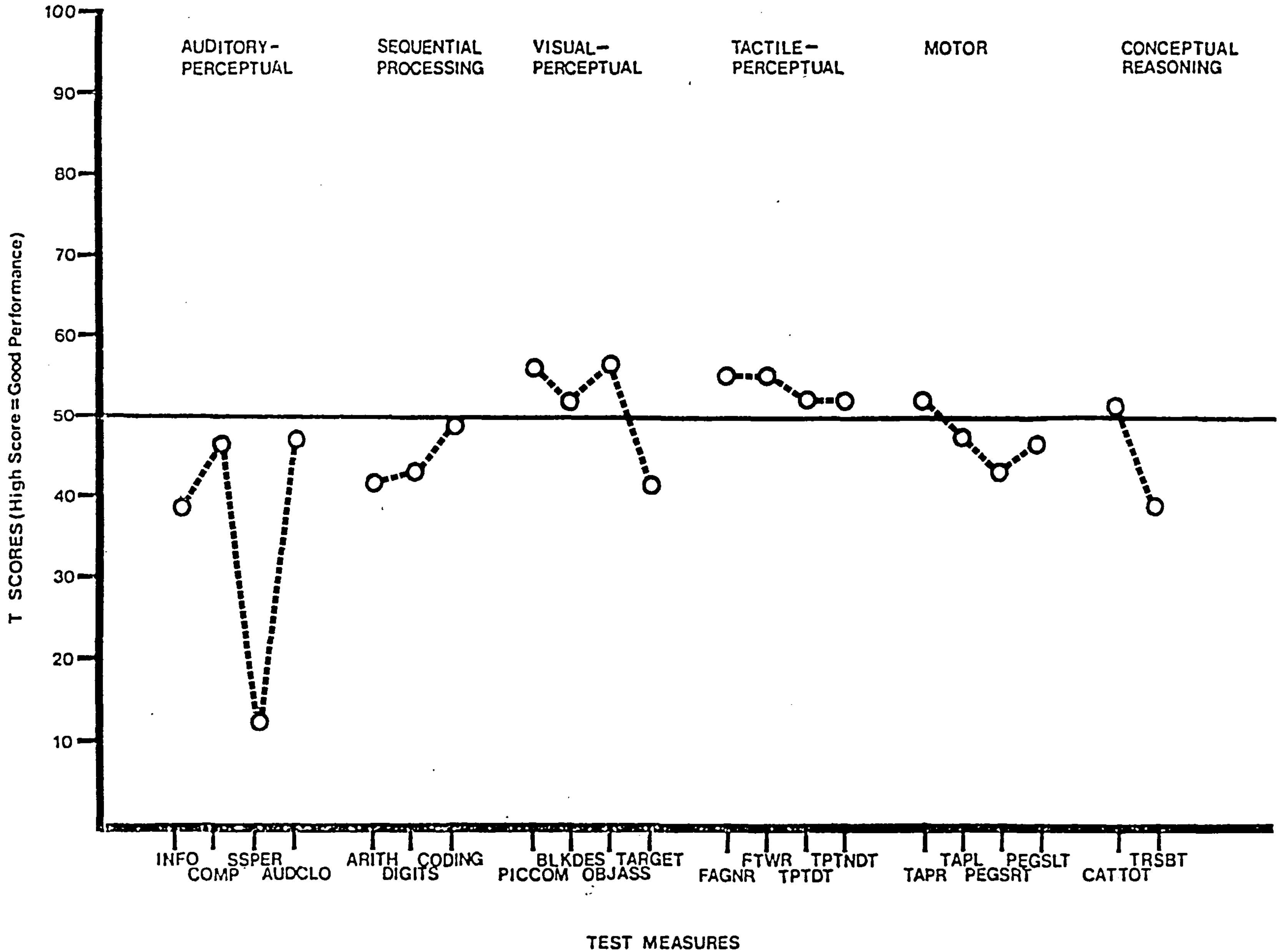

Figure 4. Plot of T score means for Factor 2 of sinistral sample.

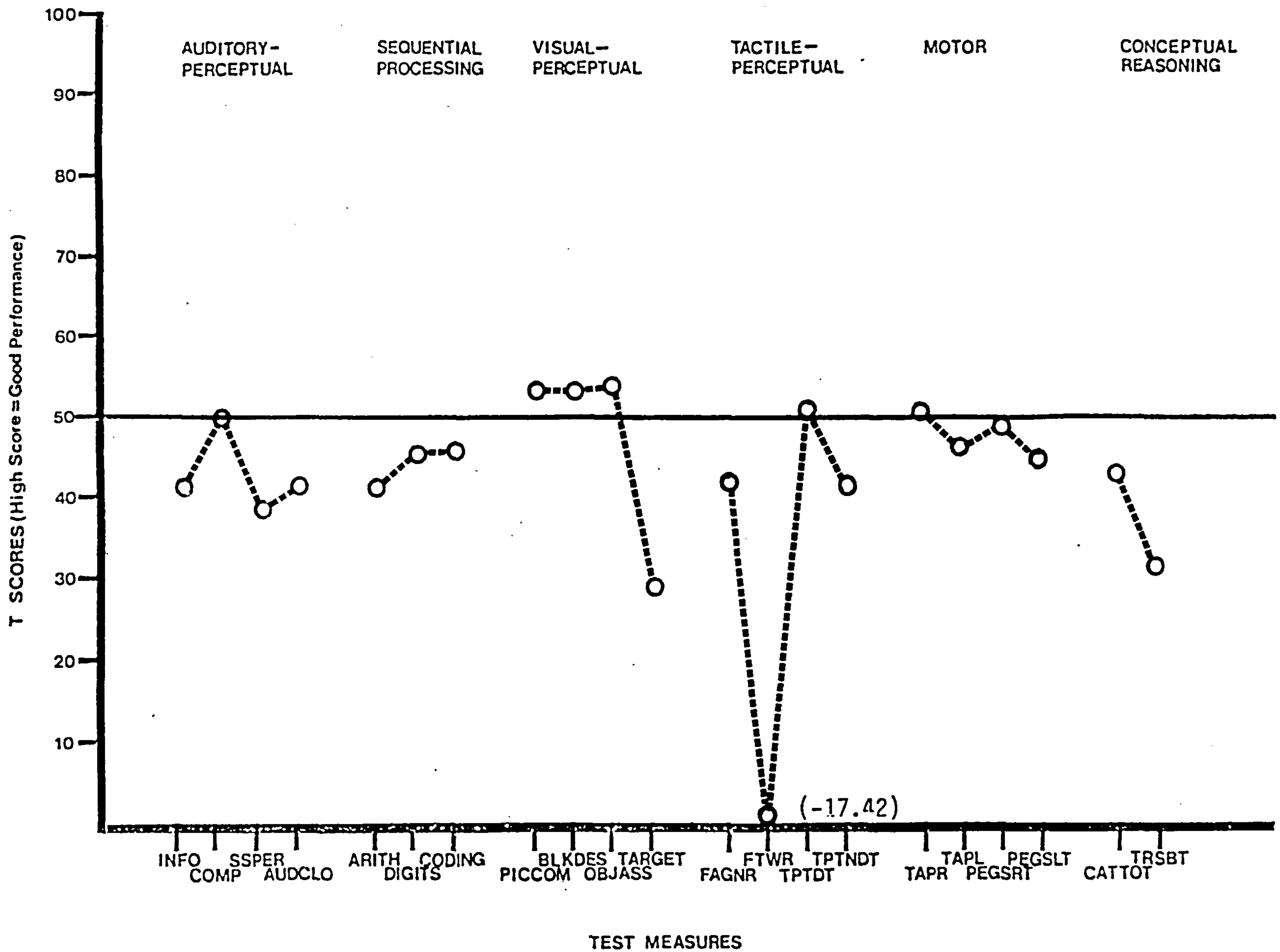

Figure 5. Plot of T score means for Factor 3 of sinistral sample.

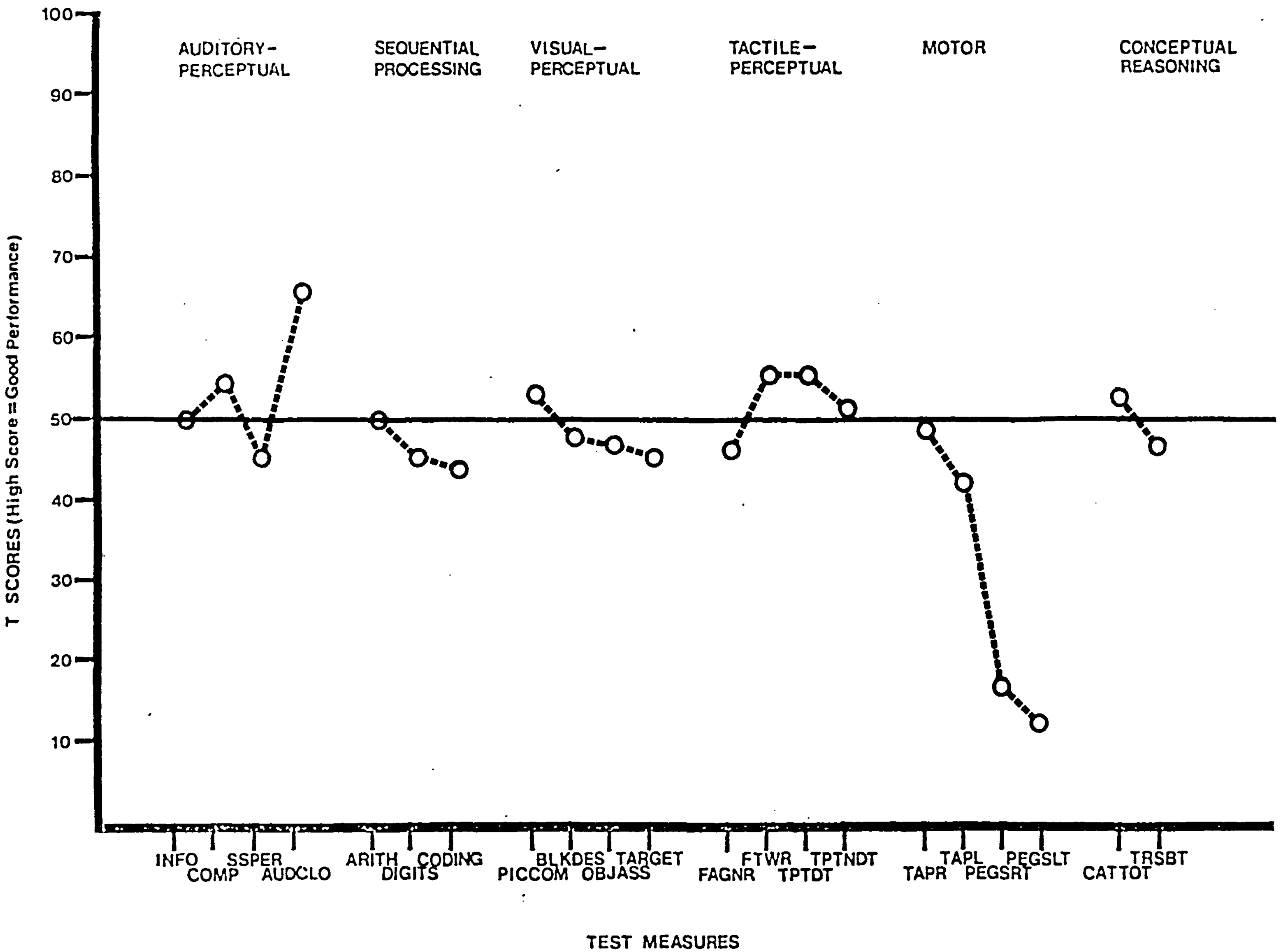

Figure 6. Plot of T score means for Factor 4 of sinistral sample.

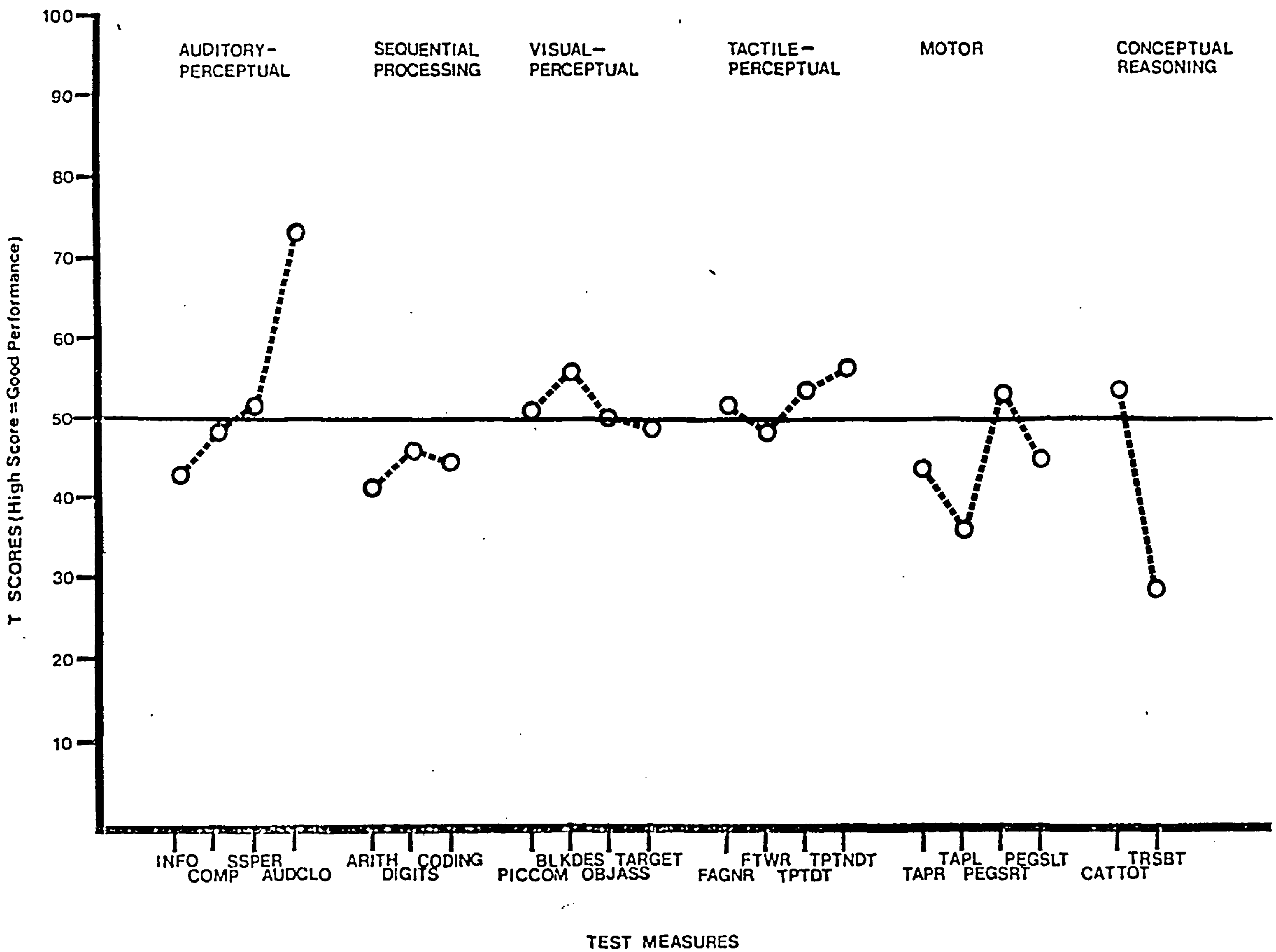

Figure 7. Plot of T score means for Factor 5 of sinistral sample.

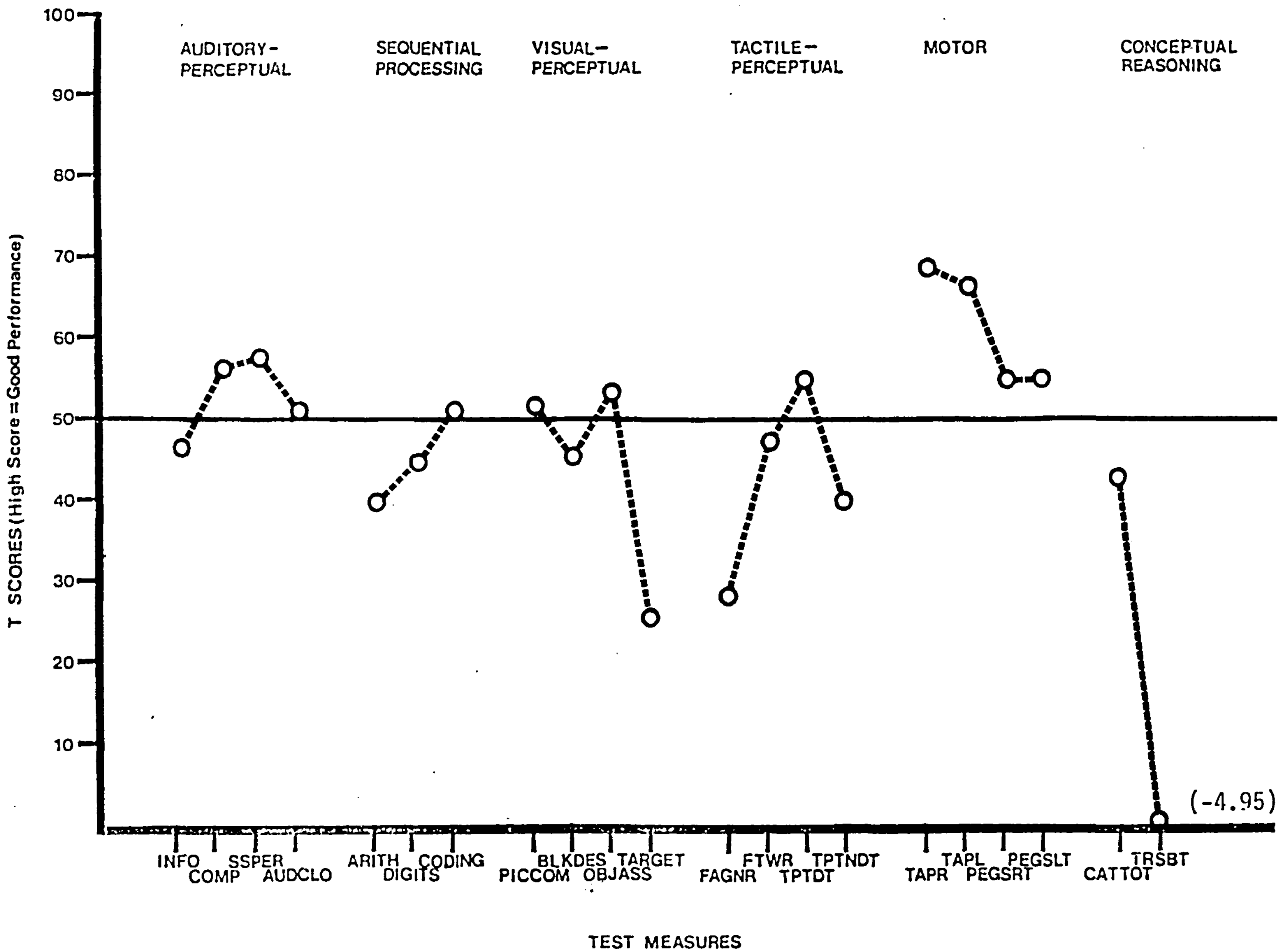

Figure 8. Plot of T score means for Factor 6 of sinistral sample.

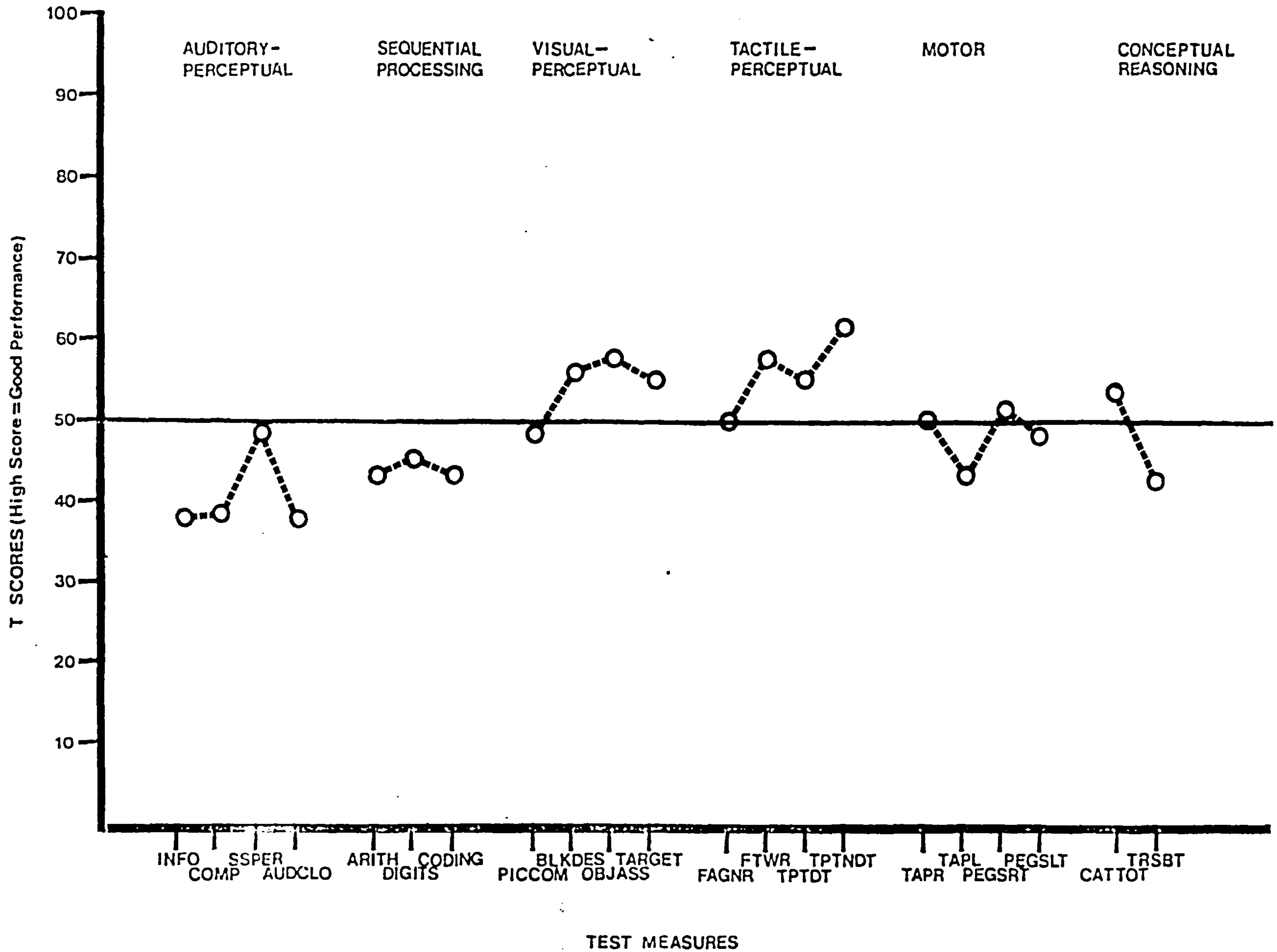

Figure 9. Plot of T score means for Factor 7 of sinistral sample.

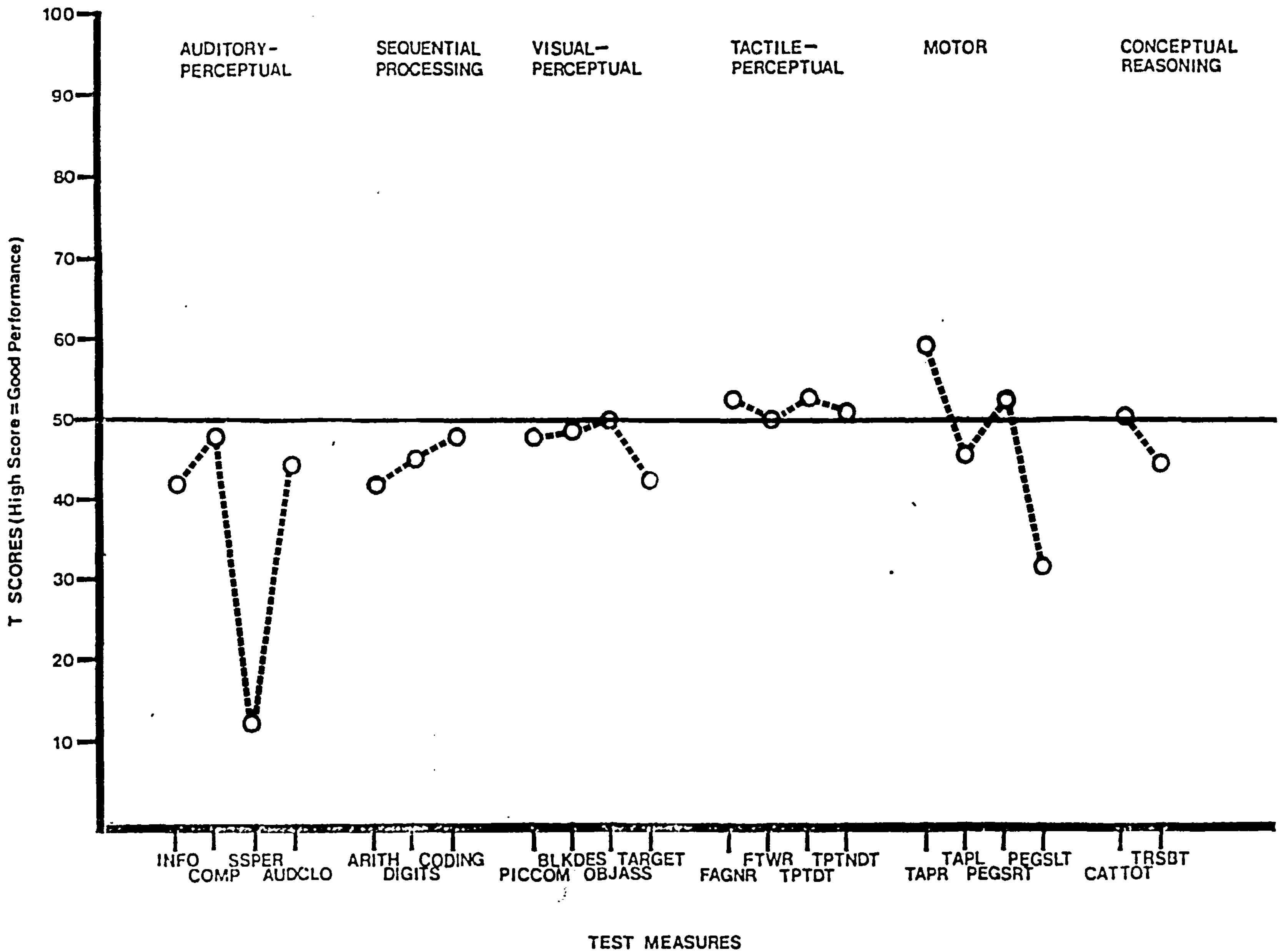

Figure 10. Plot of T score means for Factor 1 of dextral sample.

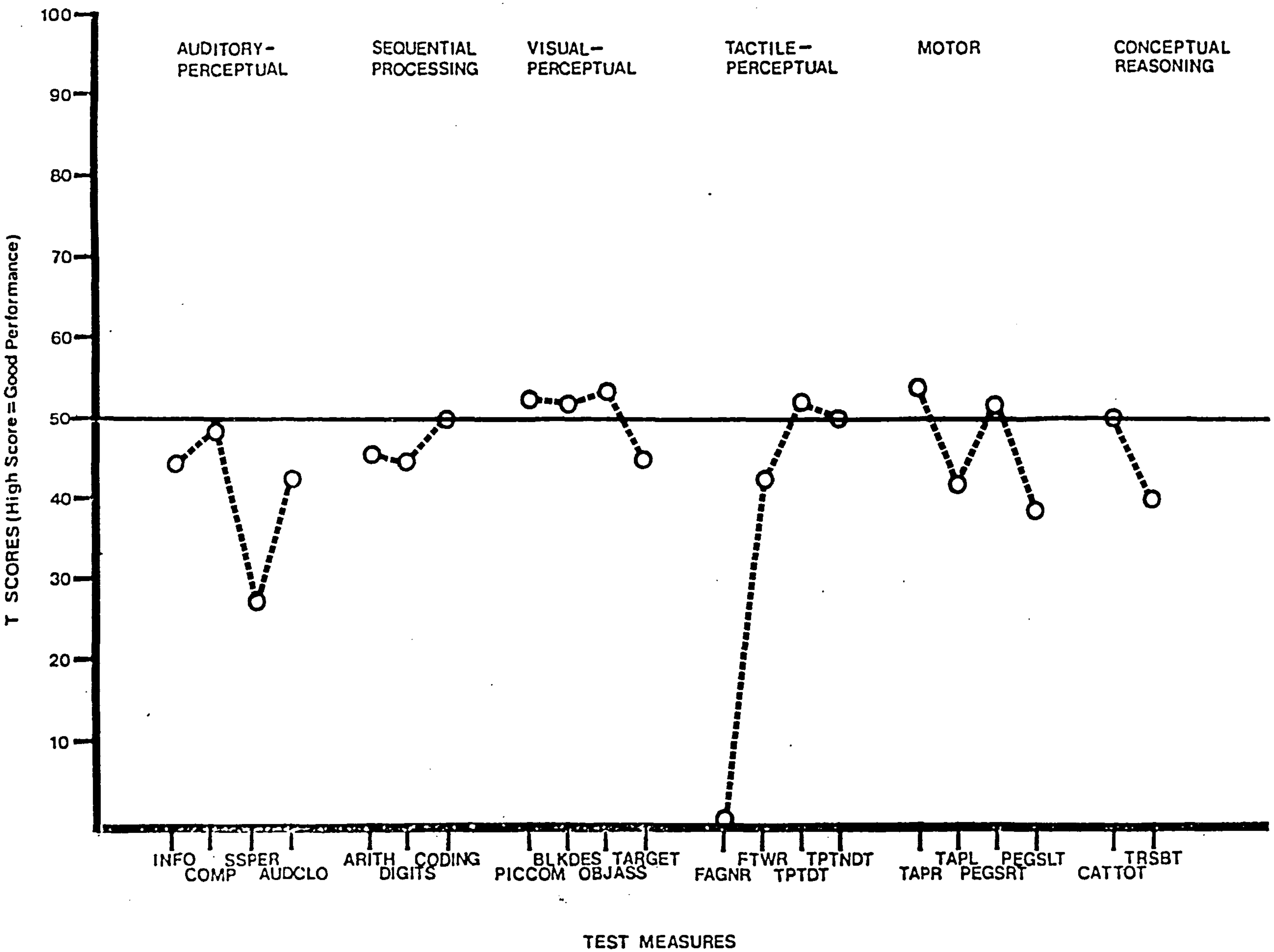

Figure 11. Plot of T score means for Factor 2 of dextral sample.

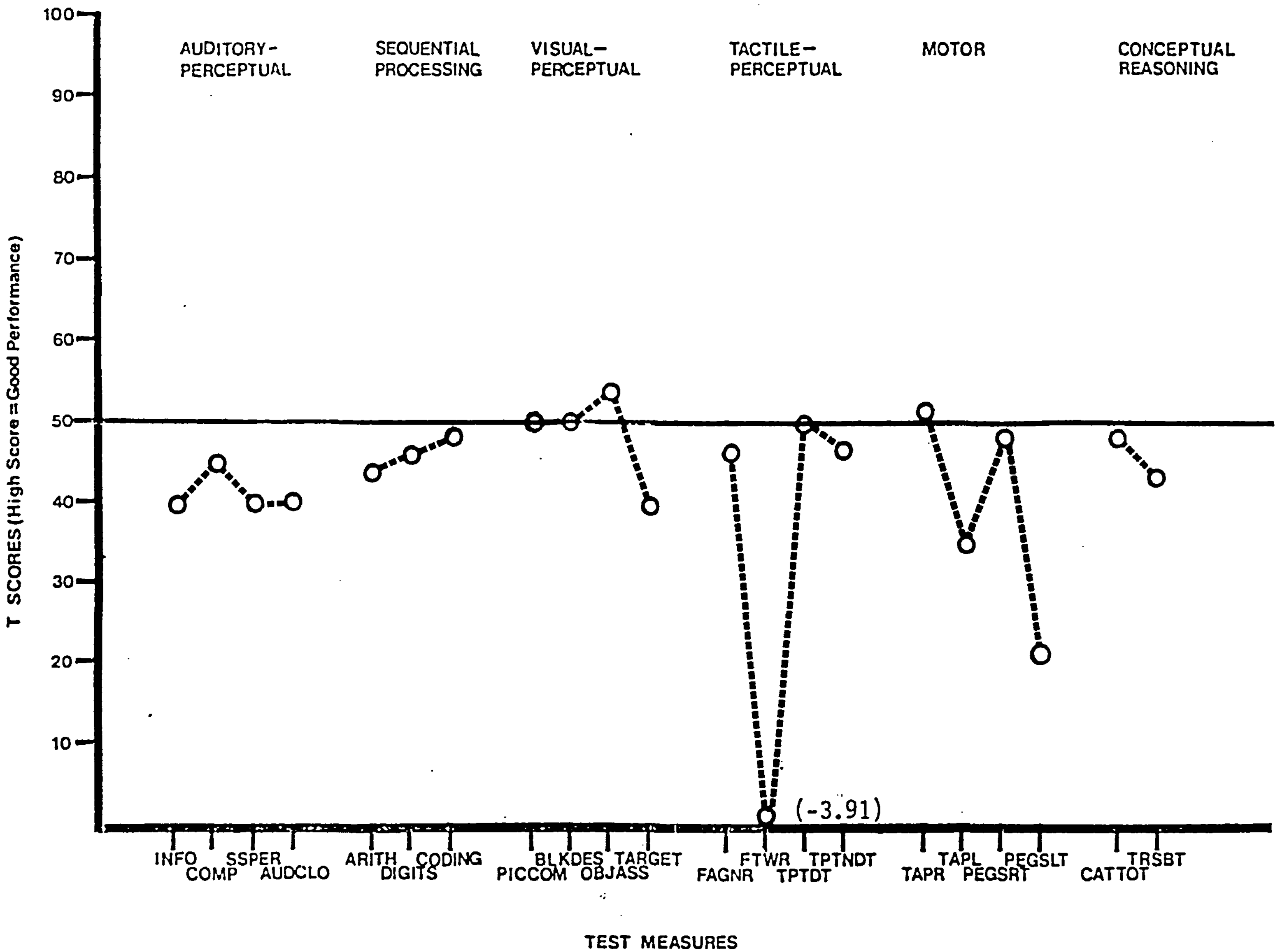

Figure 12. Plot of T score means for Factor 3 of dextral sample.

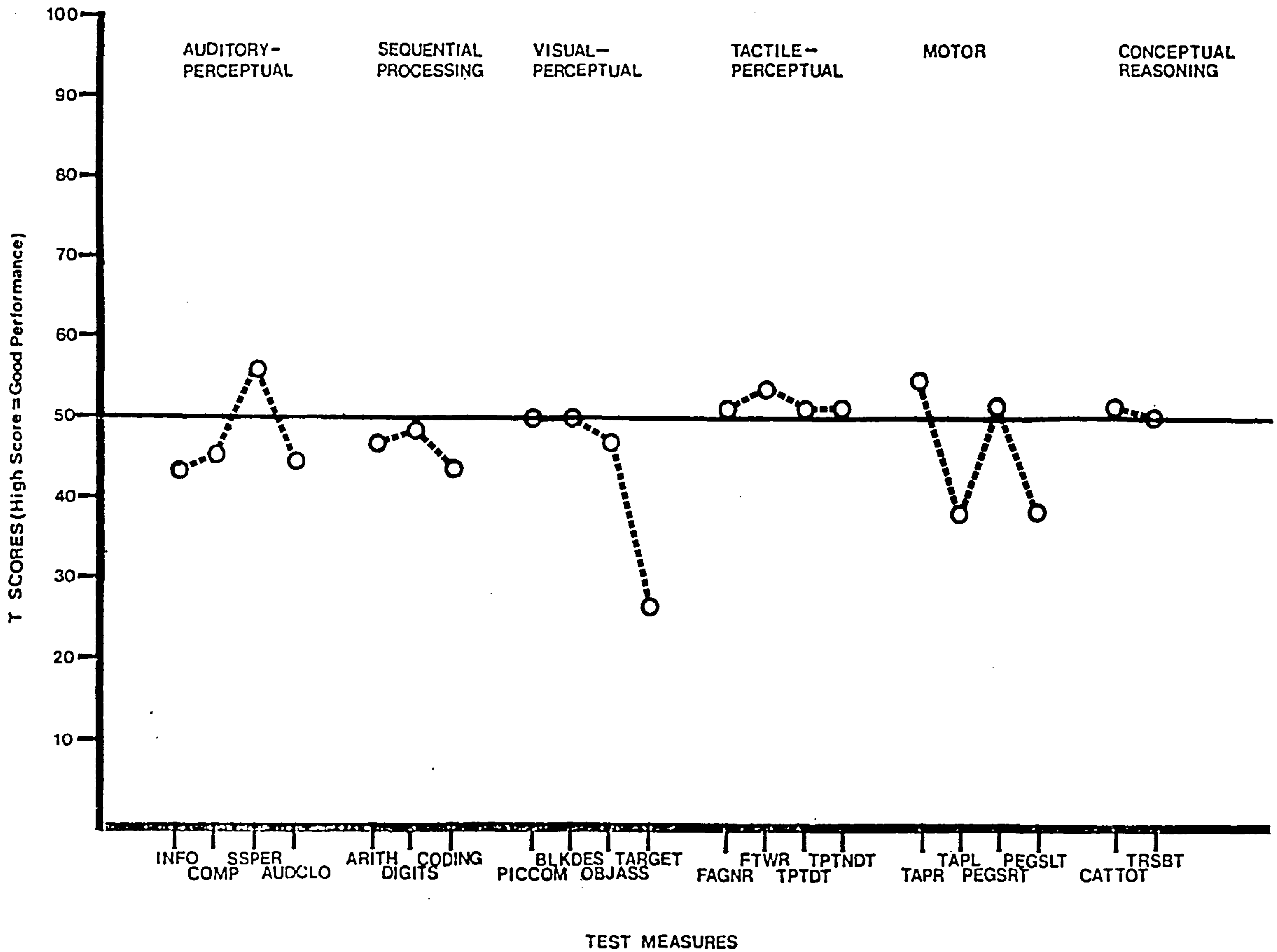

Figure 13. Plot of T score means for Factor 4 of dextral sample.

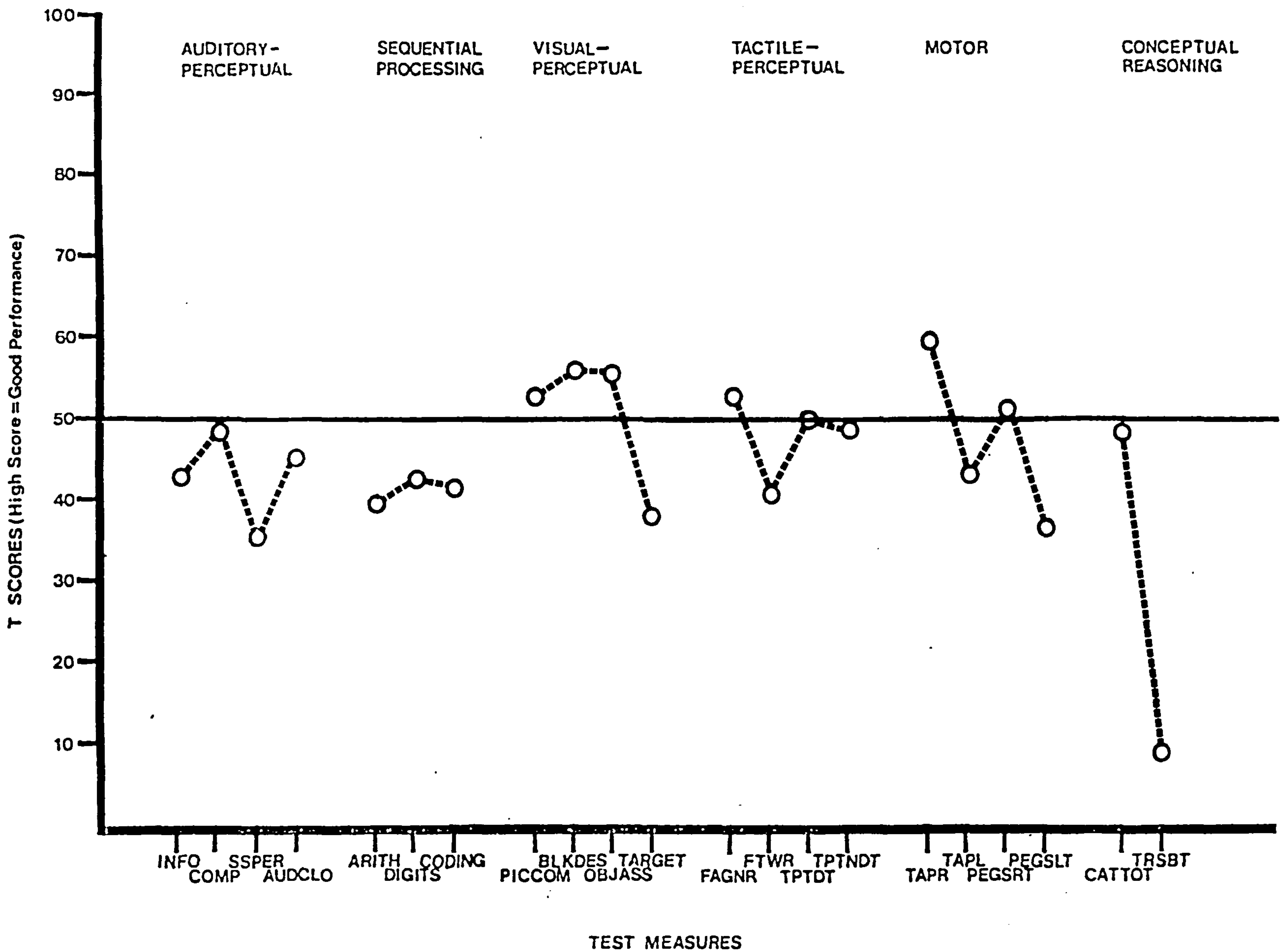

Figure 14. Plot of T score means for Factor 5 of dextral sample.

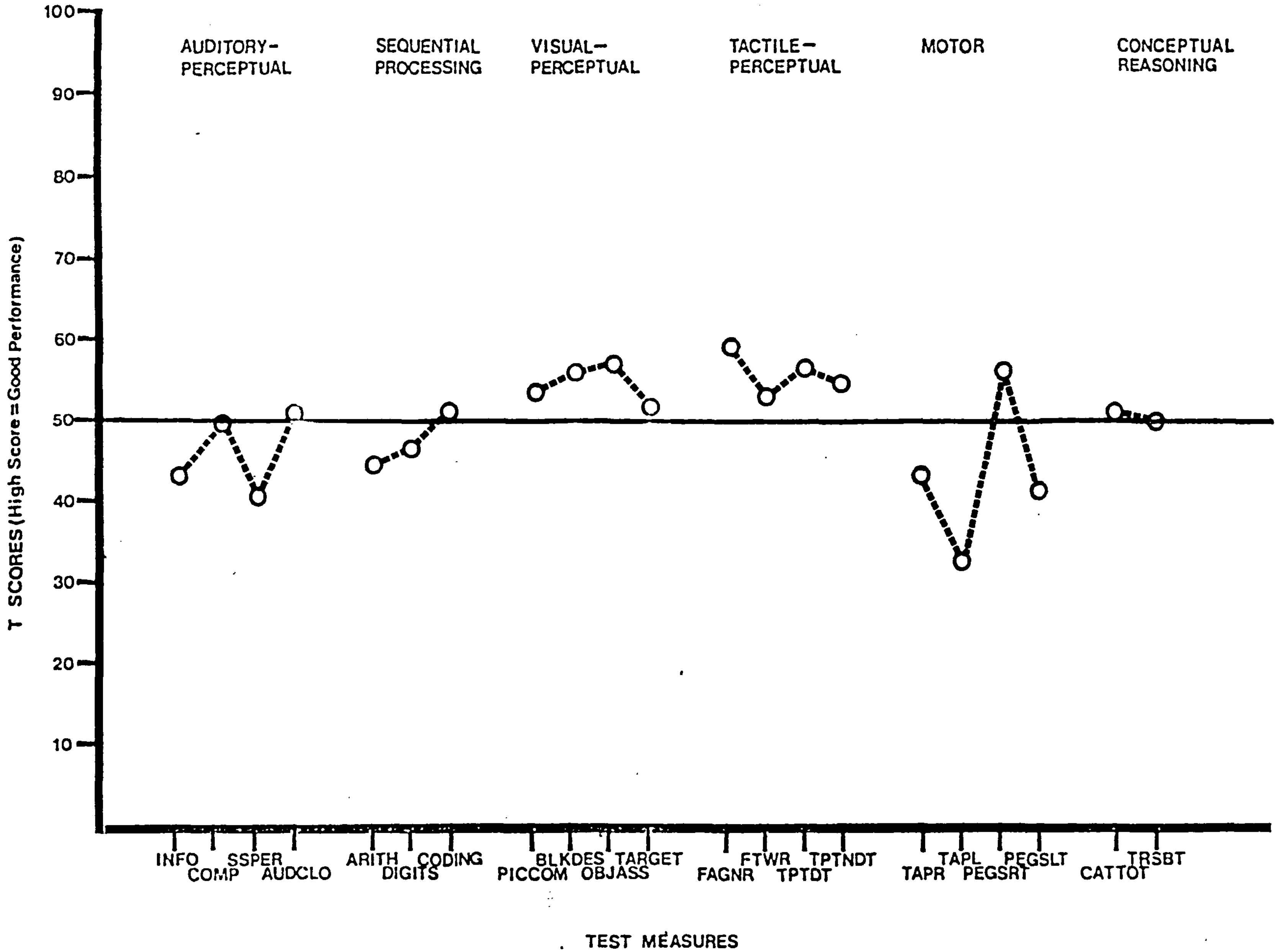

Figure 15. Plot of T score means for Factor 6 of dextral sample.

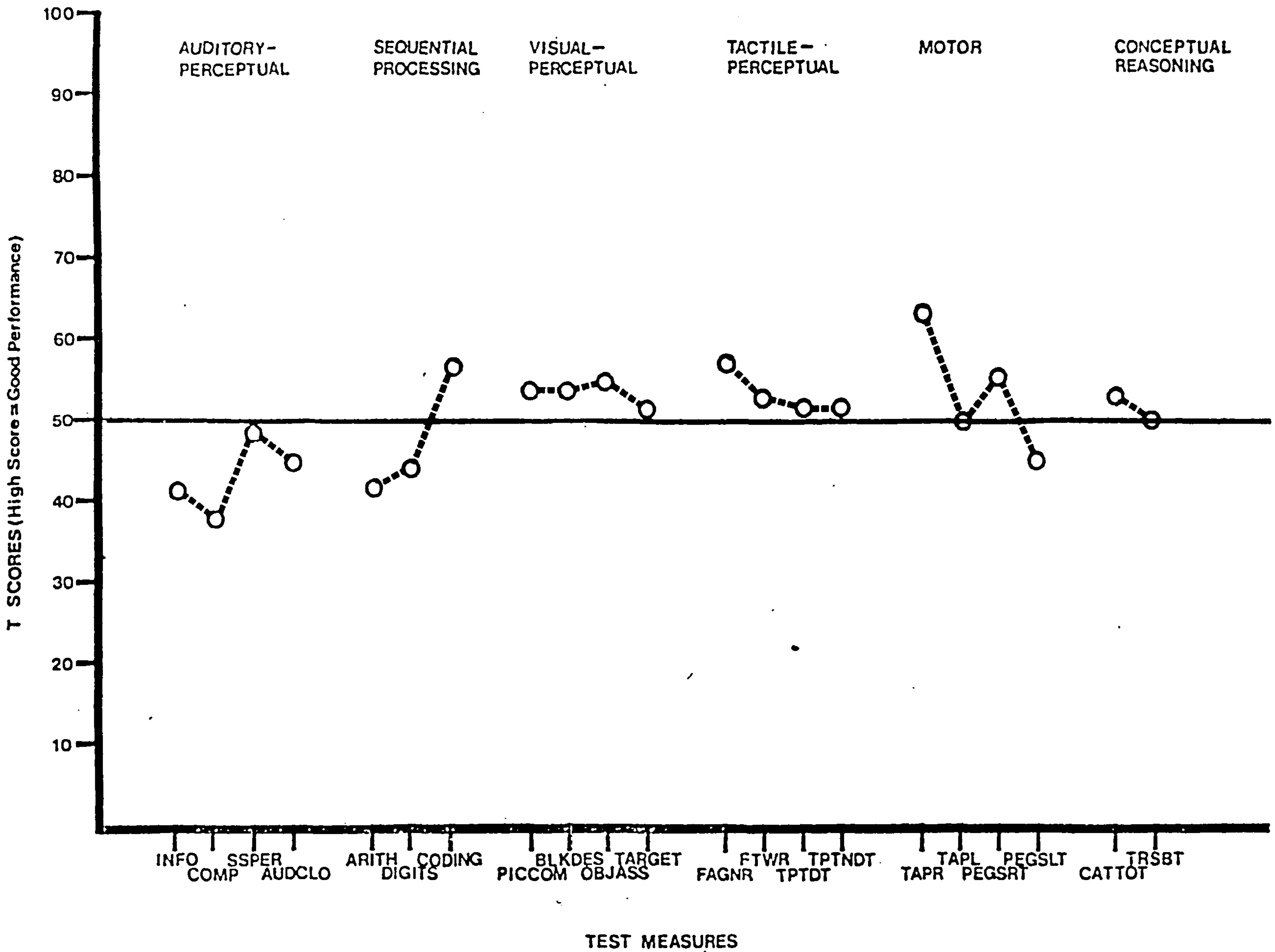

Figure 16. Plot of T score means for Factor 7 of dextral sample.

TABLE 17

Pearson Product Moment Correlation Coefficients for

Left-Handed and Right-Handed Q Factors

	Left-Handed Factors							*Right-Handed Factors*						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Left-Handed Factors														
1	1.00	.02	.20	.06	.03	.34	-.01	-.01	.94	.12	-.12	.03	-.22	-.16
2		1.00	.08	.16	.16	.11	.28	.84	.26	.07	.01	.55	.46	.37
3			1.00	-.16	.14	.30	-.19	.08	.18	.84	-.04	.41	-.01	-.00
4				1.00	.29	-.08	-.11	.21	.07	.11	.20	.11	.16	-.08
5					1.00	.29	.19	.07	.02	.13	.13	.52	.49	.01
6						1.00	-.02	-.01	.31	-.01	.13	.66	-.30	.06
7							1.00	.19	.13	-.06	.21	.30	.46	.55
Right-Handed Factors														
1								1.00	.26	.25	.14	.48	.47	.42
2									1.00	.17	-.06	.17	-.03	-.04
3										1.00	.11	.33	.26	.19
4											1.00	.21	.24	.33
5												1.00	.32	.36
6													1.00	.36
7														1.00

product moment correlations based on comparisons between mean T scores for all variables between all possible pairs of subtypes. Indeed, as can be seen from this table, the correlation coefficient between Factor 1 of the left-handers and Factor 2 of the right-handers was 0.94; between left-handed Factor 2 and right-handed Factor 1 it was 0.84; and between left-handed Factor 3 and right-handed Factor 3 it was again 0.84. These values are indicative of the high degree of similarity between the pattern of mean T scores for these factors. The profiles of test performances associated with the factors, as well as the correlation coefficients between factors were interpreted to define three highly similar subtypes of left- and right-handed children. The three factors from each handedness sample accounted for a total of 86 (78%) of the left-handed and 64 (55%) of the right-handed classified children (Table 14).

Comparisons between the remaining factors revealed that Factors 5 and 6 from the left-handed sample correlated with Factor 5 from the right-handed sample at 0.52 and 0.66, respectively. Factors 7 from each handedness sample were found to correlate with each other at 0.55. Factors 4 from each handedness sample exhibited very low intercorrelations with all of the remaining left- or right-handed factors. Visual inspection of the T score plots for all of the above comparisons revealed factor profiles that were, for the most part, quite dissimilar. Finally, the number of children who constituted Factors 4, 5, 6 and 7 for the left- and right-handed samples differed considerably. The membership distributions can be ascertained from Table 14. For the left-handed sample, Factor 4 was comprised of 9 children, while Factors 5, 6 and 7 had only a small number of subjects within each (6, 4 and 5 children, respectively). On the other hand, for the right-handed sample, the smallest factor (Factor 6) included 8 children as members, while each of Factors 4, 5 and 7 were seen to have a sizeable number of classified subjects (11, 18 and 15 children, respectively). On the basis of the factor analyses solutions, the right-handed sample of children would appear to constitute a much more heterogeneous population regarding patterns of performances on the battery of neuropsychologic measures administered.

Cluster Analyses Solutions

The results of the multivariate cluster analyses procedures are reported on as follows: (1) cluster solutions derived from the left-handed sample; (2) validation of the sinistral classifications; (3) cluster solutions derived from the right-handed sample; (4) validation of the dextral cluster results. Included within the discussions on the cluster solutions are reports on the Pearson product moment correlation coefficients based on comparisons between mean _T_ scores for all variables between all possible pairs of factors and clusters. Also, the results of misclassification comparisons between _Q_ type factors and cluster groups for each handedness sample are reported.

Left-Handed Cluster Solutions

The _T_ score means and standard deviations of clustering variables for the left-handed sample are presented in Table 18.

TABLE 18

_T_ Score Means and Standard Deviations of
Clustering Variables for the Left-Handed Sample

Variable	Mean	S. D.
INFO	42.960	6.616
COMP	47.701	9.513
SSPER	36.026	20.729
AUDCLO	49.989	15.771
ARITH	43.167	6.688
DIGITS	44.553	8.588
CODING	48.218	9.591
PICCOM	53.891	9.462
BLKDES	51.427	8.037
OBJASS	53.353	9.104
TARGET	41.337	13.511
FAGNR	31.306	34.838
FTWR	37.865	30.838
TPTDT	50.328	9.664
TPTNDT	48.198	14.028
TAPR	50.974	11.291
TAPL	46.765	12.660
PEGSRT	45.133	17.018
PEGSLT	43.615	15.757
CATTOT	49.798	9.287
TRSBT	38.521	21.122

It was clear that many of the measures deviated significantly from a normal distribution, suggesting the presence of multiple populations (i.e., subgroups or clusters) within the data (Morris et al., 1981).

The hierarchical trees (dendrograms) obtained by applying the group average and centroid sorting agglomerative hierarchical techniques to the sinistral data set are presented in Figures 17 and 18, respectively. Both dendrograms indicated clearly that the data was structured and contained several clusters. To aid in identifying the number of clusters present in the data, Table 19 presents the clustering coefficients (i.e., an indication of the amount of variance accounted for at each step of the clustering process) of the group average and centroid sorting methods. Plots of these values against the number of clusters are seen in Figures 19 and 20. The sharp decrease from a four-cluster to a three-cluster solution depicted on Figure 19 suggested that two clusters were combined to form a heterogeneous cluster (i.e., one with a high degree of within-cluster variability). Thus, the more homogeneous four-cluster solution previous to this fusion was chosen as the terminal solution. The number of clusters present in the centroid sorting results was not as clear-cut. The graph of the clustering coefficients for this method (Figure 20) did not reveal any significant precipitous changes in the plots of these values. Most changes were quite minimal and of similar magnitude. However, since the Q technique of factor analysis applied to the same sinistral data set suggested what appeared to be the presence of four reasonably

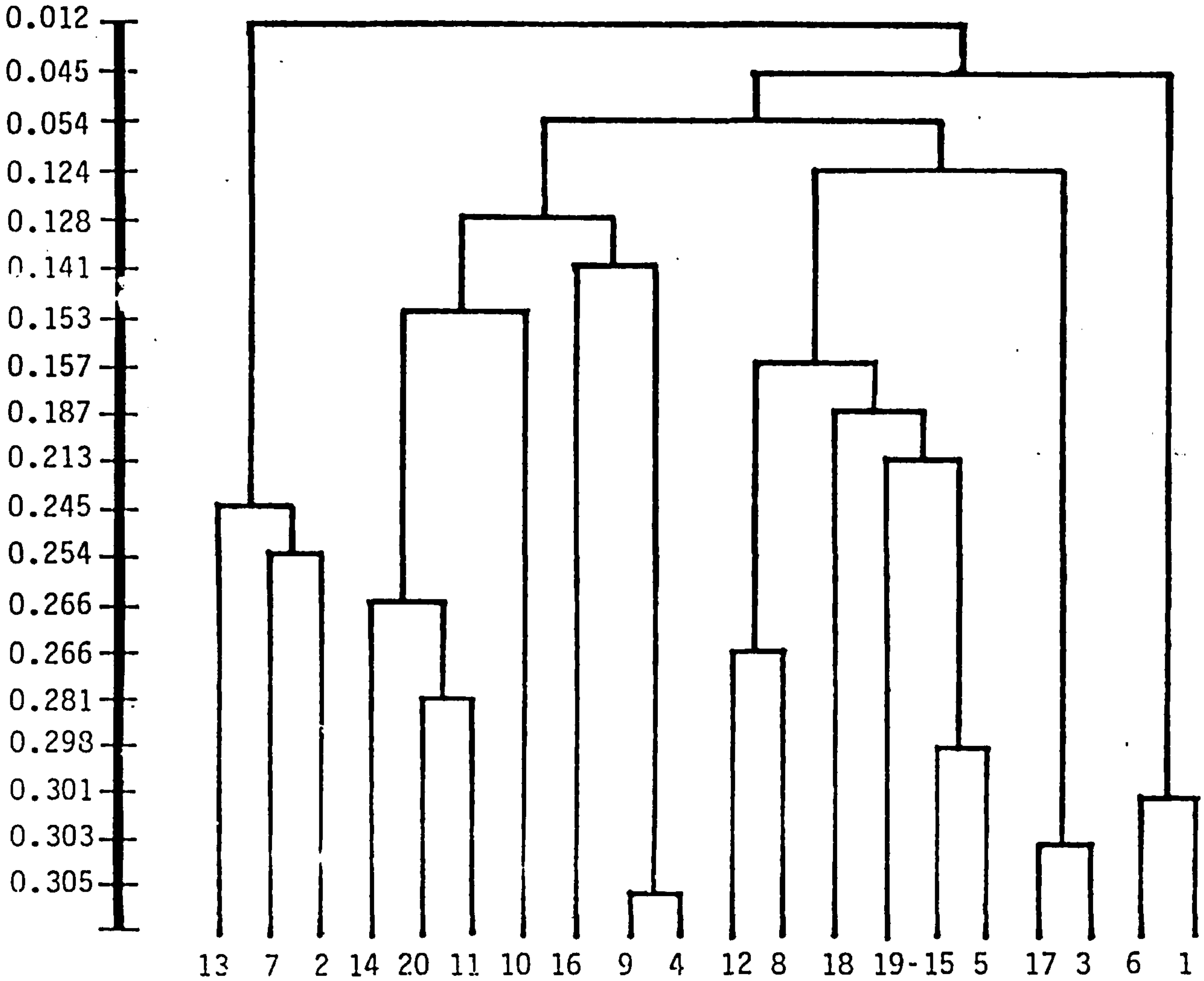

Figure 17. Hierarchical tree using group average on sinistral sample.

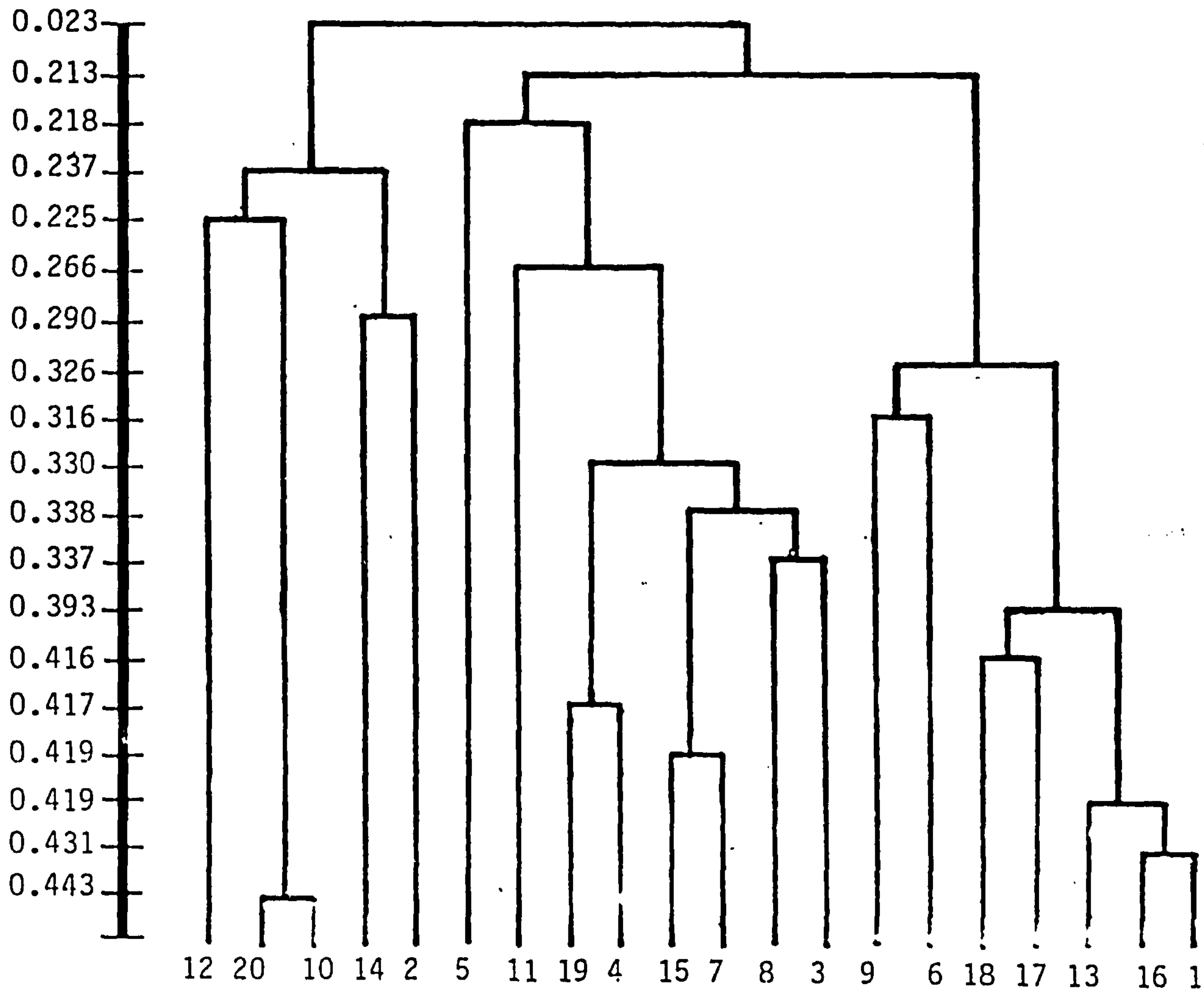

Figure 18. Hierarchical tree using centroid sorting on sinistral sample.

TABLE 19

Cluster Coefficients of Group Average and Centroid Sorting Hierarchical Agglomerative Methods for the Left-Handed Sample

n of Clusters	Group Average	Centroid Sorting
10	.213	.330
9	.187	.316
8	.157	.326
7	.153	.290
6	.141	.266
5	.128	.225
4	.124	.237
3	.054	.218
2	.045	.213
1	.012	.023

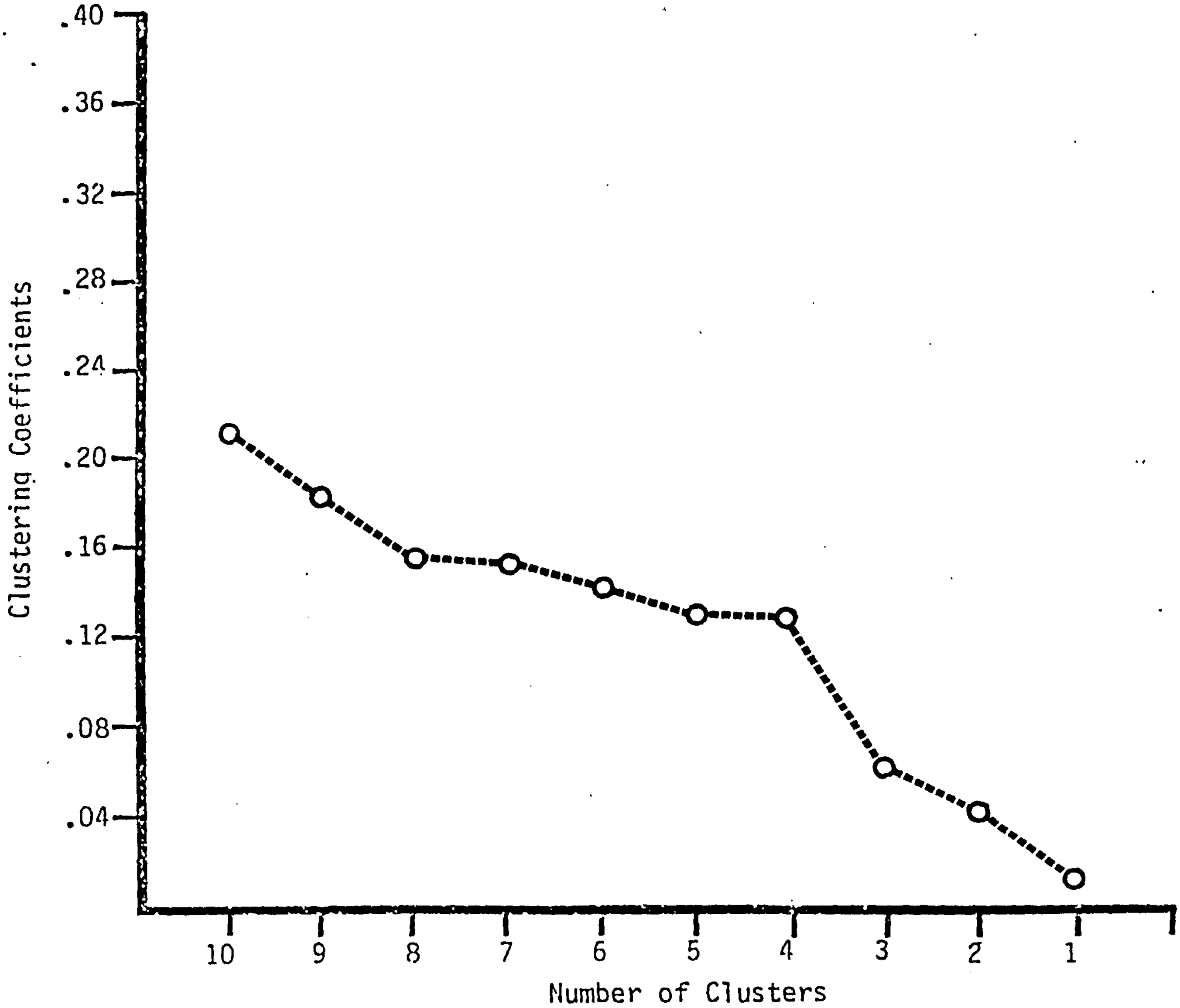

Figure 19. Plot of group average hierarchical cluster coefficients for sinistral sample.

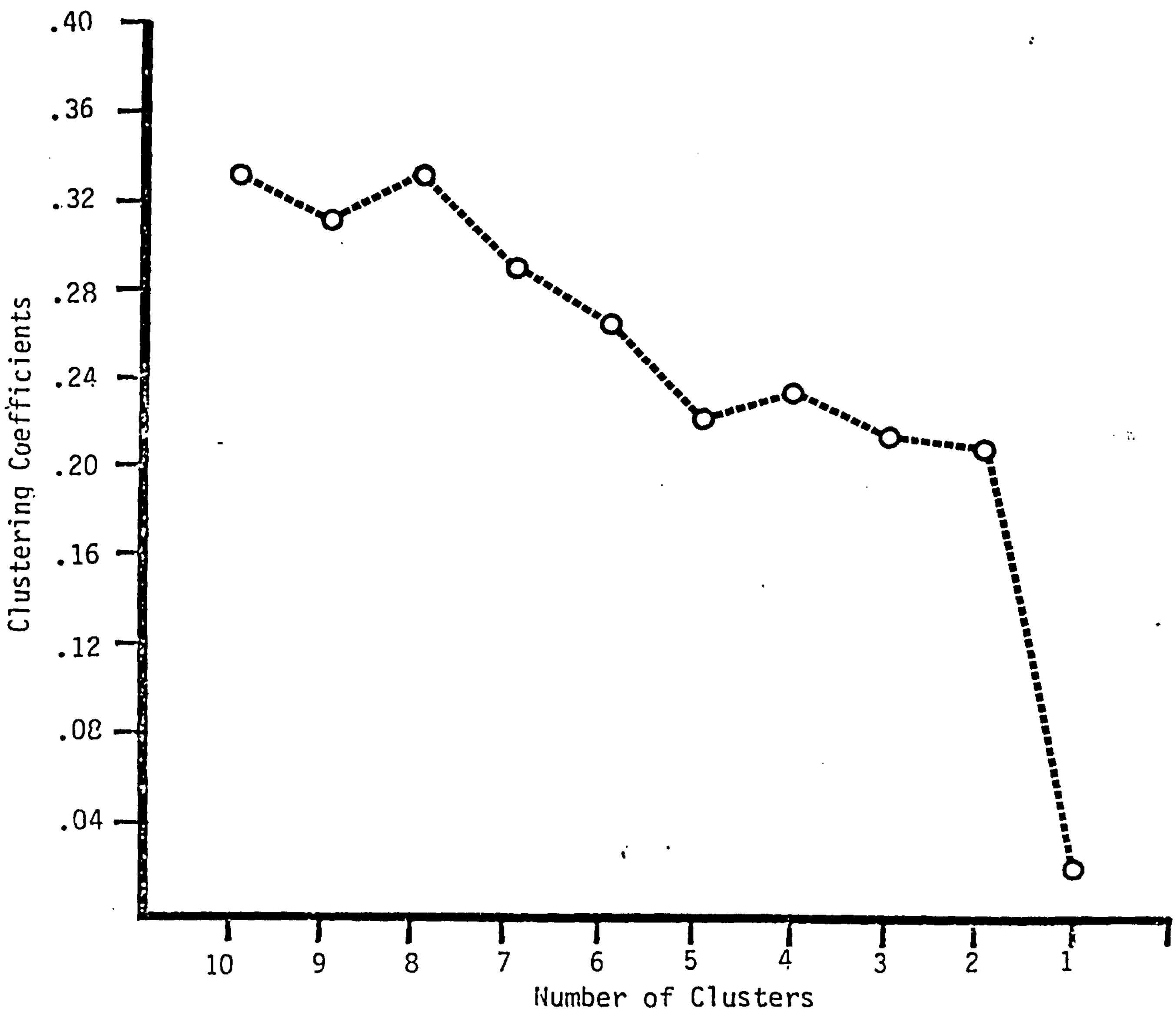

Figure 20. Plot of centroid sorting hierarchical cluster coefficients for sinistral sample.

strong and interpretable factors, a four cluster solution was felt to be a plausible criterion to adopt for termination of the clustering process.

In an attempt to correct for poor initial partitions, the initial cluster solutions from the group average and centroid sorting methods were each subjected to a iterative relocation procedure. The method attempted to clarify the cluster solutions by searching for subjects which should be reallocated to another group. An index of the stability of the solution was also provided by examining the number of subjects that changed clusters during iteration. For the four-cluster solutions from the group average and centroid sorting analyses, only 7% and 9% of the subjects, respectively, were actually placed in a different cluster. To improve further upon the corrected solutions and to increase the likelihood that 'global optimum' solutions had been reached, the relocate procedure was repeated using a different starting configuration. Table 20 indicates that the same four-cluster solutions were replicated perfectly i.e., 100% agreement) from different starting classifications. The four-cluster classification arrays produced by group average, centroid sorting, group average relocate, centroid sorting relocate, group average relocate (random) and centroid sorting relocate (random) are presented in Appendix E.

The group membership distributions for the four-cluster relocate solutions can be ascertained from Table 21. The number of subjects classified into eight clusters down to two are provided in Table 21 so the reader is able to view the incorporation of clusters

TABLE 20

Comparison of Relocate Cluster Solutions for Sinistral Sample from Different Starting Classifications (Shape Difference Classification vs Random Start)

Cluster Analysis Method	Starting Classification Shape Difference	Random	% Agreement
Group Average			
1	49	49	
2	26	26	
3	51	51	
4	35	35	100%
Centroid Sorting			
1	51	51	
2	35	35	
3	49	49	
4	26	26	100%

TABLE 21

Number of Left-Handed Children in Each Cluster for 8, 7, 6, 5, 4, 3, and 2 Relocate Cluster Results

Cluster Analysis	Clusters						
Method	8	7	6	5	4	3	2
Group Average							
1	45	45	45	48	49	64	72
2	20	20	22	20	26	31	89
3	14	14	14	47	51	66	
4	11	24	28	28	35		
5	38	39	39	18			
6	7	10	13				
7	24	9					
8	2						
Centroid Sorting							
1	34	38	38	48	51	66	72
2	14	15	15	16	35	64	89
3	19	29	30	30	49	31	
4	46	46	46	49	26		
5	14	14	18	18			
6	14	14	14				
7	5	5					
8	15						

during the fusion process. It also allows for the detection of *outliers* (unique individuals within the sample or viewed as resulting from measurement errors) in the data. In the current study, no children were removed from the analyses. As indicated in Table 21, the group average and centroid sorting relocate methods generated identical four-cluster solutions. Cluster sizes were 49, 26, 51 and 35 children.

The _T_ score means and standard deviations of variables used in the cluster analyses procedures for each sinistral cluster group are shown in Table 22. Again, an asterisk next to the variable name denotes those measures used in the clustering methods. Other pertinent measures listed on the table include CAGE, WISC VIQ, PIQ and FSIQ, and WRAT RPERC, SPERC and ARPERC values for each cluster. For the CAGE variable, Clusters 1, 2 and 3 exhibited similar mean ages (11.14, 11.24 and 11.18, respectively), while Cluster 4 exhibited the oldest mean age (12.43). Clusters 1, 2 and 3 also exhibited very similar mean WISC FSIQs (48.14, 48.12 and 48.60, respectively), whereas the mean WISC FSIQ for Cluster 4 was slightly higher (49.31). Similar lower mean VIQ-higher mean PIQ patterns were seen across all clusters, although the discrepancy was significantly smaller between the two values within Cluster 2 relative to the other groups. Finally, Clusters 1 and 3 were found to have mean WRAT Reading, Spelling and Arithmetic scores that were all below the 30th centile. For Clusters 2 and 4, RPERC exceeded the 30th centile (somewhat moreso within the former group), while both SPERC and ARPERC were below this value.

TABLE 22

T Score Means and Standard Deviatios

of Variables for Each Sinistral Cluster Group

Cluster 1

	VARIABLE	N	MEAN	STANDARD DEVIATION
*	INFO	49	44.01360544	6.04686909
*	COMP	49	46.46258503	9.03717024
	SIMIL	49	51.56462585	7.70107138
	VOCAB	49	48.29931973	6.94297037
	PPVTIQ	49	49.52380952	7.97217383
	AUDR	49	0.08163265	0.39982990
	AUDL	49	0.20408163	0.91240506
*	SSPER	49	37.35027829	17.12474675
*	AUDCLO	49	50.94081633	17.62039294
	SENMEM	48	33.34963768	11.24515907
	VFLU	49	39.96938776	9.27721681
*	ARITH	49	42.44897959	7.12895472
*	DIGITS	49	42.99319728	7.88355350
*	CODING	49	48.57142857	9.71825316
*	PICCOM	49	55.17006803	8.47275657
	PICARR	49	50.88435374	7.84028977
*	BLKDES	49	51.42857143	8.41625412
*	OBJASS	49	51.63265306	8.84858351
	VISR	49	0.20408163	0.64483822
	VISL	49	0.40816327	0.81441102
*	TARGET	49	40.34873691	12.70916183
	TACR	49	0.71428571	1.17260394
	TACL	49	0.61224490	1.07657494
*	FAGNR	49	-16.61224490	46.80492154
	FAGNL	49	21.49659864	40.55438292
*	FTWR	49	35.25151337	17.55530589
	FTWL	49	30.18800247	25.86466535
	ASTR	49	41.29514839	13.30305614
	ASTL	49	42.07559214	14.97534121
*	TPTDT	49	45.94731322	12.80758732
*	TPTNDT	49	46.27819903	13.70315579
	TPTBT	49	36.41781388	36.38985616
	TPTMEM	48	49.48958333	11.85658021
	TPTLOC	48	45.64060245	12.22960990
*	TAPR	49	49.65694596	11.15286757
*	TAPL	49	46.15029891	13.56758121
	FTAPR	49	31.15714285	7.08014330
	FTAPL	49	30.93142857	7.09304707
	GRIPR	45	40.79092063	14.03853370
	GRIPL	45	36.01184090	13.53580369
*	PEGSRT	49	45.09618755	12.35505248
*	PEGSLT	49	44.45578231	11.52093856
*	CATTOT	49	50.92492721	8.96969467
*	TRSBT	49	36.03073919	27.79690578
	CAGE	49	11.14534694	1.23965897
	VIQ	49	44.87074830	5.53976213
	PIQ	49	52.10884354	6.28688662
	FSIQ	49	48.14965986	4.84245367
	RPERC	49	24.46938776	22.73864372
	SPERC	49	18.44897959	19.92910479
	ARPERC	49	17.44897959	11.82169831

TABLE 22 (cont'd)

Cluster 2

VARIABLE	N	MEAN	STANDARD DEVIATION
* INFO	26	44.87179487	7.73050346
* COMP	26	48.97435697	9.83279008
SIMIL	26	51.92307692	7.12885074
VOCAB	26	49.23076923	8.28962899
PPVTIQ	26	50.38461538	8.15003783
AUDR	26	0.03846154	0.19611614
AUDL	26	0.00000000	0.00000000
* SSPER	26	49.81713287	14.40574944
* AUDCLO	26	60.27500000	13.96991410
SENMEM	26	38.66555184	10.95000337
VFLU	26	40.24450549	11.56448068
* ARITH	26	45.76923077	7.57526339
* DIGITS	26	44.74358974	8.70111497
* CODING	26	46.02564103	9.61569230
* PICCOM	26	53.58974359	10.28150775
PICARR	26	48.71794872	7.72165343
* BLKDES	26	48.84615385	7.05170162
* OBJASS	26	51.02564103	7.87509327
VISR	26	0.03846154	0.19611614
VISL	26	0.11538462	0.43145550
* TARGET	26	44.12158282	10.05092488
TACR	26	0.23076923	0.31523946
TACL	26	0.11538462	0.32581259
* FAGNR	26	47.30769231	17.78036947
FAGNL	26	45.74358974	17.67164903
* FTWR	26	46.44465354	12.20085137
FTWL	26	42.61369322	20.67271579
ASTR	26	42.51152437	12.94581225
ASTL	26	46.41330891	11.11706896
* TPTDT	26	51.87589227	6.78408752
* TPTNDT	26	46.78602919	13.07677862
TPTBT	26	47.08309501	13.89460584
TPTMEM	26	49.33333333	10.15480182
TPTLOC	26	43.25740926	11.18444569
* TAPR	26	47.54822308	10.31945142
* TAPL	26	42.72136752	10.86502110
FTAPR	26	32.02961538	7.46607285
FTAPL	26	33.02192308	8.23705385
GRIPR	22	39.03907724	13.61427581
GRIPL	22	32.61441460	12.66065728
* PEGSRT	26	28.86574864	22.36811675
* PEGSLT	26	25.40975181	22.74026772
* CATTOT	26	50.08890436	8.86293836
* TRSBT	26	43.11354230	12.27540333
CAGE	26	11.24126923	1.54340671
VIQ	26	47.05128205	6.84345092
PIQ	26	49.43589744	5.61170937
FSIQ	26	48.12820513	4.78151712
RPERC	26	47.76923077	33.10867885
SPERC	26	29.00000000	21.66287146
ARPERC	26	17.96153846	9.11034914

TABLE 22 (cont'd)

Cluster 3

	VARIABLE	N	MEAN	STANDARD DEVIATION
*	INFO	51	40.45751634	6.21895339
*	COMP	51	47.18954248	8.49503251
	SIMIL	51	51.24183007	7.97108063
	VOCAB	51	48.36601307	5.93941819
	PPVTIQ	51	48.13071895	8.54168301
	AUDR	51	0.07843137	0.44014258
	AUDL	51	0.07843137	0.27152438
*	SSPER	51	22.61149733	22.16983153
*	AUDCLO	51	47.77892157	14.07743351
	SENMEM	51	33.51065644	12.93977278
	VFLU	51	37.24859944	9.30654247
*	ARITH	51	42.35294118	6.40465517
*	DIGITS	51	44.31372549	8.41411823
*	CODING	51	47.77777778	9.46729262
*	PICCOM	51	55.09803922	9.55342734
	PICARR	51	52.41830065	9.93486412
*	BLKDES	51	51.96078431	7.48855336
*	OBJASS	51	53.29411765	8.97345395
	VISR	51	0.05882353	0.23763541
	VISL	51	0.13725490	0.40097919
*	TARGET	51	45.70378509	11.32825679
	TACR	51	0.39215686	0.98139556
	TACL	51	0.15686275	0.70349269
*	FAGNR	51	50.50980392	14.18643373
	FAGNL	51	48.23529412	12.84701334
*	FTWR	51	55.91984460	11.71896870
	FTWL	51	51.20173036	14.92817288
	ASTR	51	46.89464914	12.58034541
	ASTL	51	47.73576097	13.11852664
*	TPTDT	51	52.83299703	7.79455646
*	TPTNDT	51	52.64691975	8.75219927
	TPTBT	51	42.91784628	26.68996603
	TPTMEM	51	53.09803922	7.02583933
	TPTLOC	51	50.14854427	11.59092074
*	TAPR	51	52.25880157	10.54131460
*	TAPL	51	48.11048723	10.47149745
	FTAPR	50	31.95540000	5.25659827
	FTAPL	50	31.43580000	5.79575569
	GRIPR	47	48.93022556	12.21196475
	GRIPL	47	43.16158766	12.66985762
*	PEGSRT	51	50.34326800	14.21977820
*	PEGSLT	51	48.63983689	10.71258059
*	CATTOT	51	51.40692094	8.65776289
*	TRSBT	51	38.24822623	18.56736162
	CAGE	51	11.18111765	1.39142365
	VIQ	51	44.64052288	5.25434979
	PIQ	51	53.38562092	6.97276370
	FSIQ	51	48.60130719	5.15407912
	RPERC	51	12.98039216	12.70667572
	SPERC	51	9.78431373	10.94771890
	ARPERC	51	13.84313725	11.15414282

TABLE 22 (cont'd)

Cluster 4

	VARIABLE	N	MEAN	STANDARD DEVIATION
*	INFO	35	43.71428571	6.25030345
*	COMP	35	49.23809524	11.26292182
	SIMIL	35	51.80952381	7.93531270
	VOCAB	35	47.61904762	7.25679436
	PPVTIQ	35	50.38095238	9.77697136
	AUDR	35	0.14285714	0.55001910
	AUDL	35	0.11428571	0.40376380
*	SSPER	35	43.47766234	16.05204150
*	AUDCLO	35	44.23571429	13.17683641
	SENMEM	35	35.35403727	12.16265986
	VFLU	35	40.06122449	12.47792340
*	ARITH	35	43.42857143	5.39218233
*	DIGITS	35	46.95238095	9.47550777
*	CODING	35	50.00000000	9.59983660
*	PICCOM	35	50.57142857	9.58231331
	PICARR	35	50.76190476	7.88337020
*	BLKDES	35	52.57142857	8.82234664
*	OBJASS	35	54.66666667	9.97382194
	VISR	35	0.22857143	0.49024089
	VISL	35	0.20000000	0.58410313
*	TARGET	35	34.29489896	16.76063097
	TACR	35	0.28571429	0.78857386
	TACL	35	0.17142857	0.45281565
*	FAGNR	35	48.05714286	20.76470826
	FAGNL	35	44.19047619	24.86490107
*	FTWR	35	8.84677977	48.03061686
	FTWL	35	7.19488966	80.34324777
	ASTR	35	44.93124019	16.71485297
	ASTL	35	46.73829532	14.98927539
*	TPTDT	35	51.66322087	6.61490262
*	TPTNDT	35	45.45583537	19.44736324
	TPTBT	35	42.03031043	16.71786217
	TPTMEM	35	45.66666667	13.01965583
	TPTLOC	35	44.95102041	13.44254914
*	TAPR	35	53.49353890	12.72340221
*	TAPL	35	42.67510823	15.04808427
	FTAPR	34	35.38000000	6.18449626
	FTAPL	34	35.96823529	6.28252674
	GRIPR	17	44.74628925	12.47602131
	GRIPL	17	39.24844994	13.90596241
*	PEGSRT	35	49.68334555	14.74644625
*	PEGSLT	35	48.64309778	10.65597014
*	CATTOT	35	45.66862031	10.03464258
*	TRSBT	35	38.99771112	19.11747857
	CAGE	35	12.43168571	2.01494494
	VIQ	35	46.41904762	6.27701631
	PIQ	35	52.43809524	7.40419040
	FSIQ	35	49.31428571	5.18541372
	RPERC	35	35.97142857	27.24559944
	SPERC	35	19.48571429	20.96267191
	ARPERC	35	17.20000000	13.86447004

*Denotes dependent measures used in statistical treatment of data.

N.B. The four cluster solution listed on this table represents the results of both the Group Average and Centroid Sorting Methods, since identical solutions were generated from each.

Graphic illustrations of the mean T scores for each variable for each sinistral cluster are presented in Figures 21 to 24. Inspection of these Figures indicated that there was a high degree of visual similarity between these cluster profiles and the four sinistral factor profiles depicted in Figures 3 to 6, as well as the three dextral factor profiles shown in Figures 10 to 12. Table 23 contains the Pearson product moment correlations based on comparisons between mean T scores for all variables between all possible pairs of left- and right-handed Q factors, and left-handed cluster groups. Examination of Table 23 revealed that the correlation values between sinistral Clusters 1, 2, 3 and 4, and left-handed Factors 1, 4,2 and 3 were 0.99, 0.94, 0.97 and 0.99, respectively. These correlation values attest to the near perfect match between performance patterns generated from the Q technique of factor analysis, and performance patterns derived from the cluster analytic methods following the application of both procedures to a sample of left-handed children. Comparisons between Clusters 1, 3 and 4, and dextral Factors 2, 1 and 3 revealed very high correlation values between these pairs of T score plots as well. The respective correlation coefficients were 0.93, 0.81 and 0.83.

Misclassification analysis was the last method used to compare the cluster and factor analytic solutions derived from the left-handed data set. Table 24 shows the number of children from each of the Q type factors who were not classified together by a given method of cluster analysis. As can be seen from Table 24, all of

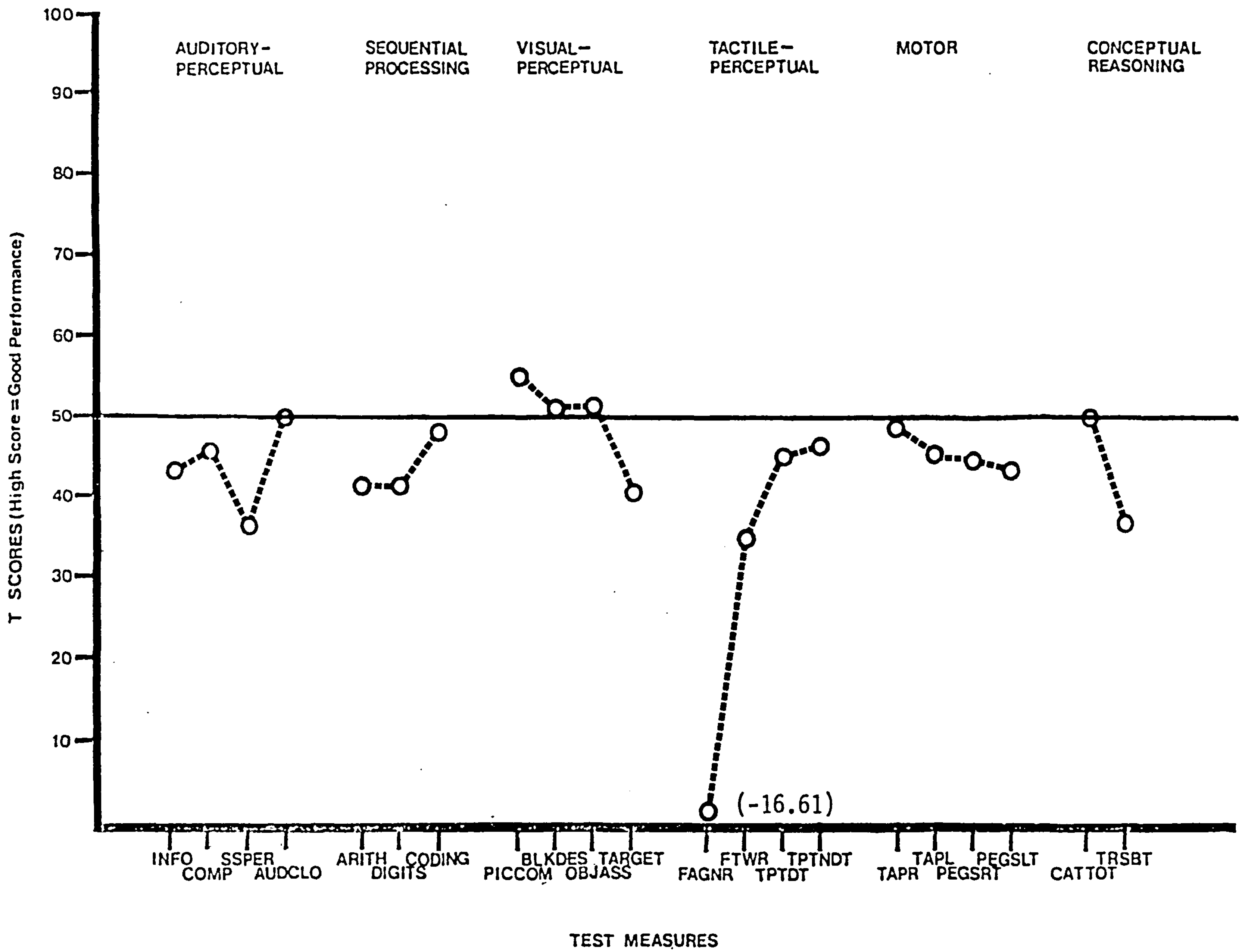

Figure 21. Plot of T score means for Cluster 1 of sinistral sample.

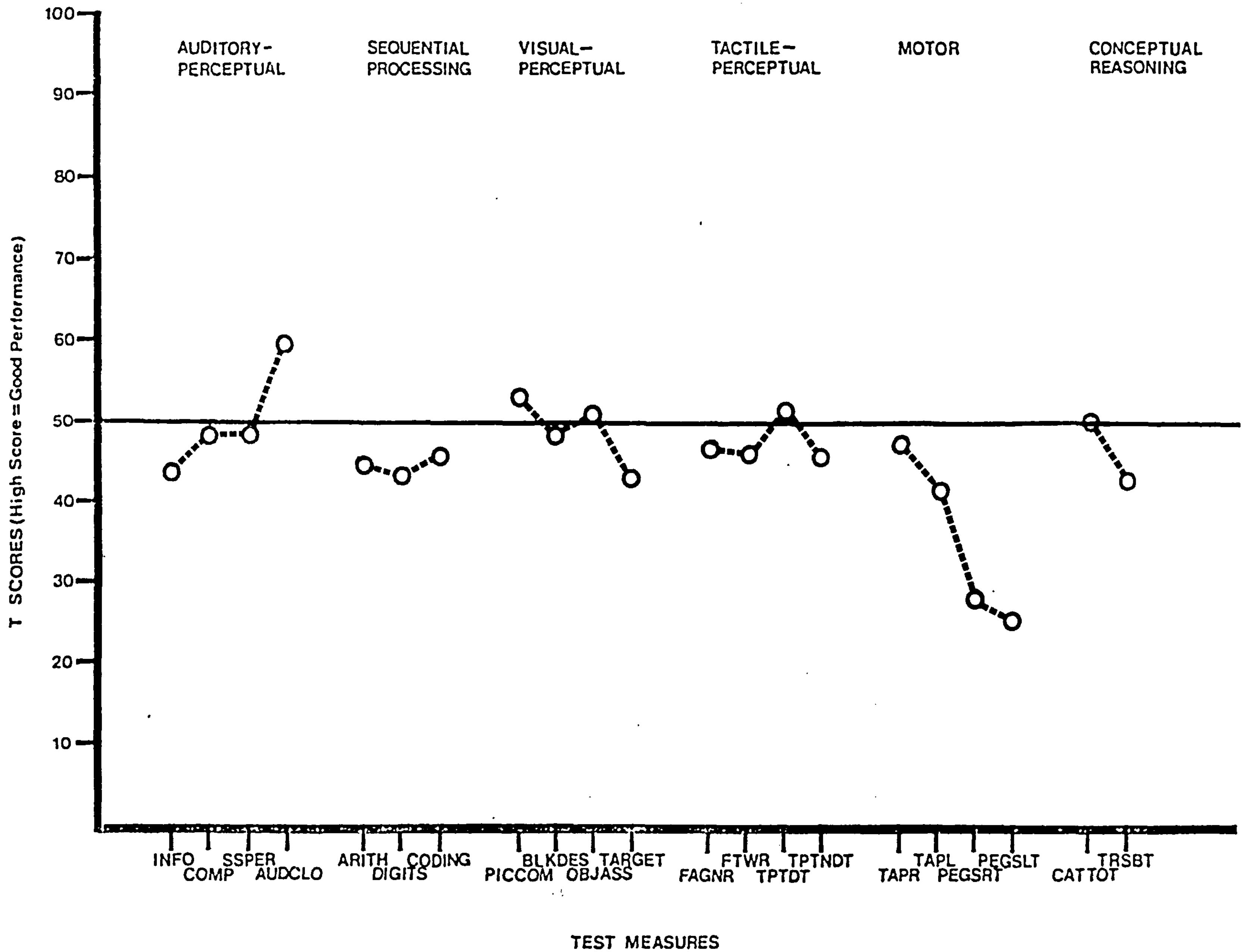

Figure 22. Plot of T score means for Cluster 2 of sinistral sample.

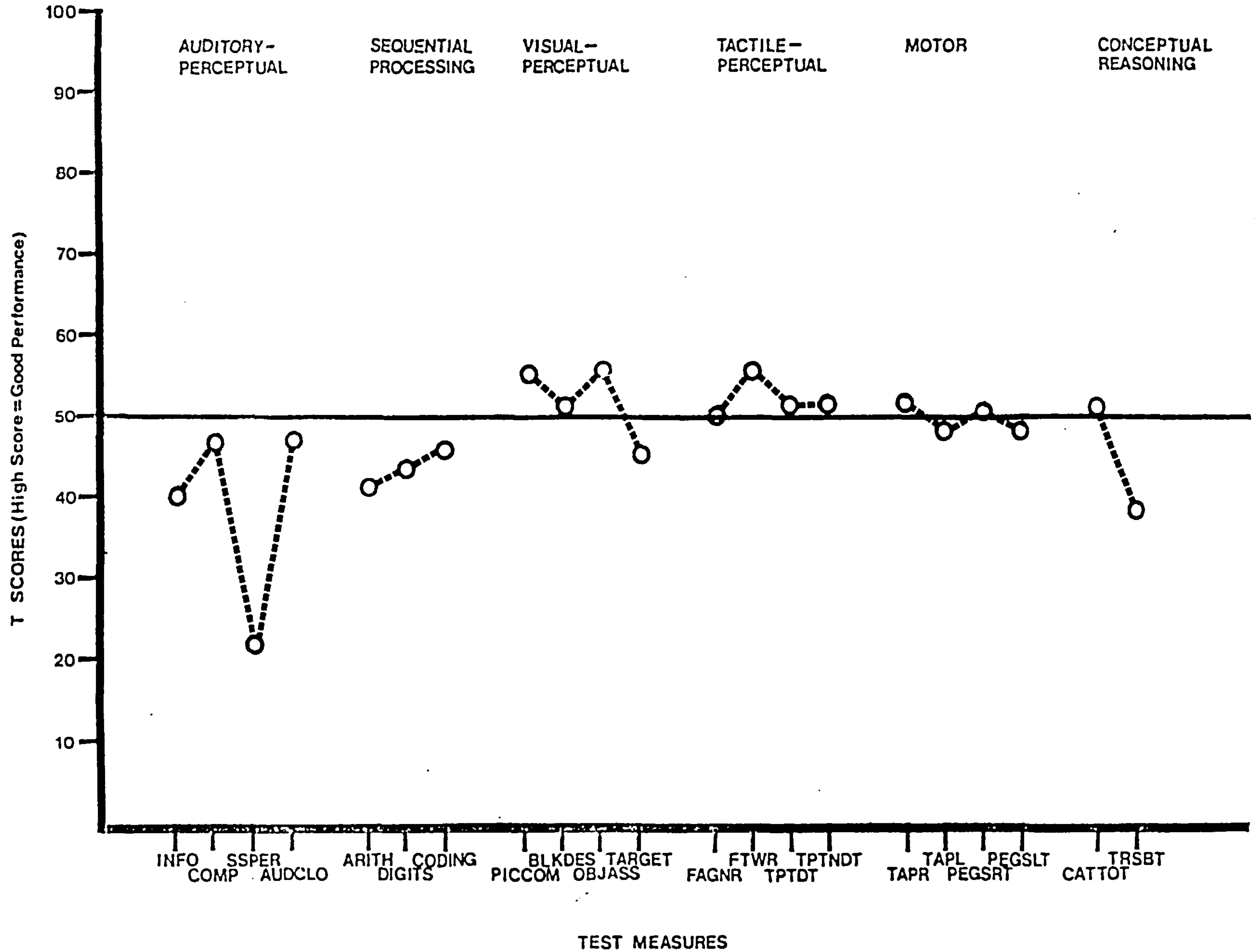

Figure 23. Plot of T score means for Cluster 3 of sinistral sample.

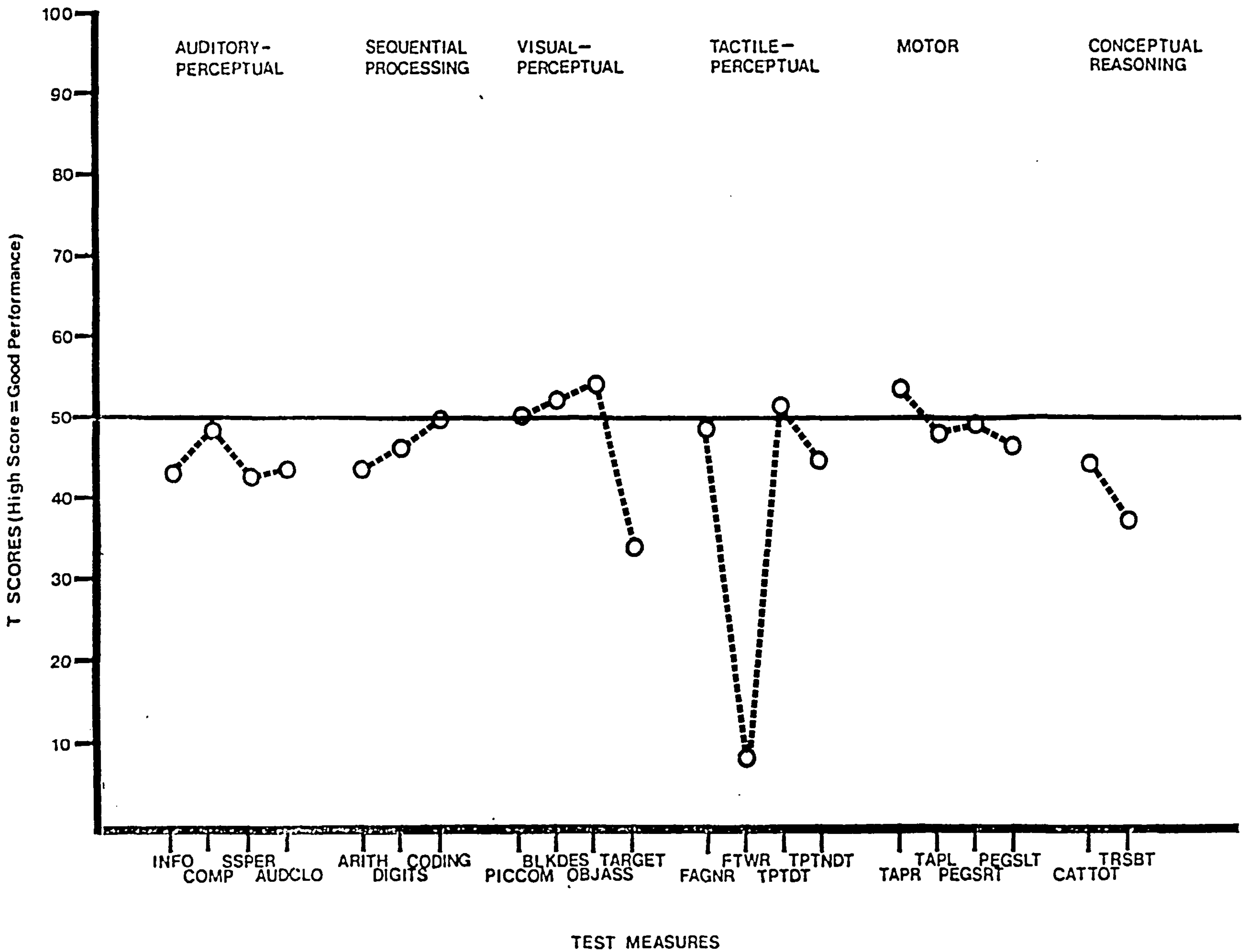

Figure 24. Plot of T score means for Cluster 4 of sinistral sample.

TABLE 23

Pearson Product Moment Correlation Coefficients for

Sinistral and Dextral Q Factors and Sinistral Cluster Groups

	Sinistral Factors							*Dextral Factors*							*Sinistral Clusters*			
	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4
nistral Factors																		
1	1.00	.02	.20	.06	.03	.34	-.01	-.01	.94	.12	-.12	.03	-.22	-.16	.99	.09	.09	.15
2		1.00	.08	.16	.16	.11	.28	.84	.26	.07	.01	.55	.46	.37	.06	.14	.97	.12
3			1.00	-.16	.14	.30	-.19	.08	.18	.84	-.04	.41	-.01	-.00	.25	.04	.03	.99
4				1.00	.29	-.08	-.11	.21	.07	.11	.20	.11	.16	-.08	.05	.94	.05	-.19
5					1.00	.29	.19	.07	.02	.13	.13	.52	.49	.01	.08	.44	.25	.11
6						1.00	-.02	-.01	.31	-.01	.13	.66	-.30	.06	.41	.03	.19	.33
7							1.00	.19	.13	-.06	.21	.30	.46	.55	-.01	-.06	.41	-.15
xtral Factors																		
1								1.00	.26	.25	.14	.48	.47	.42	.01	.13	.81	.11
2									1.00	.17	-.06	.17	-.03	-.04	.93	.06	.29	.13
3										1.00	.11	.33	.26	.19	.14	.27	-.01	.83
4											1.00	.21	.24	.33	-.11	.24	.01	.04
5												1.00	.32	.36	.10	.23	.60	.43
6													1.00	.36	-.23	.25	.49	.01
7														1.00	-.14	.04	.41	.10
nistral Clusters																		
1															1.00	.09	.12	.19
2																1.00	.05	.01
3																	1.00	.05
4																		1.00

TABLE 24

Number of Left-Handed Children from Each of
the Q Type Factors Misclassified
by Cluster Analytic Methods

Cluster Analysis Method	No. of Clusters	Q Factors 1 (n=41)	2 (n=26)	3 (n=19)	4 (n=9)	Total Misclassification (n=95)
Group Average	4	0	0	0	0	0
Centroid Sorting	4	0	0	0	0	0

the children classified together by the Q technique of factor analysis were also classified together by cluster analysis. In other words, on the basis of subgroup membership the classification solutions generated from the two different multivariable taxonomic methods were in perfect agreement with each other.

Taken together, the visual similarity findings between cluster and factor profiles, correlation values between clusters and factors, and the results of the misclassification analyses seemed to support the notion that there were four distinct subtypes of left-handers within the data set, three of which were highly similar to three subgroups of age equivalent right-handers that had been derived by means of the Q technique of factor analysis.

Validation of Left-Handed Clusters

To determine the stability and usefulness of the sinistral clustering solutions, two methods were chosen. First, it has been suggested that similar solutions generated by different clustering techniques tends to support the presence of well-defined clusters within the data. Along this line, analyses of the membership assignments within clusters between the group average relocate and centroid sorting relocate solutions revealed that very few subjects were placed in a different cluster for the eight-cluster down to the five-cluster solutions, with identical assignment of subjects into clusters being achieved at the four-cluster solution level.

Second, a split-sample design was employed which randomly divided the total sinistral data set into two subsamples, and each half was then clustered independently. The expectation was that if the clusters were stable, then membership assignment in the partitioned samples would be similar to the results derived for the entire sample.

The hierarchical trees (dendrograms) obtained by applying the group average and centroid sorting techniques to the two sinistral subsamples are presented in Figures 25 to 28. The dendrograms can be seen to demonstrate clearly that both subsample data sets contained group structure. The clustering coefficients of the group average and centroid sorting methods applied to the two subsamples are listed in Table 25, and the corresponding plots of these values against the number of clusters are seen in Figures 29 to 32. Inspection of the dendrograms and clustering coefficients for subsample 1 suggested a range of clustering solutions. From an analysis of these results for subsample 2, a four-cluster group average solution appeared plausible, while the centroid sorting method suggested a three-cluster terminal solution. Since a range of clustering results appeared to emerge from the split-sample replication procedure, a subjective decision was made to examine the four-cluster terminal solutions within each subsample data set. The final group membership distributions for the four-cluster solutions for each subsample following iterative partitioning of the initial group average and centroid sorting results can be ascertained from Tables 26 and 27. As was found in the standard, the group average and centroid sorting relocate methods generated identical four-cluster solutions in the case of both subsample analyses. For subsample 1, cluster sizes

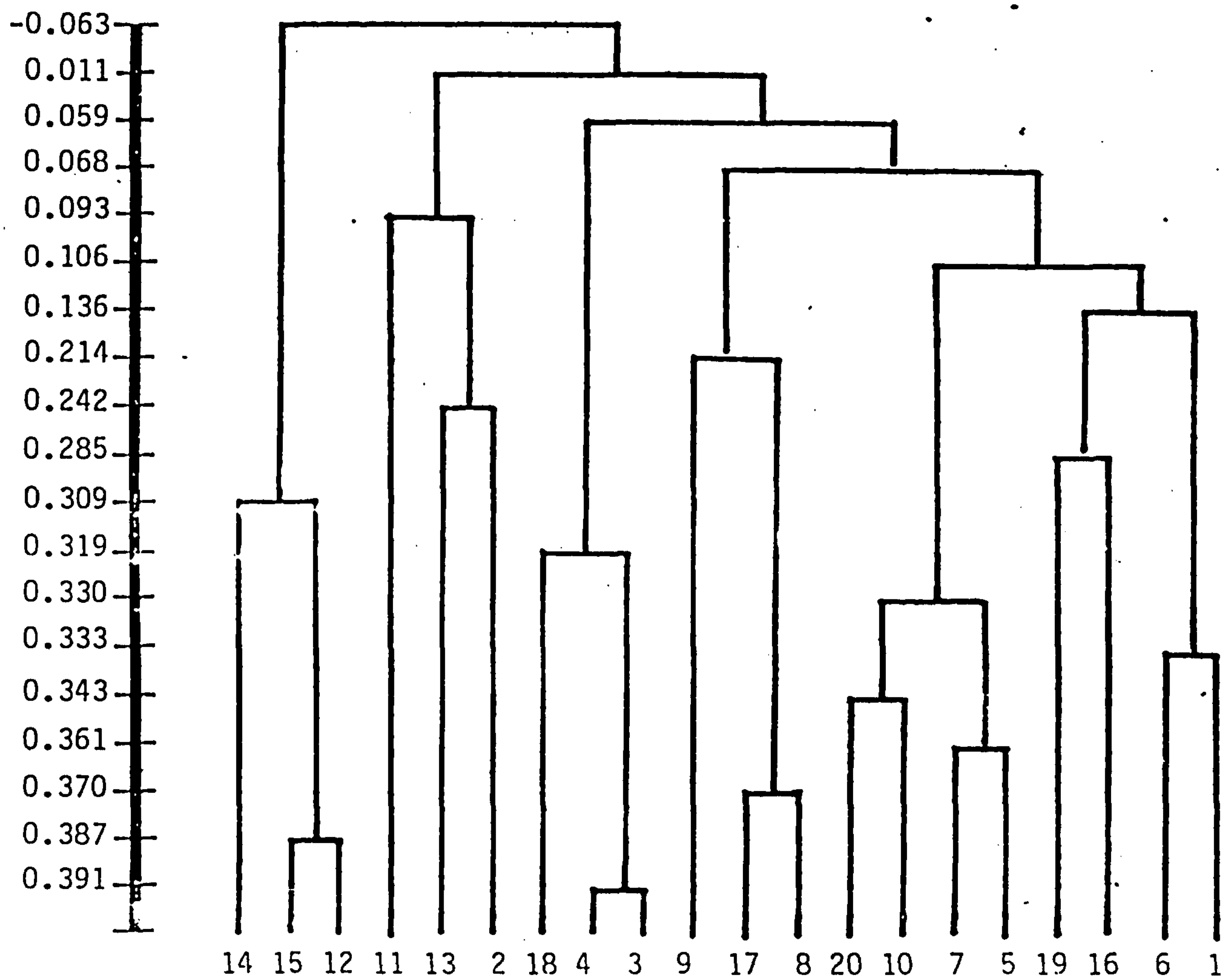

Figure 25. Split sample validation hierarchical tree using group average on sinistral subsample 1.

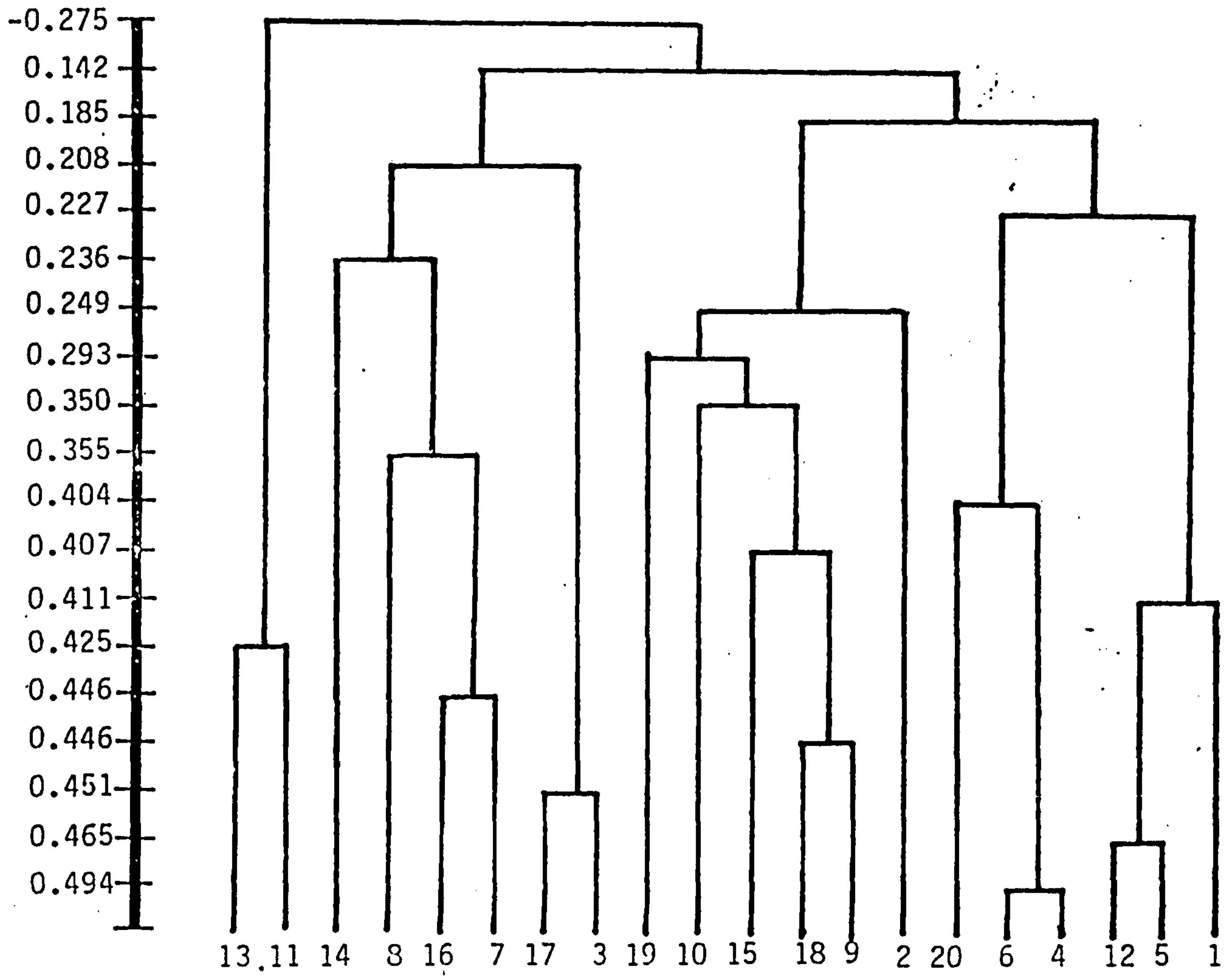

Figure 26. Split sample validation hierarchical tree using centroid sortingon sinistral subsample 1.

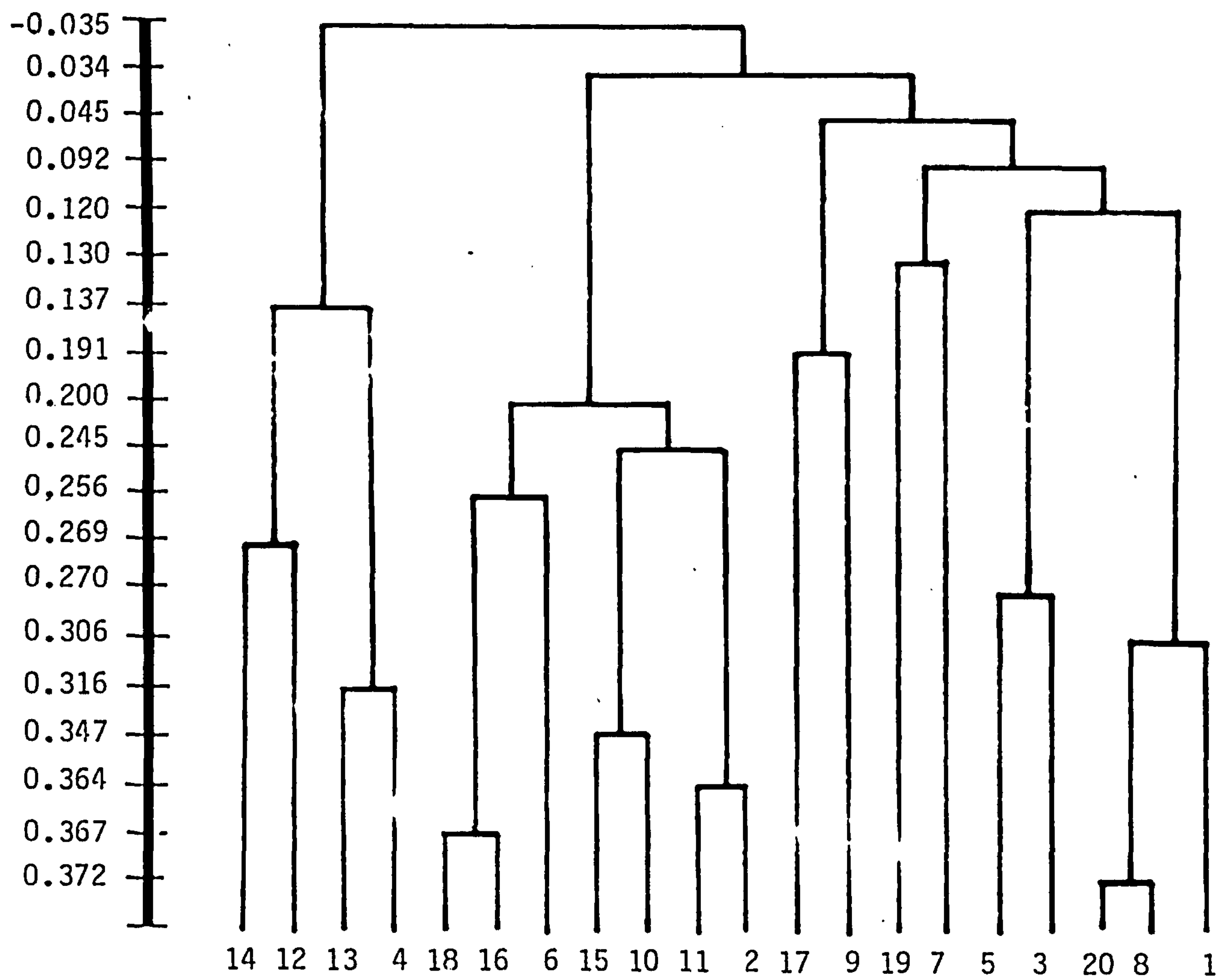

Figure 27. Split sample validation hierarchical tree using group average on sinistral subsample 2.

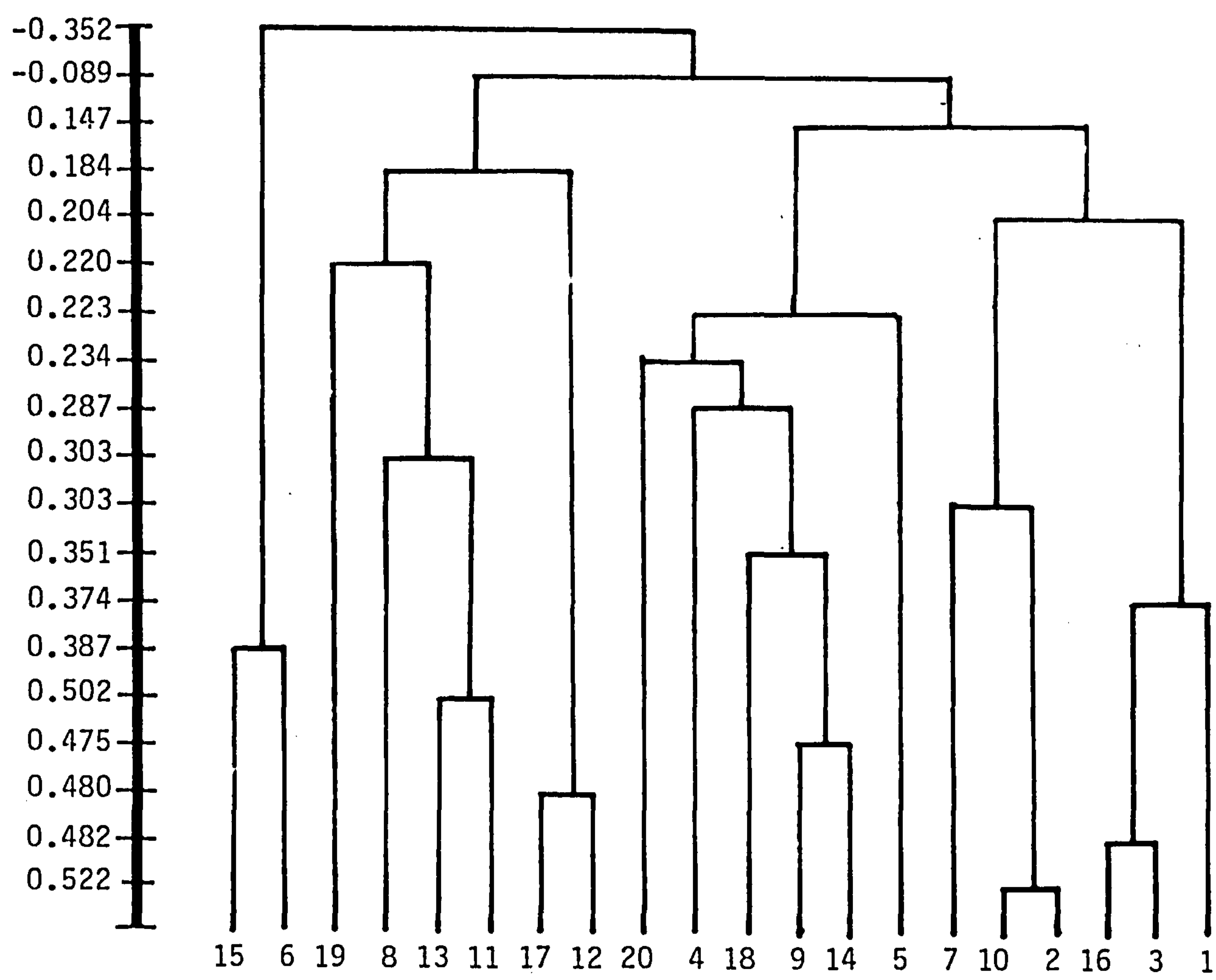

Figure 28. Split sample validation tree using centroid sorting on sinistral subsample 2.

TABLE 25

Split Design Validation Clustering Coefficients
of Group Average and Centroid Sorting Hierarchical
Agglomerative Methods Applied to Two Sinistral Subsamples

	Subsample 1		Subsample 2	
n of Clusters	Group Average	Centroid Sorting	Group Average	Centroid Sorting
10	.285	.355	.245	.303
9	.242	.350	.200	.287
8	.214	.293	.191	.234
7	.136	.249	.137	.223
6	.106	.237	.130	.220
5	.093	.227	.120	.204
4	.068	.208	.092	.184
3	.059	.185	.045	.147
2	.011	.142	.034	-.089
1	-.063	-.275	-.035	-.352

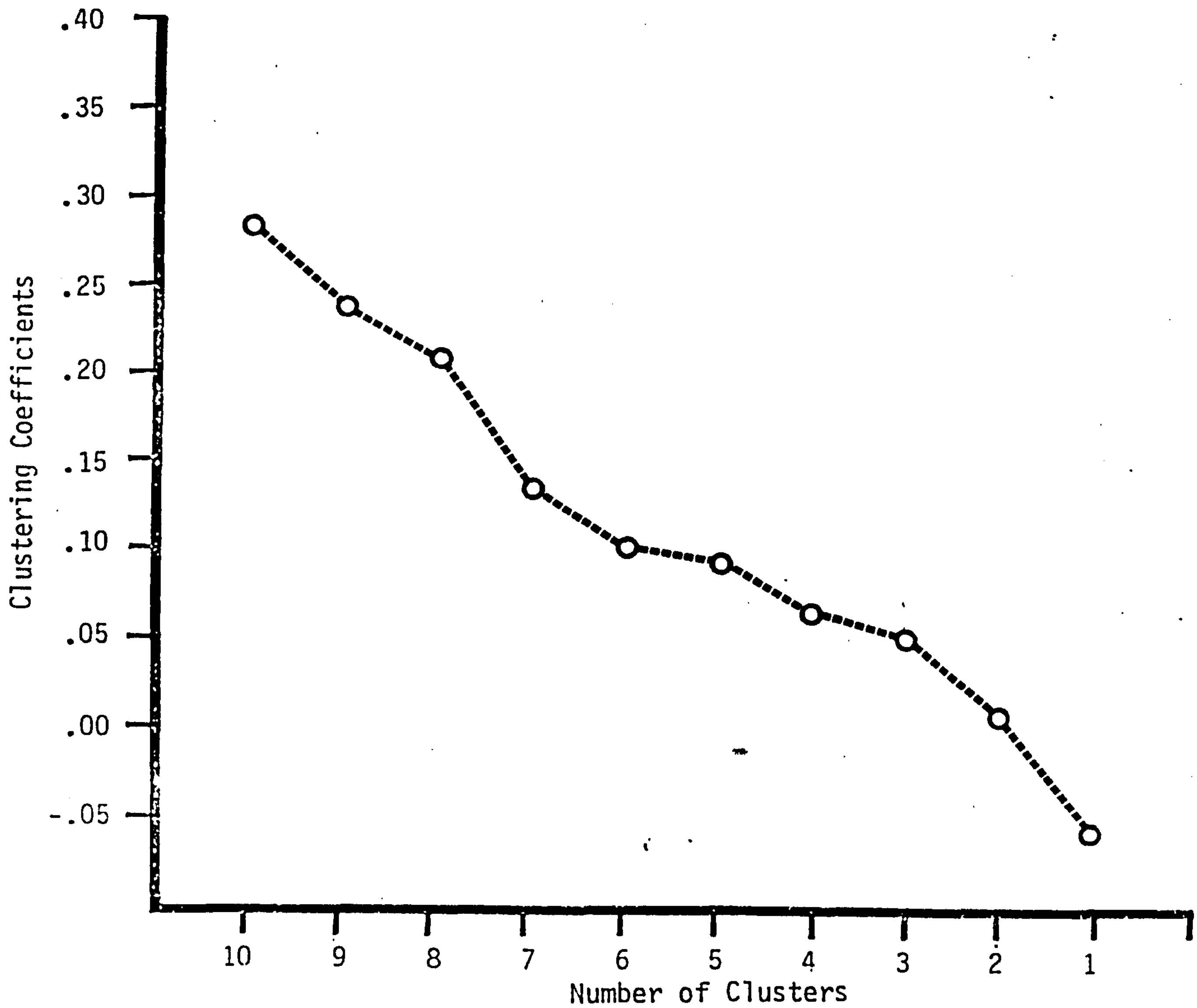

Figure 29. Plot of group average hierarchical clustering coefficients for split sample validation procedure using sinistral subsample 1.

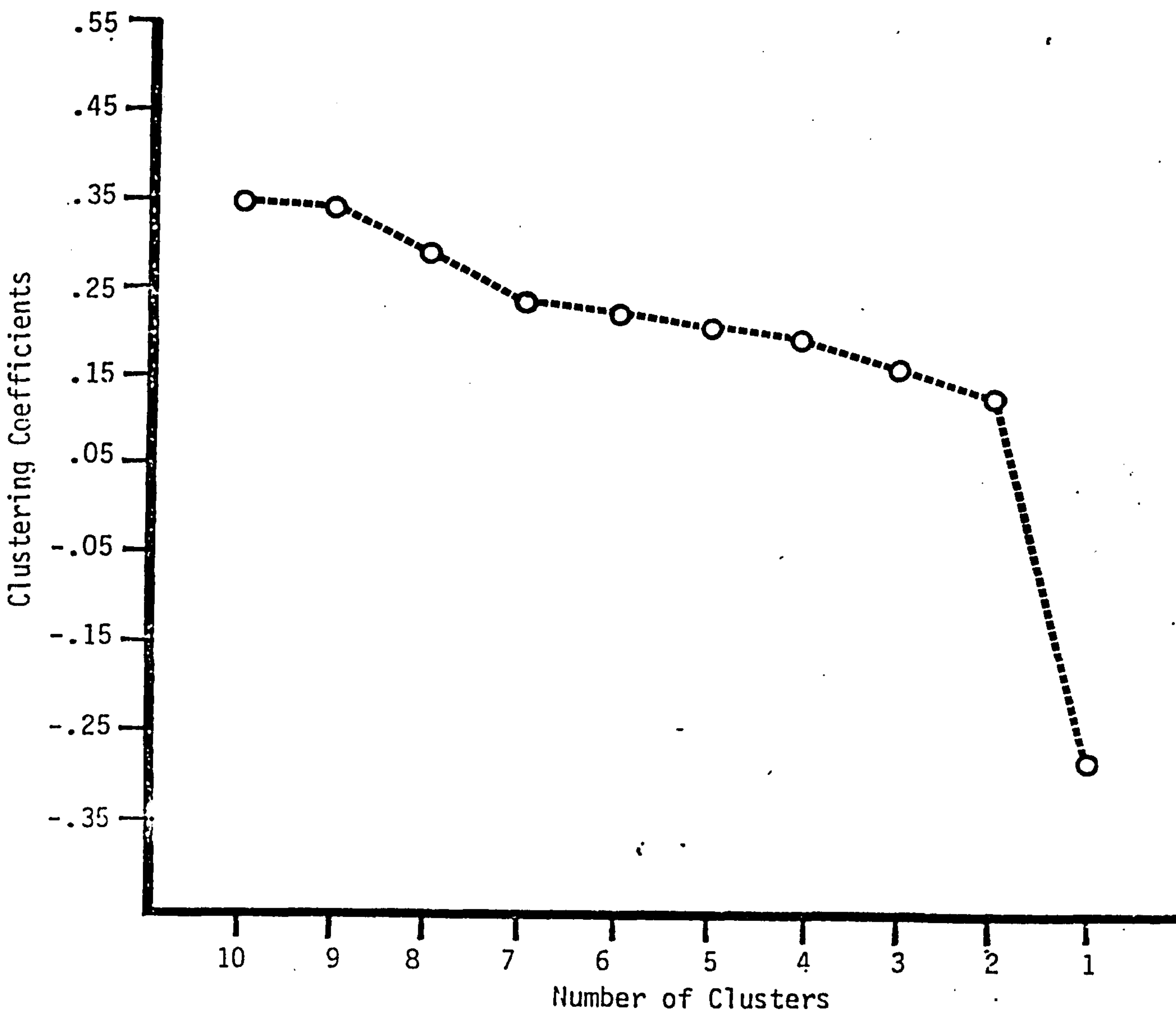

Figure 30. Plot of centroid sorting hierarchical clustering coefficients for split sample validation procedure using sinistral subsample 1.

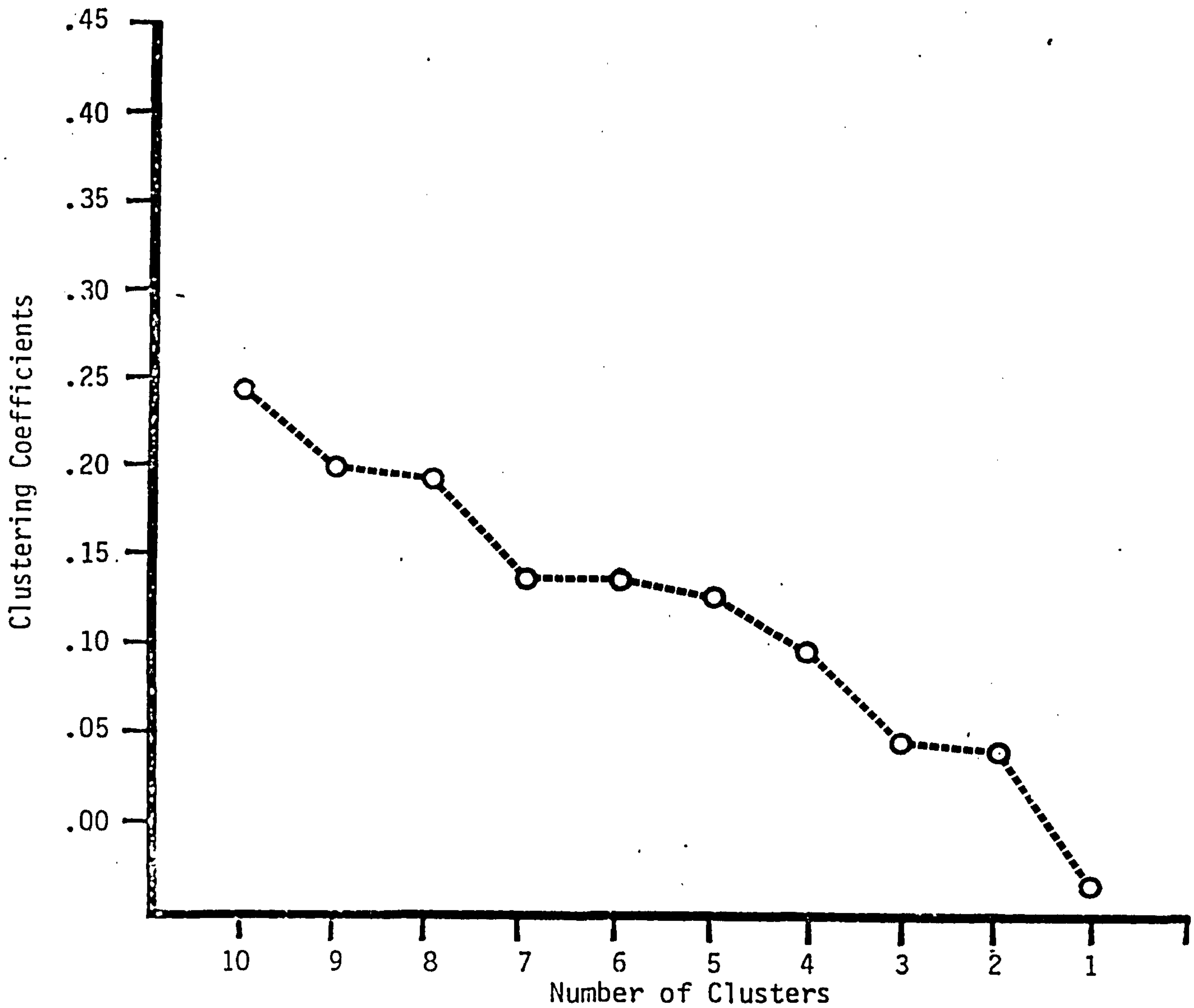

Figure 31. Plot of group average hierarchical clustering coefficients for split sample validation procedure using sinistral subsample 2.

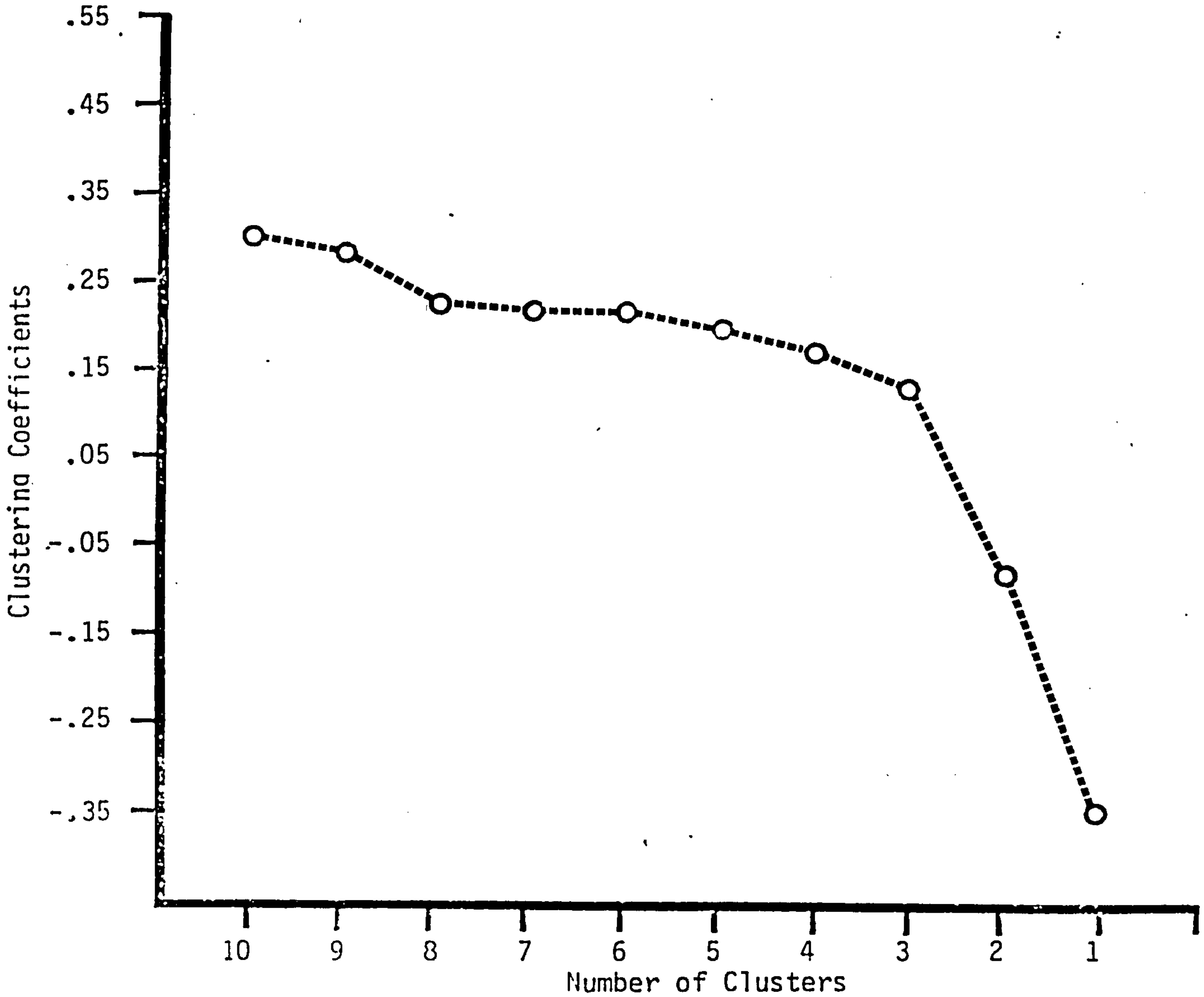

Figure 32. Plot of centroid sorting hierarchical clustering coefficients for split sample validation procedure using sinistral subsample 2.

TABLE 26

Number of Left-Handed Children in Each Cluster for 8, 7, 6, 5, 4, 3 and 2 Relocate Cluster Results for Subsample 1 of the Split Sample Validation Procedure

Cluster Analysis Method	Clusters 8	7	6	5	4	3	2
Group Average							
1	4	7	6	6	29	33	44
2	7	7	10	13	14	15	37
3	23	22	30	30	31	33	
4	22	22	23	25	7		
5	11	5	5	7			
6	5	7	7				
7	6	11					
8	3						
Centroid Sorting							
1	5	5	5	5	29	33	44
2	3	3	3	12	14	15	37
3	24	23	31	31	31	33	
4	22	23	26	26	7		
5	10	9	9	7			
6	7	7	7				
7	7	11					
8	3						

TABLE 27

Number of Left-Handed Children in Each Cluster for 8, 7, 6, 5, 4, 3 and 2 Relocate Cluster Results for Subsample 2 of the Split Sample Validation Procedure

Cluster Analysis Method	Clusters 8	7	6	5	4	3	2
Group Average							
1	24	25	26	27	27	31	55
2	3	3	3	5	8	21	25
3	4	16	16	15	23	28	
4	9	10	6	12	22		
5	14	1	21	21			
6	1	22	8				
7	22	3					
8	3						
Centroid Sorting							
1	22	20	27	27	27	31	55
2	17	10	11	15	23	28	25
3	9	5	5	5	8	21	
4	3	1	1	12	22		
5	1	21	21	21			
6	21	14	15				
7	4	9					
8	3						

were 29, 14, 31 and 7 subjects. For Subsample 2, clusters consisted of 27, 8, 23 and 22 children.

To assess the degree of comparability between the split-sample and standard results, a count was made of the number of subjects within split-samples 1 and 2 who changed from their original clusters. Table 28 indicates that for subsample 1 there were a total of 16 misclassifications, equivalent to 11% of the sample. For subsample 2, Table 29 shows that there were 17 misclassifications within this data set, equivalent to 21% of that sample. Between the two subsamples 16% of the subjects changed from their original clusters, leaving 84% of the subjects who clustered together in both procedures.

Finally, the _T_ score means and standard deviations of variables used in the split-sample cluster analyses procedures for each subsample cluster are shown in Appendix F. Plots of the mean _T_ scores for each variable for each subsample cluster are also presented in Appendix F. For the most part, gross inspection of these graphs revealed a high degree of visual similarity between profile characteristics of the standard and split-sample clusters. Because of the small number of subjects in two of the clusters (Cluster 9 subsample 1 and Cluster 2 subsample 2), the actual cluster profiles did show some differences in their characteristics.

Right-Handed Cluster Solutions

The _T_ score means and standard deviations of clustering variables for the right-handed sample are presented in Table 30.

TABLE 28

Number of Left-Handed Children in Subsample 1 from Each of the Cluster Groups Misclassified by the Split Sample Validation Procedure

Cluster Analysis Method	No. of Clusters	Clusters 1 (*n*=29)	2 (*n*=14)	3 (*n*=31)	4 (*n*=7)	Total Misclassifications (*n*=81)	% Sample
Group Average	4	9	1	6	0	16	11%
Centroid Sorting	4	9	1	6	0	16	11%

TABLE 29

Number of Left-Handed Children in Subsample 2 from Each of the Cluster Groups Misclassified by the Split Sample Validation Procedure

Cluster Analysis Method	No. of Clusters	Clusters 1 (n=27)	2 (n=8)	3 (n=23)	4 (n=22)	Total Misclassifications (n=80)	% Sample
Group Average	4	4	4	6	3	17	21%
Centroid Sorting	4	4	4	6	3	17	21%

TABLE 30

T Score Means and Standard Deviations of
Clustering Variables for the Right-Handed Sample

Variables	Mean	S.D.
INFO	43.684	6.054
COMP	47.411	8.030
SSPER	36.965	20.387
AUDCLO	45.419	13.928
ARITH	44.761	7.284
DIGITS	45.858	8.292
CODING	49.150	9.780
PICCOM	52.090	9.897
BLKDES	52.338	8.557
OBJASS	53.477	10.177
TARGET	42.494	13.055
FAGNR	42.514	27.202
FTWR	40.645	24.575
TPTDT	52.248	8.418
TPTNDT	49.874	14.156
TAPR	56.130	10.742
TAPL	42.570	9.529
PEGSRT	52.406	13.843
PEGSLT	36.295	23.841
COTTOT	50.745	7.636
TRSBT	41.307	18.553

Clearly, the frequency distribution for many of these variables deviated significantly from the normal _T_ score distribution. Again, this finding suggests the presence of multiple populations within the data set.

The hierarchical trees (dendrograms) summarizing cluster solutions obtained by applying the group average and the centroid sorting agglomerative techniques to the dextral data set are presented in Figures 33 and 34, respectively. These figures clearly showed clusters in the data. The clustering coefficients of the group average and centroid sorting methods are shown in Table 31. Figures 35 and 36 represent graphs of these data. From an analysis of the changes in cluster coefficients depicted in Table 31, and from inspections of the clustering coefficient plots, a seven-cluster solution appeared plausible.

A provision for the reallocation of subjects who may have been poorly classified during the initial cluster analysis was provided by subjecting the group average and centroid sorting solutions to a iterative relocation procedure. For the seven-cluster group average solution, 17% of the subjects were found to be placed in a different cluster. However, for the seven-cluster centroid sorting results, 38% of the children were reallocated to a different cluster. The rather large number of subjects found to be changing clusters during the latter procedure does tend to call into question both the stability and adequacy of the centroid sorting results.

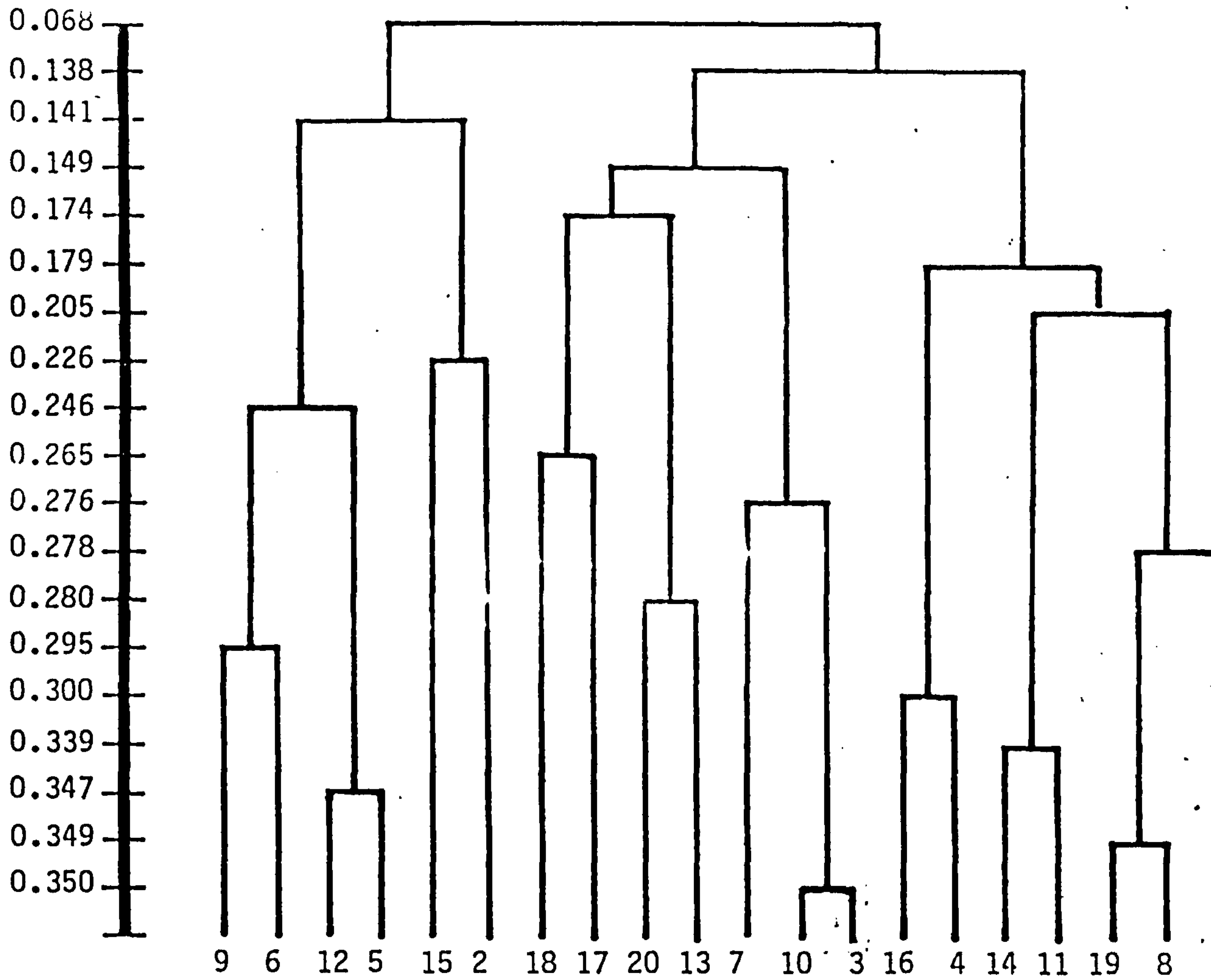

Figure 33. Hierarchical tree using group average on dextral sample.

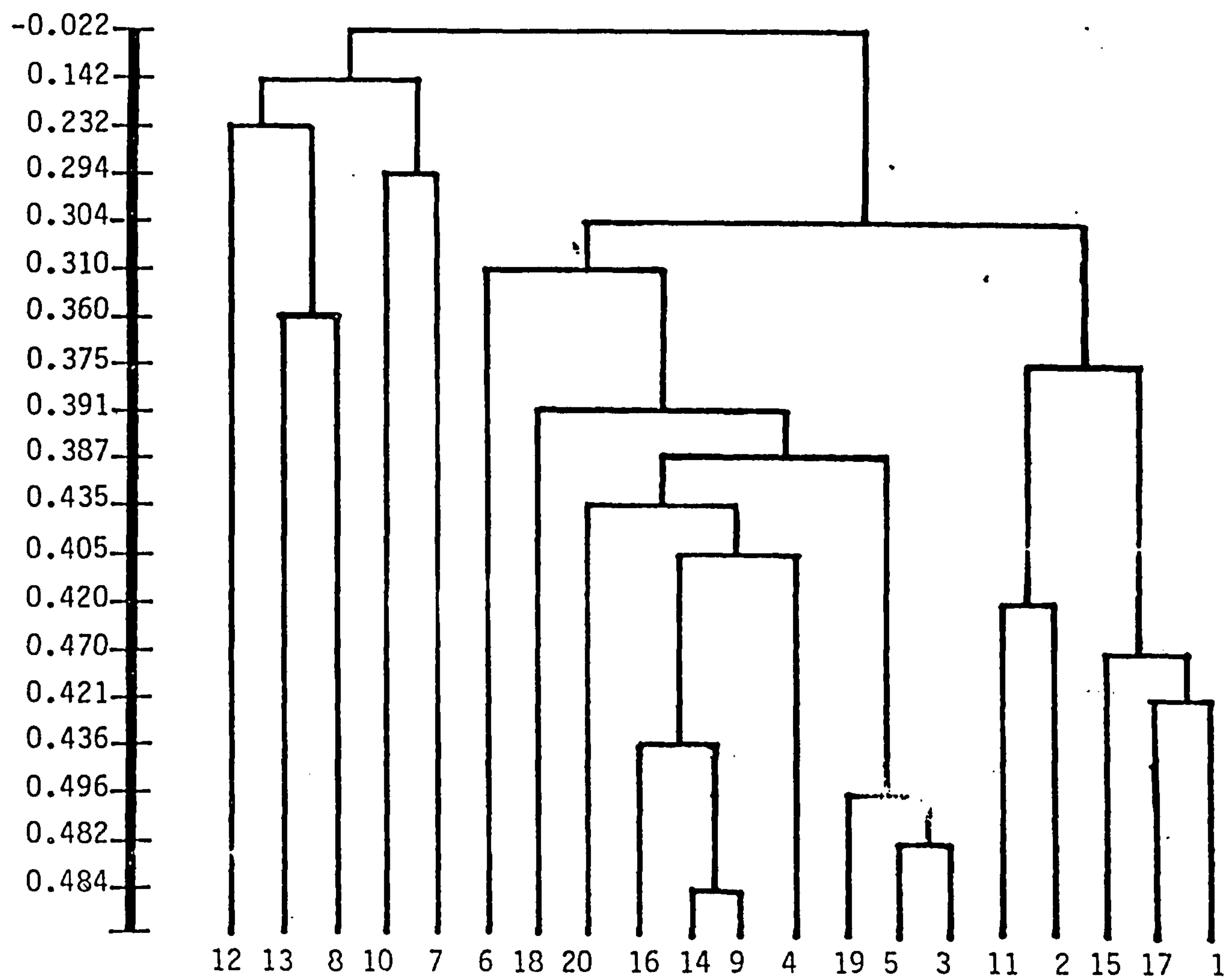

Figure 34. Hierarchical tree using centroid sorting on dextral sample.

TABLE 31

Cluster Coefficients of Group Average and Centroid Sorting Hierarchical Agglomerative Methods for the Right-Handed Sample

n of Clusters	Group Average	Centroid Sorting
10	.265	.387
9	.246	.391
8	.226	.375
7	.205	.360
6	.179	.310
5	.174	.304
4	.149	.294
3	.141	.232
2	.138	.142
1	.068	-.022

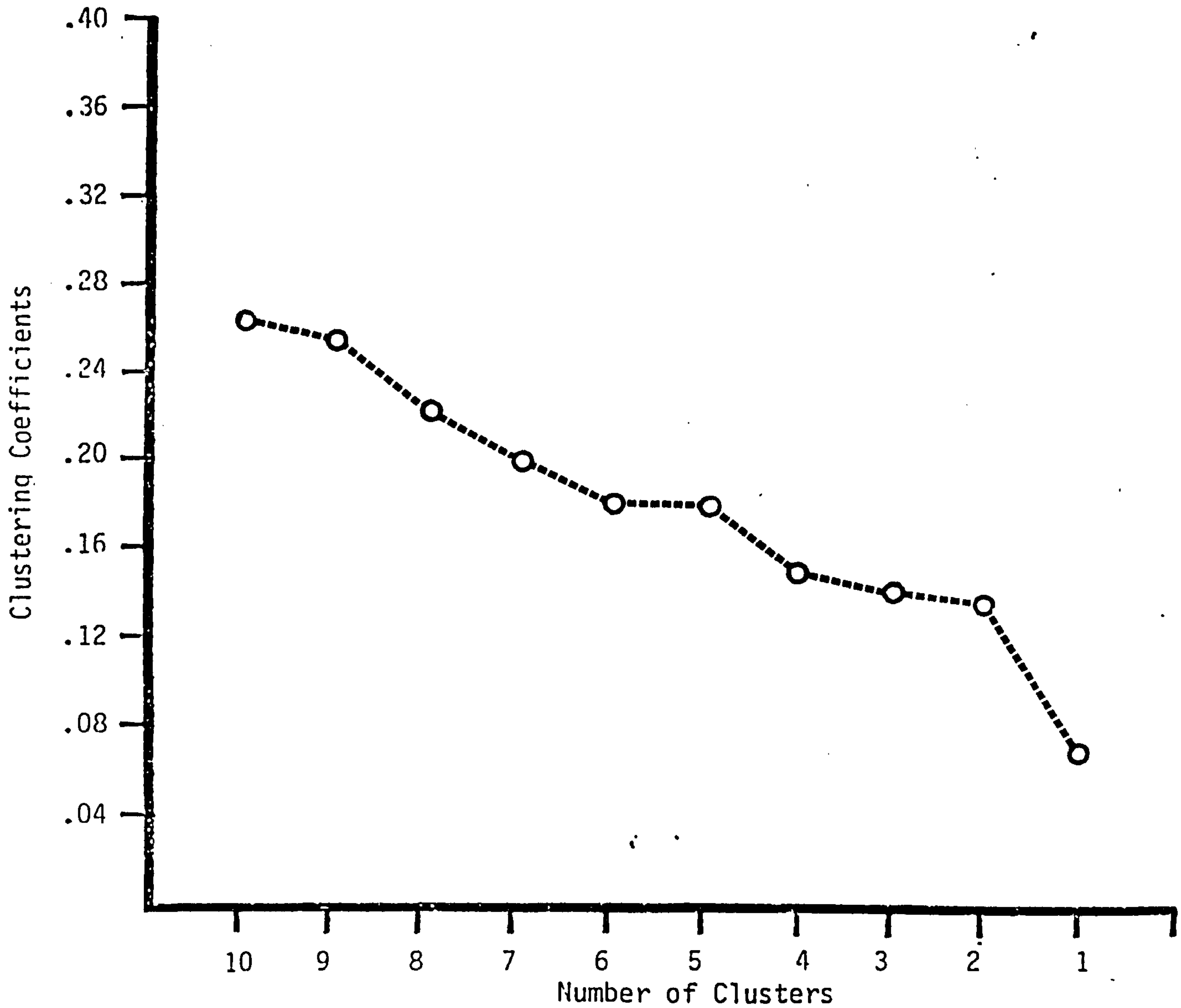

Figure 35. Plot of group average hierarchical cluster coefficients for dextral sample.

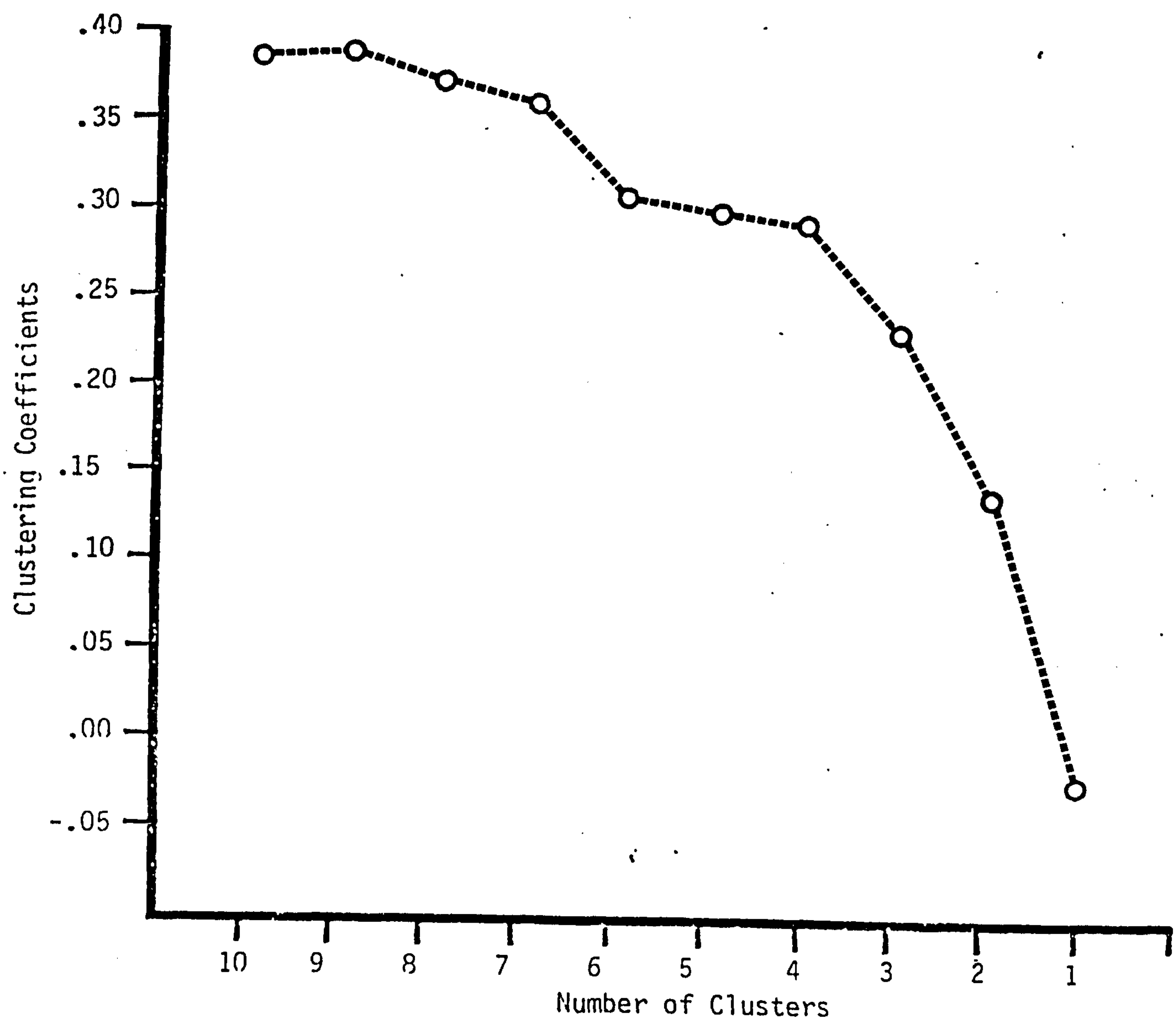

Figure 36. Plot of centroid sorting hierarchical cluster coefficients for dextral sample.

An attempt was made to improve upon the relocate solutions, as well as to increase the likelihood of obtaining 'global optimum' solutions by repeating the relocate procedure using a different starting configuration. Table 32 indicates that there was a 96% conformity rate between solutions derived from the different starting points. The seven-cluster classification arrays produced by group average, centroid sorting, group average relocate, centroid sorting relocate, group average relocate (random), and centroid sorting relocate (random) are presented in Appendix G.

Membership distributions for the seven-cluster relocate solutions can be ascertained from Table 33. The number of subjects classified into eight clusters down to two are provided in Table 33 in order to view the cluster fusions and detect *outliers* in the data set. For the right-handed sample, no children were removed from the analyses. As can be seen in Table 33, cluster sizes between the group average and centroid sorting relocate methods were very close. Cluster sizes were 24, 30, 31, 21, 12, 10 and 23 children for the group average method, and 30, 40, 22, 22, 15, 9 and 23 subjects for the centroid sorting results.

The T score means and standard deviations of variables for each dextral group average and centroid sorting cluster are shown in Tables 34 and 35, respectively. Again, mean cluster age, mean WISC VIQ, PIQ and FSIQ, and mean WRAT RPERC, SPERC, and ARPERC values are provided in these tables as well. Briefly, for the group average relocate solutions, Clusters 2, 3 and 6 exhibited fairly similar mean age values (10.64, 10.76 and 10.42, respectively).

TABLE 32

Comparison of Relocate Cluster Solutions for Dextral Sample from Different Starting Classifications (Shape Difference Classification vs Random Start)

Cluster Analysis Method	Starting Classification: Shape Difference	Starting Classification: Random	% Agreement
Group Average			
1	24	40	
2	30	29	
3	41	7	
4	21	23	
5	12	23	
6	10	20	
7	23	19	96%
Centroid Sorting			
1	30	40	
2	40	29	
3	22	7	
4	22	23	
5	15	23	
6	9	20	
7	23	19	96%

TABLE 33

Number of Right-Handed Children in Each Cluster
for 8, 7, 6, 5, 4, 3 and 2 Relocate Cluster Results

Cluster Analysis Method	Clusters						
	8	7	6	5	4	3	2
Group Average							
1	19	24	31	31	64	43	109
2	29	30	32	36	40	47	52
3	37	41	43	46	30	71	
4	18	21	21	24	27		
5	20	12	10	24			
6	9	10	24				
7	9	23					
8	20						
Centroid Sorting							
1	31	30	32	36	40	44	52
2	23	40	43	46	63	44	109
3	18	22	21	24	29	73	
4	20	22	24	31	29		
5	12	15	31	24			
6	9	9	10				
7	25	23					
8	23						

TABLE 34

T.Score Means and Standard Deviations

of Variables for Each Dextral Group Average Cluster

Cluster 1

VARIABLE	N	MEAN	STANDARD DEVIATION
* INFO	24	45.00000000	6.05928839
* COMP	24	46.52777778	7.51675530
SIMIL	24	53.19444444	8.87264518
VOCAB	24	47.77777778	5.70334817
PPVTIQ	24	48.88888889	7.47987100
AUDR	24	0.08333333	0.28232985
AUDL	24	0.00000000	0.00000000
* SSPER	24	41.15814394	15.95531410
* AUDCLO	24	49.83854167	14.14460832
SENMEM	24	36.35869565	13.20430933
VFLU	24	40.93005952	7.90462417
* ARITH	24	45.83333333	6.31308740
* DIGITS	24	47.77777778	8.32124727
* CODING	24	46.11111111	9.95966099
* PICCOM	24	48.75000000	9.67153800
PICARR	24	49.58333333	8.30066059
* BLKDES	24	53.19444444	9.99899351
* OBJASS	24	51.66666667	8.51256531
VISR	24	0.08333333	0.28232985
VISL	24	0.16666667	0.48154341
* TARGET	24	41.39262223	15.15637049
TACR	24	0.41666667	0.65386255
TACL	24	0.37500000	0.76966961
* FAGNR	24	51.41666667	13.51944386
FAGNL	24	43.63888889	20.30870846
* FTWR	24	40.61839731	17.16656225
FTWL	24	38.00033275	22.78083785
ASTR	24	44.23835438	14.69160514
ASTL	24	43.57590258	15.43223305
* TPTDT	24	52.51444157	7.52680434
* TPTNDT	24	40.67410335	29.95346150
TPTBT	24	43.34992073	25.06145703
TPTMEM	24	48.51368889	10.90272278
TPTLOC	24	43.59686147	13.83767861
* TAPR	24	53.19000495	10.32751374
* TAPL	24	39.45911195	10.29127448
FTAPR	24	31.82500000	5.52240401
FTAPL	24	29.95541667	7.31205436
GRIPR	17	44.37940042	10.28918541
GRIPL	17	39.7[illegible]1879	8.63641675
* PEGSRT	24	36.11459813	16.81822771
* PEGSLT	24	4.49225246	42.41353020
* CATTOT	24	50.91001227	7.43575818
* TRSBT	24	42.92209401	12.00070222
CAGE	24	11.57295833	1.63391566
VIQ	24	47.25000000	5.99939610
PIQ	24	49.97222222	7.61762301
FSIQ	24	48.38888889	4.61845350
RPERC	24	33.66666667	24.96722489
SPERC	24	21.70833333	24.55956232
ARPERC	24	25.04166667	14.30256641

TABLE 34 (cont'd)

Cluster 2

VARIABLE	N	MEAN	STANDARD DEVIATION
* INFO	30	45.33333333	5.71246464
* COMP	30	49.11111111	9.21969076
SIMIL	30	53.44444444	6.15778070
VOCAB	30	47.44444444	5.91661945
PPVTIQ	30	46.93333333	8.44472675
AUDR	30	0.10000000	0.30512858
AUDL	30	0.26666667	0.52083046
* SSPER	30	22.92106061	24.65239886
* AUDCLG	30	44.40250000	14.95570515
SENMEM	30	36.97971014	12.03482190
VFLU	30	36.58214286	8.10466668
* ARITH	30	45.44444444	7.19106157
* DIGITS	30	44.77777778	8.10294556
* CODING	30	49.22222222	10.56573415
* PICCOM	30	53.55555556	10.31805817
PICARR	30	51.33333333	7.56073746
* BLKDES	30	50.11111111	9.03307390
* OBJASS	30	52.22222222	12.07630825
VISR	30	0.40000000	0.89442719
VISL	30	0.86666667	2.09652148
* TARGET	30	43.90525116	10.48825935
TACR	30	0.96666667	1.54212870
TACL	30	0.86666667	1.19577301
* FAGNR	30	-5.00000000	37.79709896
FAGNL	30	16.77777776	26.71093070
* FTWR	30	40.79554823	12.93192799
FTWL	30	40.04163587	19.38901130
ASTR	30	34.37098901	14.72525174
ASTL	30	39.26314970	12.85601698
* TPTDT	30	51.86754201	11.41575735
* TPTNDT	30	49.39641853	9.76446910
TPTBT	30	47.65019240	11.76325543
TPTMEM	30	50.45555556	11.26984697
TPTLOC	30	46.79177489	12.26884953
* TAPR	30	52.82179971	10.24973774
* TAPL	30	41.63218855	8.42433015
FTAPR	30	30.53233333	4.77454940
FTAPL	30	28.07300000	3.97082874
GRIPR	28	48.30098281	14.52167589
GRIPL	28	41.38663496	14.34761443
* PEGSRT	30	50.99419127	9.64314609
* PEGSLT	30	37.01481481	13.42880240
* CATTOT	30	49.77661977	9.03724735
* TRSBT	30	40.17328777	13.79421550
CAGE	30	10.64610000	1.22080011
VIQ	30	47.17777778	5.30649377
PIQ	30	51.77777778	9.70733946
FSIQ	30	49.31111111	5.02402911
RPERC	30	15.23333333	19.16297316
SPERC	30	11.36666667	13.43049370
ARPERC	30	20.63333333	12.27973754

TABLE 34 (cont'd)

Cluster 3

VARIABLE	N	MEAN	STANDARD DEVIATION
* INFO	41	42.11382114	5.90461672
* COMP	41	48.04878049	7.88724743
SIMIL	41	51.54471545	5.37987820
VOCAB	41	48.45528455	6.54461445
PPVTIQ	41	48.63414634	9.32374653
AUDR	41	0.00000000	0.00000000
AUDL	41	0.00000000	0.00000000
* SSPER	41	27.57616408	17.05181787
* AUDCLO	41	42.44329263	10.94009637
SENME4	41	32.15694592	10.61137207
VFLU	41	38.20034843	8.37607316
* ARITH	41	41.86991870	5.27303310
* DIGITS	41	41.78861789	7.26856095
* CODING	41	48.21138211	8.75904488
* PICCOM	41	53.17073171	10.69660433
PICARR	41	48.26178862	9.55082050
* BLKDES	41	54.55284553	7.94970541
* OBJASS	41	53.49593496	9.97082405
VISR	41	0.19512195	0.67895185
VISL	41	0.36585366	1.35565662
* TARGET	41	43.45868581	11.55473773
TACR	41	0.34146341	0.88345221
TACL	41	0.29268293	0.92854463
* FAGNR	41	57.12195122	11.90839016
FAGNL	41	52.27642276	13.01791553
* FTWR	41	47.02622290	17.29482304
FTWL	41	45.93268797	16.06991052
ASTR	41	45.36939158	14.52766729
ASTL	41	40.69435904	13.45810908
* TPTDT	41	53.78322319	6.75313730
* TPTNDT	41	51.49053740	6.44683137
TPTBT	41	49.44233066	11.08431891
TPTMEM	41	42.65352659	9.01414982
TPTLOC	41	47.27494457	11.22977284
* TAPR	41	62.22414094	10.09253468
* TAPL	41	47.15546933	8.43091525
FTAPR	41	32.27804578	5.02241457
FTAPL	41	30.42780488	5.25297605
GRIPR	36	43.40021328	10.13993582
GRIPL	36	41.53882260	10.53850730
* PEGSRT	41	54.90035500	7.14052388
* PEGSLT	41	41.34281843	11.20765110
* CATTOT	41	49.97334710	7.39137441
* TRSBT	41	29.72240619	28.35854999
CAGE	41	10.76217073	1.34212004
VIQ	41	44.58536585	4.04473628
PIQ	41	52.30894309	7.59546292
FSIQ	41	49.09756098	5.13930600
RPERC	41	18.14634146	14.55804890
SPERC	41	11.04878049	11.30696958
ARPERC	41	17.29268293	11.16746144

TABLE 34 (cont'd)

Cluster 4			
VARIABLE	N	MEAN	STANDARD DEVIATION
* INFO	21	43.33333333	6.74945558
* COMP	21	45.39682540	6.62287203
SIMIL	21	51.26984127	9.51467816
VOCAB	21	46.66666667	8.31917104
PPVTIQ	21	48.98412698	8.54951343
AUDR	21	0.04761905	0.21821789
AUDL	21	0.04761905	0.21821789
* SSPER	21	37.50930735	19.28142607
* AUDCLU	20	41.87625000	13.37572053
SENMEM	20	31.41739130	11.03610990
VFLU	20	37.07857143	7.84478351
* ARITH	21	44.76190476	9.63624112
* DIGITS	21	47.30158730	9.22671529
* CODING	21	51.58730159	9.52301584
* PICCOM	21	49.52380952	6.85449684
PICARR	21	49.68253968	11.24992651
* BLKDES	21	48.09523810	5.82622906
* OBJASS	21	52.22222222	8.38870493
VISR	21	0.42857143	0.97833678
VISL	21	0.33333333	0.73029674
* TARGET	21	38.93624640	10.66095052
TACR	21	0.52380952	1.16700675
TACL	21	0.42857143	1.12122382
* FAGNR	21	41.42857143	16.00176561
FAGNL	21	33.90476190	27.98276113
* FTWR	21	-1.78859403	32.19914731
FTWL	21	-0.14238201	49.54641031
ASTR	21	35.63069946	14.34039913
ASTL	21	43.29309502	13.02632350
* TPTDT	21	48.82389918	8.48341101
* TPTNDT	21	48.92448502	11.17707911
TPTBT	21	43.26095084	16.32454755
TPTMEM	21	53.62698413	6.47921994
TPTLOC	21	53.04555762	12.36011321
* TAPR	21	52.19190938	11.59739248
* TAPL	21	38.65180375	10.57283026
FTAPR	21	33.48095238	7.55629665
FTAPL	21	32.04285714	6.35386272
GRIPR	11	45.18373206	19.32238875
GRIPL	11	35.29156456	18.62201878
* PEGSRT	20	56.30194220	10.99610439
* PEGSLT	20	41.99444444	12.65777491
* CATTOT	21	49.71492243	6.72330654
* TRSBT	21	46.04102941	8.91493592
CAGE	21	12.30452381	1.49577423
VIQ	21	45.68253968	6.95259839
PIQ	21	50.34920635	7.64378919
FSIQ	21	48.03174603	5.20032559
RPERC	20	17.40000000	13.23631369
SPERC	20	15.30000000	16.64521426
ARPERC	20	16.40000000	12.90613869

TABLE 34 (cont'd)

Cluster 5

VARIABLE	N	MEAN	STANDARD DEVIATION
* INFO	12	44.16666667	6.08557923
* COMP	12	48.33333333	9.04534034
SIMIL	12	54.16666667	5.86183301
VOCAB	12	47.50000000	7.53778361
PPVT IQ	12	50.38888889	7.13765563
AUDR	12	0.08333333	0.28867513
AUDL	12	0.08333333	0.28867513
* SSPER	12	53.68901515	7.30173787
* AUDCLU	12	48.93958333	9.09380070
SENMEM	12	43.73913043	7.18201722
VFLU	12	40.74702381	8.44921611
* ARITH	12	46.94444444	6.58403447
* DIGITS	12	48.61111111	7.31103129
* CODING	12	43.88888889	8.50826495
* PICCOM	12	54.16666667	9.22502037
PICARR	11	50.90909091	8.17732761
* BLKDES	12	50.55555556	5.28640974
* OBJASS	12	52.50000000	11.90233071
VISR	12	0.00000000	0.00000000
VISL	12	0.00000000	0.00000000
* TARGET	12	22.86085446	12.62569343
TACR	12	0.33333333	1.15470054
TACL	12	0.08333333	0.28867513
* FAGNR	12	54.83333333	5.07317672
FAGNL	12	47.61111111	13.04059964
* FTWR	12	53.77460816	11.70770438
FTWL	12	48.96994334	24.24100802
ASTR	12	50.04816850	8.94930874
ASTL	12	52.34438220	10.44490195
* TPTDT	12	49.38874201	9.11063467
* TPTNDT	12	51.41812143	5.75925703
TPTBT	12	44.53970376	13.95163337
TPTMEM	12	52.11111111	10.37268493
TPTLOC	12	52.41310967	10.59919486
* TAPR	12	55.98907180	7.40100622
* TAPL	12	43.26923401	10.81273475
FTAPR	12	34.19416667	6.52919521
FTAPL	12	32.30250000	5.08384987
GRIPR	10	49.06766917	12.63323695
GRIPL	10	41.53558107	12.88222923
* PEGSRT	12	48.22343753	8.66443920
* PEGSLT	12	38.32638889	8.07179767
* CATTOT	12	52.91862849	6.70401763
* TRSBT	12	44.69318046	10.91261742
CAGE	12	11.46916667	1.38931892
VIQ	12	48.50000000	5.52039378
PIQ	12	50.38888889	7.18279838
FSIQ	12	49.38888889	6.51002852
RPERC	12	50.08333333	31.19282649
SPERC	12	30.08333333	27.07047480
ARPERC	12	22.41666667	21.33055143

TABLE 34 (cont'd)

Cluster 6

VARIABLE	N	MEAN	STANDARD DEVIATION
* INFO	10	44.33333333	4.72712164
* COMP	10	43.66666667	5.31710494
SIMIL	10	51.33333333	3.58322567
VOCAB	10	47.66666667	5.22340412
PPVTIQ	10	47.46666667	8.40223368
AUDR	10	0.00000000	0.00000000
AUDL	10	0.00000000	0.00000000
* SSPER	10	50.37727273	7.12932001
* AUDCLU	10	65.15000000	14.03972539
SENMEM	10	39.47826087	17.37898114
VFLU	10	40.20714285	9.59254659
* ARITH	10	44.66666667	9.322745[illegible]
* DIGITS	10	50.66666667	7.33669956
* CODING	10	55.00000000	10.09216785
* PICCOM	10	48.66666667	9.45424328
PICARR	10	54.00000000	6.99205[illegible]
* BLKDES	10	54.66666667	9.96280[illegible]
* OBJASS	10	59.33333333	11.63222429
VISR	10	0.20000000	0.42163702
VISL	10	0.30000000	0.67494856
* TARGET	10	49.06359125	9.41446127
TACR	10	0.60000000	1.26491106
TACL	10	0.10000000	0.31622777
* FAGNR	10	59.40000000	10.91583966
FAGNL	10	50.26666667	8.76130663
* FTWR	10	50.02249516	7.73982913
FTWL	10	49.66226903	11.48440776
ASTR	10	33.68864469	12.89829362
ASTL	10	38.72875817	7.32998838
* TPTDT	10	53.64589743	7.37586920
* TPTNDT	10	52.87304248	6.50371569
TPTBT	10	49.87575758	12.01910865
TPTMEM	10	[illegible].60000000	12.21242031
TPTLOC	10	50.65714286	14.11216987
* TAPR	10	45.32958904	10.53807372
* TAPL	10	39.95063657	7.88607711
FTAPR	10	31.51700000	4.57973511
FTAPL	10	28.33600000	4.69300709
GRIPR	9	46.32163743	11.77166990
GRIPL	9	33.74932345	13.39610715
* PEGSRT	10	56.13162026	5.43204973
* PEGSLT	10	41.75555556	9.07563101
* CATTOT	10	49.84745655	7.16062259
* TRSBT	10	49.94106616	8.56821859
CAGE	10	10.42820000	1.19375922
VIQ	10	46.26666667	4.87067314
PIQ	10	56.06666667	8.03357153
FSIQ	10	50.86666667	4.46716415
RPERC	10	38.00000000	25.94438496
SPERC	10	28.10000000	23.43525360
ARPERC	10	25.20000000	7.72873426

TABLE 34 (cont'd)

Cluster 7

VARIABLE	N	MEAN	STANDARD DEVIATION
* INFO	23	42.75362319	6.08460335
* COMP	23	47.97101449	8.68873242
SIMIL	23	53.76811594	7.05707953
VOCAB	23	47.82608696	6.48297659
PPVTIQ	23	75.36231884	125.33985771
AUDP	23	0.13043478	0.45769659
AUDL	23	0.04347826	0.20851441
* SSPER	23	52.41897233	10.17454642
* AUDCLO	23	42.07173913	8.54120462
SENMEM	23	37.47069943	12.91600192
VFLU	23	37.71428571	7.36652252
* ARITH	23	46.81159420	7.68563272
* DIGITS	23	47.68115942	7.87752093
* CODING	23	51.88405797	9.41876951
* PICCOM	23	54.40275362	10.32838031
PICARR	23	55.79710145	10.54663798
* BLKDES	23	54.20289855	8.83161168
* OBJASS	23	56.08695652	9.13712451
VISR	23	0.00000000	0.00000000
VISL	23	0.08695652	0.28810407
* TARGET	23	50.72010343	8.57968822
TACR	23	0.21739130	0.51843486
TACL	23	0.04347826	0.20851441
* FAGNR	23	51.04347826	8.71507712
FAGNL	23	42.43478261	20.67019393
* FTWR	23	56.91642094	8.87171111
FTWL	23	48.69579071	24.85162529
ASTR	23	53.99075323	5.66778340
ASTL	23	51.36991029	10.03633021
* TPTDT	23	53.74952637	6.94348199
* TPTNDT	23	55.19782895	6.09954905
TPTBT	23	48.63242952	14.19546862
TPTMEM	23	53.62318841	10.00192120
TPTLOC	23	50.17447770	10.84210178
* TAPR	23	58.91247216	6.88760413
* TAPL	23	43.22512077	8.45350616
FTAPR	22	35.78590909	4.62533567
FTAPL	22	33.18045455	4.43225459
GRIPR	18	50.32414369	9.82232584
GRIPL	18	41.43404264	11.02435311
* PEGSRT	23	66.25496206	8.31565978
* PEGSLT	23	52.74033816	6.52810879
* CATTOT	23	53.42874061	7.75468600
* TPSBT	23	51.91547642	6.62501349
CAGE	23	12.13004348	1.05107467
VIQ	23	47.53623188	5.34254803
PIQ	23	56.28985507	6.94226140
FSIQ	23	51.82608696	4.98165277
RPERC	23	29.73913043	26.98689478
SPERC	23	20.17391304	25.93988185
ARPERC	23	18.43478261	10.28160797

*Denotes dependent measures used in statistical treatment of the data.

TABLE 35

T Score Means and Standard Deviations
of Variables for Each Dextral Centroid Sorting Cluster

Cluster 1

	VARIABLE	N	MEAN	STANDARD DEVIATION
*	INFO	30	45.33333333	5.71346464
*	COMP	30	49.11111111	9.21989076
	SIMIL	30	53.44444444	6.15778070
	VOCAB	30	47.44444444	5.91561945
	PPVTIQ	30	46.93333333	8.44472675
	AUDR	30	0.10000000	0.30512853
	AUDL	30	0.26666667	0.52083046
*	SSPER	30	22.98105061	24.65239386
*	AUDCLO	30	44.40250000	14.95870515
	SENMEM	30	36.97971014	12.03482190
	VFLU	30	36.58214286	8.10446668
*	ARITH	30	45.44444444	7.19106157
*	DIGITS	30	44.77777778	8.10294556
*	CODING	30	49.22222222	10.36573413
*	PICCOM	30	53.55555556	10.31605617
	PICARR	30	51.33333333	7.56073746
*	BLKDES	30	50.11111111	9.03307390
*	OBJASS	30	52.22222222	12.07680825
	VISR	30	0.60000000	0.89442719
	VISL	30	0.36666667	2.09652148
*	TARGET	30	43.90525816	10.48828935
	TACR	30	0.96666667	1.54212870
	TACL	30	0.86666667	1.19577601
*	FAGNR	30	-5.00000000	37.79709896
	FAGNL	30	16.77777778	26.71093070
*	FTWR	30	40.79554823	12.93192799
	FTWL	30	40.04163587	19.38901160
	ASTR	30	34.87098901	14.72525174
	ASTL	30	39.26314970	12.85601698
*	TPTDT	30	51.36754201	11.41575735
*	TPTNDT	30	49.99641853	9.76440910
	TPTBT	30	47.65019240	11.76328543
	TPTMEM	30	50.45555556	11.[illegible]6984697
	TPTLOC	30	46.79177439	12.2[illegible]34953
*	TAPR	30	52.02179971	10.[illegible]73774
*	TAPL	30	41.63218855	[illegible]430015
	FTAPR	30	30.52233333	4.774[illegible]940
	FTAPL	30	28.07600000	5.970[illegible]874
	GRIPR	28	48.30098281	14.[illegible]167589
	GRIPL	28	41.38663496	14.34761483
*	PEGSRT	30	50.99419127	9.64314609
*	PEGSLT	30	37.01481481	13.42880240
*	CATTOT	30	49.77661977	9.03724735
*	TRSBT	30	40.17328777	13.79421550
	CAGE	30	10.64610000	1.22083011
	VIQ	30	47.17777778	5.30649377
	PIQ	30	51.77777778	9.70733946
	FSIQ	30	49.31111111	5.02402911
	RPERC	30	15.23333333	19.16297316
	SPERC	30	11.36666667	13.43049370
	ARPERC	30	20.63333333	12.27973754

TABLE 35 (cont'd)

Cluster 2

VARIABLE	N	MEAN	STANDARD DEVIATION
*INFO	40	42.25000000	5.81713257
*COMP	40	48.25000000	8.63925646
SIMIL	40	52.25000000	5.86590419
VOCAB	40	48.83333333	6.42954363
PPVTIQ	40	48.38333333	9.24856191
AUDR	40	0.00000000	0.00000000
AUDL	40	0.00000000	0.00000000
*SSPER	40	28.87579545	18.61053248
*AUDCLO	40	43.65437500	10.72471069
SENMEM	40	32.77608696	11.00379791
VFLU	40	38.77232143	8.14919540
*ARITH	40	42.08333333	5.58220106
*DIGITS	40	42.33333333	7.51825888
*CODING	40	47.50000000	9.20540184
*PICCOM	40	54.16666667	10.56117709
PICARR	40	48.75000000	8.76042318
*BLKDES	40	55.25000000	7.31417466
*OBJASS	40	55.25000000	9.02315792
VISR	40	0.20000000	0.68687326
VISL	40	0.37500000	1.37164509
*TARGET	40	41.81362718	12.58424436
TACR	40	0.32500000	0.88831445
TACL	40	0.27500000	0.93335623
*FAGNR	40	56.80000000	11.87801244
FAGNL	40	52.08333333	12.96692044
*FTWR	40	47.46649461	17.00595698
FTWL	40	45.91661123	15.67828729
ASTR	40	44.98576923	14.13543374
ASTL	40	40.69584500	13.58064435
*TPTDT	40	52.80252938	8.04535261
*TPTNDT	40	51.51088164	6.67925509
TPTBT	40	49.51793141	11.32499118
TPTMEM	40	49.22916667	9.86076050
TPTLOC	40	47.25551948	11.25593437
*TAPR	40	61.60075785	10.13550782
*TAPL	40	47.32879789	8.88856812
FTAPR	40	32.46075000	4.96635572
FTAPL	40	30.64175000	5.50643674
GRIPR	35	47.51658432	9.78097407
GRIPL	35	40.46963184	10.30725568
*PEGSRT	40	55.08656340	7.43096652
*PEGSLT	40	42.18055556	10.85815696
*CATTOT	40	49.96995317	7.33635121
*TRSBT	40	27.97237811	27.95168267
CAGE	40	10.80522500	1.32671256
VIQ	40	45.05000000	4.68467222
PIQ	40	53.03333333	7.37277660
FSIQ	40	48.73333333	5.41350006
RPERC	40	13.32500000	14.60485957
SPERC	40	11.32500000	11.75909359
ARPERC	40	17.55000000	11.05916490

TABLE 35 (cont'd)

Cluster 3

VARIABLE	N	MEAN	STANDARD DEVIATION
* INFO	22	42.57575758	6.16628640
* COMP	22	48.78787879	7.93795081
SIMIL	22	53.48484848	7.08805335
VOCAB	22	47.57575758	6.52077009
PPVT IQ	22	76.39393939	128.18945290
AUDR	22	0.13636364	0.46756253
AUDL	22	0.04545455	0.21320072
* SSPER	22	52.02685950	10.23456315
* AUDCLO	22	42.09772727	8.74127085
SENMEM	22	37.05928854	13.06479967
VFLU	22	37.67694805	7.53764828
* ARITH	22	46.36363636	7.55292374
* DIGITS	22	47.12121212	7.57994112
* CODING	22	51.81818182	9.63499314
* PICCOM	22	54.54545455	10.56626910
PICARR	22	55.45454545	0.76666689
* BLKDES	22	53.93939394	8.94642275
* OBJASS	22	55.75757576	9.21132373
VISR	22	0.00000000	0.00000000
VISL	22	0.09090909	0.29424494
* TARGET	22	50.37521302	8.01685698
TACR	22	0.22727273	0.52641[illegible]
TACL	22	0.04545455	0.21320[illegible]
* FAGNR	22	51.09090909	8.91712688
FAGNL	22	41.63636364	20.79044069
* FTWR	22	56.94701342	9.07924402
FTWL	22	48.42024457	25.40046545
ASTR	22	54.00929071	5.80040854
ASTL	22	51.53318903	10.24119690
* TPTDT	22	53.32683300	6.79725388
* TPTNDT	22	54.91037849	6.07734336
TPTBT	22	48.04620305	14.24171696
TPTMEM	22	53.52272727	10.22540868
TPTLOC	22	49.85773318	10.98776598
* TAPR	22	58.84435912	7.04175460
* TAPL	22	43.27770891	8.65370780
FTAPR	21	36.04714286	4.57022991
FTAPL	21	33.33190476	4.48299857
GRIPR	17	50.03265309	10.02652907
GRIPL	17	40.72654289	10.93431537
* PEGSH[illegible]	22	67.18597557	7.21137267
* PEGSL[illegible]	22	52.83459596	6.66569370
* CATTOT	22	53.15726125	7.82450571
* TRSBT	22	51.26644728	5.93589943
CAGE	22	12.23331818	0.94888026
VIQ	22	47.33333333	3.37680694
PIQ	22	56.03030303	6.99047658
FSIQ	22	51.57575758	4.94860551
RPERC	22	29.04545455	27.41128942
SPERC	22	18.95454545	25.86683347
ARPERC	22	18.04545455	10.34857834

TABLE 35 (cont'd)

Cluster 4

VARIABLE	N	MEAN	STANDARD DEVIATION
* INFO	22	43.33333333	6.82355089
* COMP	22	45.90909091	6.66125321
SIMIL	22	51.06060606	9.33709469
VOCAB	22	46.51515152	8.81760742
PPVTIQ	22	49.06060606	8.35117858
AUDR	22	0.04545455	0.21320072
AUDL	22	0.04545455	0.21320072
* SSPER	22	37.55082645	18.98850890
* AUDCLD	21	41.38333333	12.94260594
SENMEM	21	31.91304348	11.00170992
VFLU	21	37.60714286	8.03771271
* ARITH	22	44.84848485	7.41277263
* DIGITS	22	46.51515152	9.39870940
* CODING	22	51.66666667	9.12870929
* PICCOM	22	49.39393939	7.60370027
PICARR	22	50.00000000	11.17442280
* BLKDES	22	43.33333333	6.15066564
* OBJASS	22	51.66666667	9.47008657
VISR	22	0.40909091	0.95912117
VISL	22	0.31818182	0.71623112
* TARGET	22	37.74441990	12.29820201
TACR	22	0.50000000	1.14434427
TACL	22	0.40909091	1.09801079
* FAGNR	22	42.72727273	15.82698665
FAGNL	22	35.09090909	27.86934403
* FTWR	22	0.14485818	32.45031251
FTWL	22	-2.22888531	47.70361948
ASTR	22	36.72470562	14.95800725
ASTL	22	44.16072490	13.37859118
* TPTDT	22	48.60255572	8.25942930
* TPTNDT	22	48.89875235	10.91192403
TPTBT	22	41.40675857	17.29876870
TPTMEM	22	51.99242424	6.92180002
TPTLOC	22	50.59248327	12.32522791
* TAPR	22	53.28464029	11.48606341
* TAPL	22	39.23264004	10.64492176
FTAPR	22	33.41681818	7.36464100
FTAPL	22	32.17727273	6.42902139
GRIPR	12	43.06779440	18.77767951
GRIPL	12	34.52997082	18.28052841
* PEGSRT	21	56.34122461	10.67133062
* PEGSLT	21	43.81216931	10.47021755
* CATTOT	22	48.88393909	6.61491521
* TRSBT	22	45.93583796	8.92571624
CAGE	22	12.16054545	1.61441488
VIQ	22	45.87878789	6.81932009
PIQ	22	50.33333333	7.73297755
FSIQ	22	48.12121212	5.23980033
RPERC	21	20.80952381	16.22842891
SPERC	21	15.57142857	16.01115682
ARPERC	21	16.28571429	12.74810910

TABLE 35 (cont'd)

Cluster 5

	VARIABLE	N	MEAN	STANDARD DEVIATION
*	INFO	15	44.44444444	6.86221153
*	COMP	15	44.44444444	8.51391640
	SIMIL	15	53.11111111	5.83730024
	VOCAB	15	48.22222222	6.15496530
	PPVTIQ	15	49.95555556	7.68204117
	AUDR	15	0.00000000	0.00000000
	AUDL	15	0.00000000	0.00000000
*	SSPER	15	48.10454545	11.69566501
*	AUDCLO	15	41.42500000	10.48551297
	SENMEM	15	39.53623188	11.18482763
	VFLU	15	39.11666667	8.99436439
*	ARITH	15	46.22222222	6.65077471
*	DIGITS	15	51.77777776	8.24877737
*	CODING	15	52.00000000	8.43274043
*	PICCOM	15	47.11111111	8.71658396
	PICARR	15	51.33333333	7.44282006
*	BLKDES	15	47.53333333	7.25955724
*	OBJASS	15	44.66666667	7.43223353
	VISR	15	0.06666667	0.25819889
	VISL	15	0.00000000	0.00000000
*	TARGET	15	4[illegible].94450549	10.58447732
	TACR	15	0.13333333	0.35186578
	TACL	15	0.20000000	0.56061191
*	FAGNR	15	60.13333333	8.39954547
	FAGNL	15	50.53333333	13.31951665
*	FTWR	15	58.49146224	3.57627201
	FTWL	15	56.65306726	8.29510130
	ASTR	15	51.42490842	9.60204452
	ASTL	15	52.05291005	9.51468131
*	TPTDT	15	52.61084601	7.30641183
*	TPTNDT	15	50.58751281	6.85579716
	TPTBT	15	50.47241038	7.43869903
	TPTMEM	15	49.03333333	10.17489909
	TPTLOC	15	49.77749913	12.24325748
*	TAPR	15	60.22257935	8.11518790
*	TAPL	15	43.70010101	8.06527603
	FTAPR	15	33.74000000	6.86573272
	FTAPL	15	30.72866667	5.78031742
	GRIPR	12	47.42637845	10.86140181
	GRIPL	12	43.40635828	9.97371176
*	PEGSRT	15	42.31421058	9.96710133
*	PEGSLT	15	31.08703704	12.48586444
*	CATTOT	15	53.10793319	5.92834549
*	TRSBT	15	52.33202614	7.32828156
	CAGE	15	11.26053333	1.50704270
	VIQ	15	47.60000000	5.24207641
	PIQ	15	47.91111111	7.86333376
	FSIQ	15	47.46666667	4.74893472
	RPERC	15	45.40000000	27.69166971
	SPERC	15	32.86666667	26.87230144
	ARPERC	15	24.46666667	15.52816182

TABLE 35 (cont'd)

Cluster 6

VARIABLE	N	MEAN	STANDARD DEVIATION
* INFO	9	44.44444444	5.00000000
* COMP	9	43.70370370	5.63827309
SIMIL	9	51.85185185	3.37931252
VOCAB	9	48.14814815	5.29966223
PPVTIQ	9	46.66666667	8.49835586
AUDR	9	0.00000000	0.00000000
AUDL	9	0.00000000	0.00000000
* SSPER	9	50.90808081	7.34920646
* AUDCLO	9	63.66666667	14.03566885
SENMEM	9	41.01449275	17.69837603
VFLU	9	41.50000000	9.20407103
* ARITH	9	43.70370370	9.34589102
* DIGITS	9	50.37037037	7.71902444
* CODING	9	56.29629630	9.73156492
* PICCOM	9	47.03703704	8.40708109
PICARR	9	54.81481481	6.89426314
* BLKDES	9	53.33333333	9.57427108
* OBJASS	9	58.14814815	11.67988609
VISR	9	0.22222222	0.44095855
VISL	9	0.33333333	0.70710678
* TARGET	9	47.99280071	9.31794585
TACR	9	0.66666667	1.32287566
TACL	9	0.11111111	0.33333333
* FAGNR	9	59.77777778	11.50845100
FAGNL	9	49.92592593	9.22222222
* FTWR	9	50.67098946	7.91592981
FTWL	9	50.82844707	11.53598348
ASTR	9	34.09849410	13.61146537
ASTL	9	39.69862019	7.06135307
* TPTDT	9	53.96008805	7.75198346
* TPTNDT	9	53.67560386	6.35133425
TPTBT	9	49.47306397	12.67543563
TPTMEM	9	55.11111111	9.84109863
TPTLOC	9	52.76719577	13.18934679
* TAPR	9	45.16176560	11.15109487
* TAPL	9	35.38221100	8.14424779
FTAPR	9	31.70666667	4.76611477
FTAPL	9	28.78444444	4.74499239
GRIPR	8	44.65184211	11.40315383
GRIPL	8	34.75549451	14.08573460
* PEGSRT	9	56.10000851	5.76058303
* PEGSLT	9	43.17283951	8.37049328
* CATTOT	9	45.33050727	7.60113356
* TRSBT	9	48.73660131	8.22175700
CAGE	9	10.45788989	1.26225101
VIQ	9	46.29629630	5.16517302
PIQ	9	55.48148148	8.29174809
FSIQ	9	50.59259259	4.64811126
RPERC	9	40.22222222	26.48951575
SPERC	9	29.77777778	24.21145275
ARPER	9	25.00000000	8.17006732

TABLE 35 (cont'd)

Cluster 7

	VARIABLE	N	MEAN	STANDARD DEVIATION
*	INFO	23	44.63768116	5.75063724
*	COMP	23	47.24637681	6.56376447
	SIMIL	23	52.75362319	8.68357643
	VOCAB	23	46.95652174	6.26945807
	PPVTIQ	23	49.73913043	7.36285828
	AUDR	23	0.13043478	0.34435022
	AUDL	23	0.04347826	0.20851441
*	SSPER	23	41.59604743	16.05479742
*	AUDCLO	23	54.10869565	13.84714158
	SENMEM	23	36.61625709	12.61956498
	VFLU	23	39.94720497	8.08657691
*	ARITH	23	46.37681159	6.50684334
*	DIGITS	23	45.44202899	7.10360001
*	CODING	23	42.31884058	7.43296264
*	PICCOM	23	52.02898551	9.30619052
	PICARR	22	49.39393939	9.27032456
*	BLKDES	23	55.36231884	9.08651629
*	OBJASS	23	55.50724638	9.07926351
	VISR	23	0.04347826	0.20851441
	VISL	23	0.17391304	0.49102615
*	TARGET	23	35.09313654	18.26112330
	TACR	23	0.56521739	0.99206337
	TACL	23	0.34782609	0.71405982
*	FAGNR	23	47.65217391	11.35625056
	FAGNL	23	42.34782609	20.03720738
*	FTWR	23	36.17149272	16.56592445
	FTWL	23	36.36508243	22.31500395
	ASTR	23	42.43446409	14.78304893
	ASTL	23	41.26923233	15.11200242
*	TPTDT	23	53.33793072	6.75513160
*	TPTNDT	23	41.03797331	30.65300769
	TPTBT	23	42.46814694	25.53849173
	TPTMEM	23	49.92028986	11.62284732
	TPTLOC	23	46.36796537	14.82802432
*	TAPR	23	52.68994452	9.99054237
*	TAPL	23	38.53197189	10.26600304
	FTAPR	23	31.31434783	5.09543002
	FTAPL	23	29.82173913	6.77503514
	GRIPR	17	50.05522335	11.76789969
	GRIPL	17	41.38903108	11.28220415
*	PEGSRT	23	39.28097349	17.76030709
*	PEGSLT	23	4.72363058	43.46761110
*	CATTOT	23	51.66617224	7.75025301
*	TRSBT	23	41.91261344	11.90390156
	CAGE	23	11.58239130	1.57932787
	VIQ	23	46.78260870	5.68411636
	PIQ	23	51.39130435	7.23602950
	FSIQ	23	48.92753623	5.29050657
	RPERC	23	31.00000000	27.13434590
	SPERC	23	18.60869565	22.89052827
	ARPERC	23	23.91304348	17.35174354

*Denotes dependent measures used in statistical treatment of data.

The mean ages for Clusters 1 and 5 were slightly higher (11.57 and 11.46, respectively), while Clusters 4 and 7 exhibited the highest mean age values (12.30 and 12.13, respectively). For the centroid sorting relocate solution, Clusters 1, 2 and 6 had similar low mean age values (10.64, 10.80 and 10.45, respectively), while the mean age values for Clusters 5 and 7 were slightly higher (11.26 and 11.58, respectively). Finally, Clusters 3 and 4 exhibited the highest mean age values (12.23 and 12.16, respectively). It was also clear from Tables 34 and 35 that the mean WISC FSIQs were fairly uniform across the seven group average relocate and centroid sorting relocate clusters. When the discepancy between mean WISC VIQs and PIQs were examined, all of the clusters, save one (centroid sorting Cluster 5), exhibited a similar lower VIQ-higher PIQ pattern. For Cluster 5 of the centroid sorting solution, VIQ equalled PIQ. Differences between VIQ and PIQ scores within each cluster of the group average relocate solution were as follows: Cluster 1 and 5 exhibited very minimal discrepancies; Clusters 2 and 4 were found to show moderate differences; and Clusters 3, 6 and 7 exhibited the largest VIQ-PIQ discrepancies. For the centroid sorting relocate solution, Table 35 indicates that Clusters 1, 4 and 7 exhibited similar moderate VIQ-PIQ score differences, while Clusters 2, 3 and 6 each demonstrated fairly large VIQ-PIQ discrepancies. Of course, as already mentioned, there was virtually no difference between the two values within Cluster 5.

Finally, an examination of the WRAT subtest scores listed on Tables 34 and 35 revealed that the mean RPERC, SPERC, and ARPERC performances were all below the 30th centile for Clusters 2, 3, 4 and 7, and Clusters 1, 2, 3 and 4 of the group average and centroid sorting relocate solutions, respectively. RPERC was the sole score above the 30th centile within Clusters 1 and 6 of the group average relocate solution, and within Clusters 6 and 7 for the centroid sorting relocate results. Finally, RPERC and SPERC exceeded the 30th centile while, ARPERC was below this value within Cluster 5 of both the group average and centroid sorting relocate solutions.

Plots of the _T_ score means of the variables used in the cluster analysis procedure for each centroid sorting and group average cluster are shown in Figures 37 to 50. To begin with, inspection of these figures indicated that there was a high degree of visual similarity between group average relocate and centroid sorting relocate cluster profiles. Table 36 contained the Pearson product moment correlations based on comparisons between mean _T_ scores for all variables between all possible pairs of left- and right-handed Q factors, and left- and right-handed cluster groups. Examination of Table 36 revealed that the correlation values between group average relocate Clusters 1, 2, 3, 4, 6 and 7, and centroid sorting relocate Clusters 7, 1, 2, 4, 6 and 3 were 0.97, 1.00, 0.99, 0.99, 0.99 and 0.99, respectively. These values provide evidence of the stability and validity of the cluster classifications,

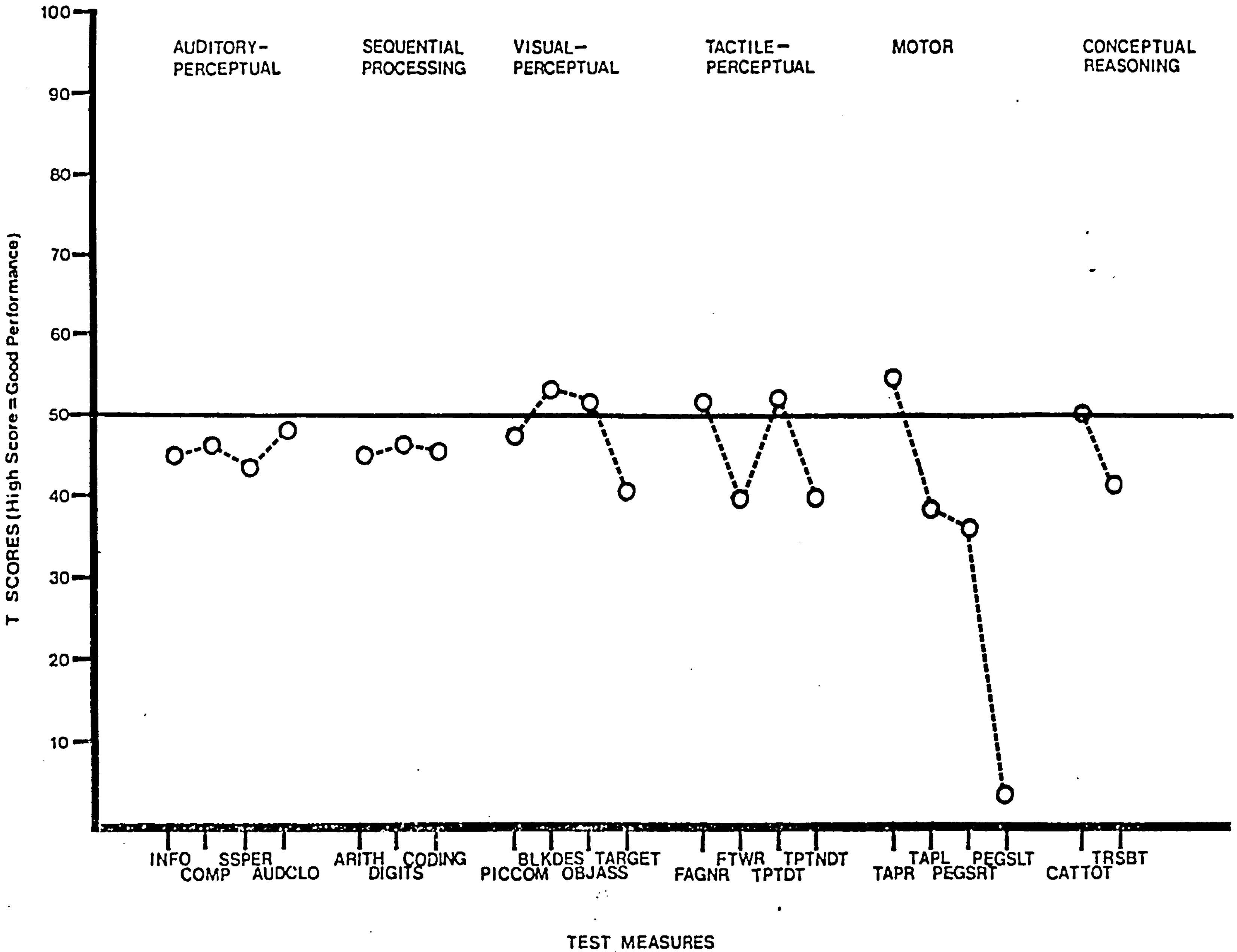

Figure 37. Plot of T score means for Cluster 1 of group average solution for dextral sample.

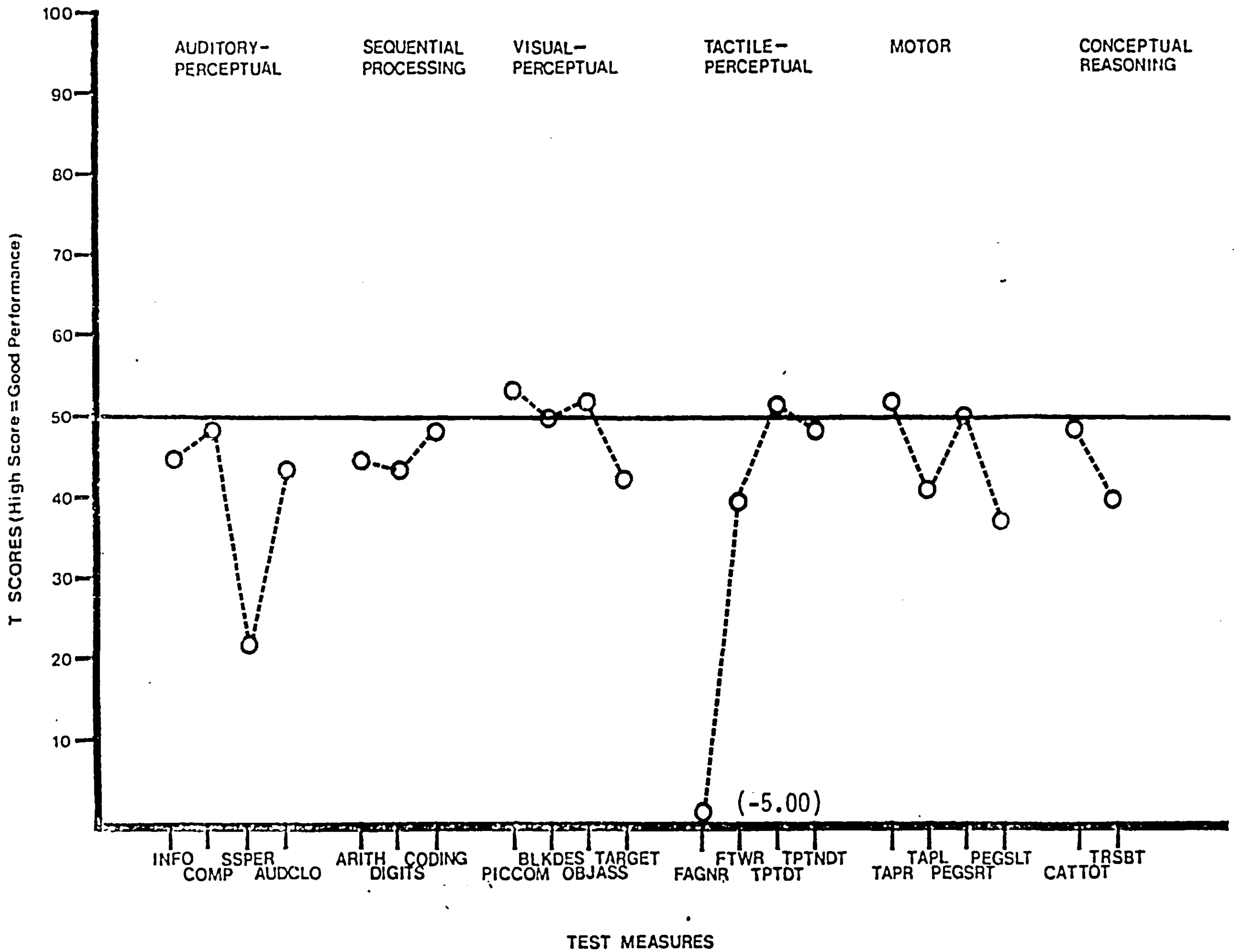

Figure 38. Plot of T score means for Cluster 2 of group average solution for dextral sample.

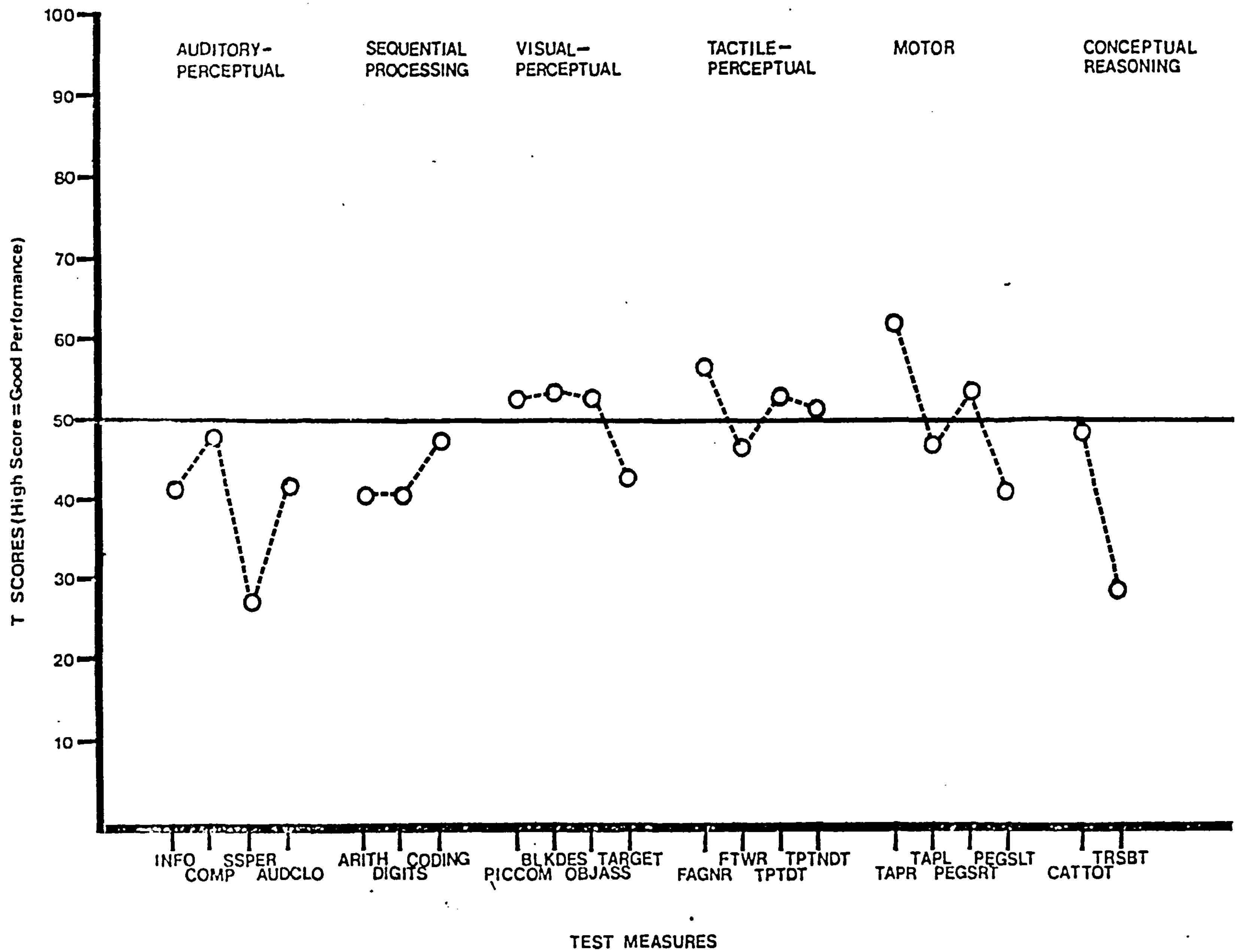

Figure 39. Plot of T score means for Cluster 3 of group average solution for dextral sample.

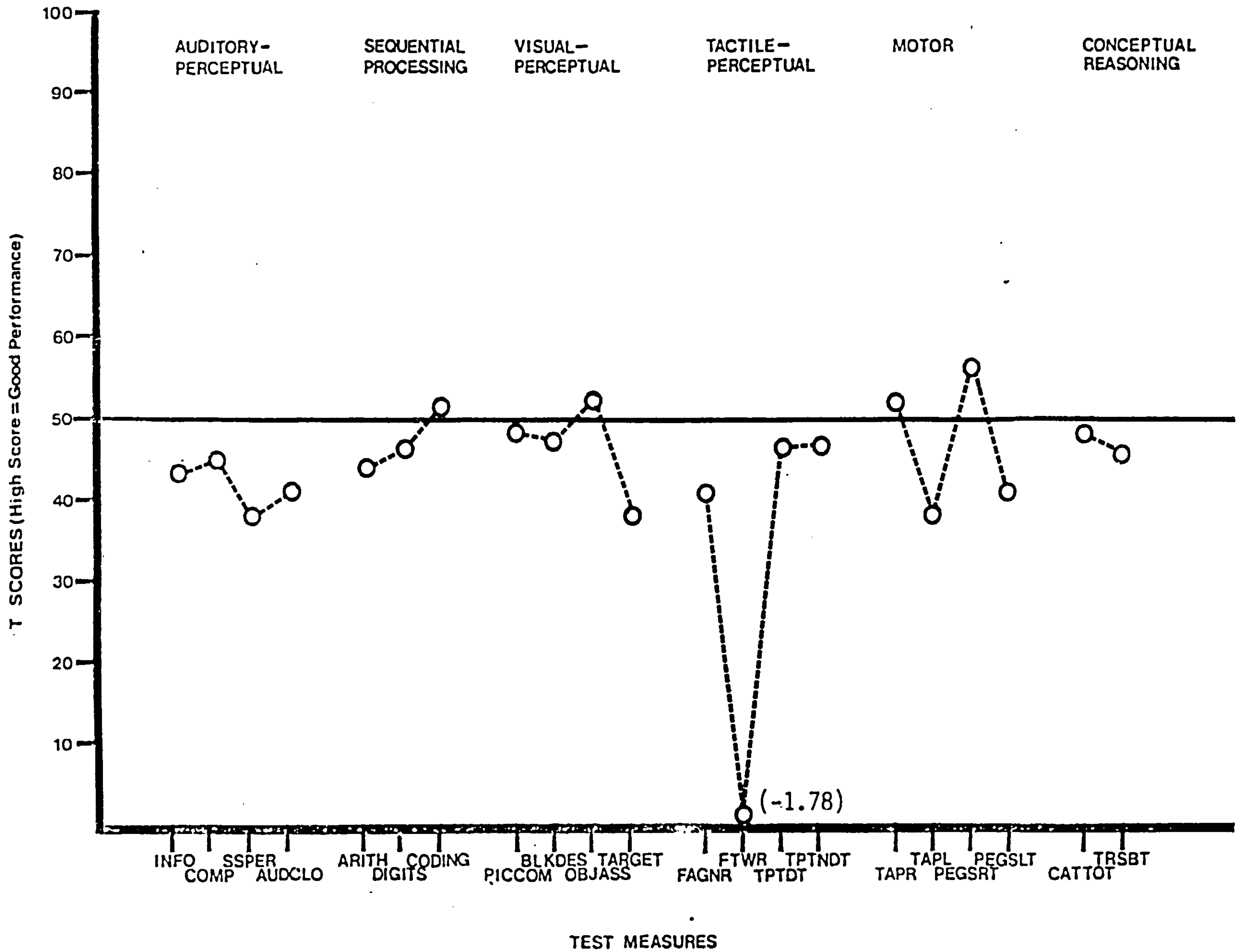

Figure 40. Plot of T score means for Cluster 4 of group average solution for dextral sample.

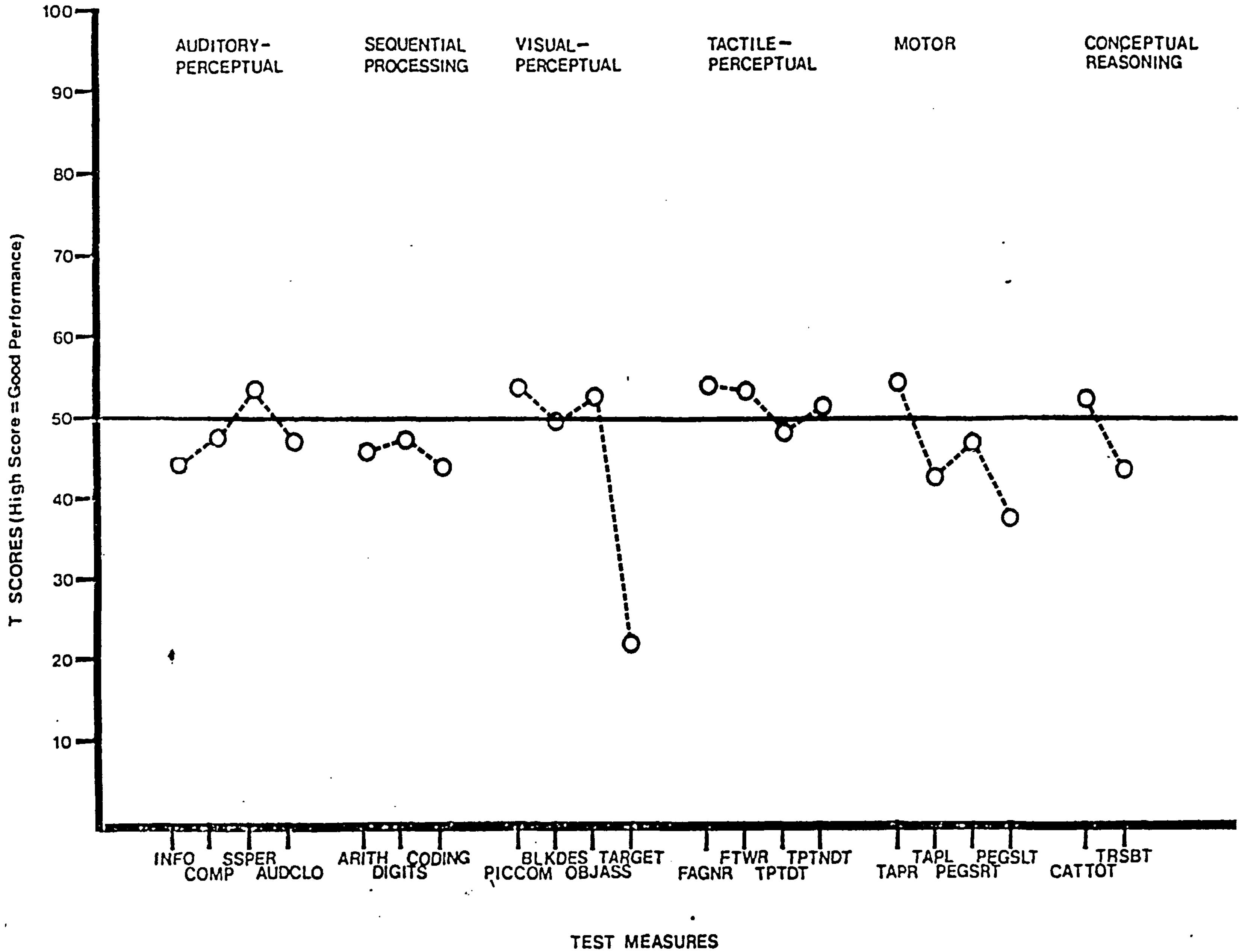

Figure 41. Plot of T score means for Cluster 5 of group average solution for dextral sample.

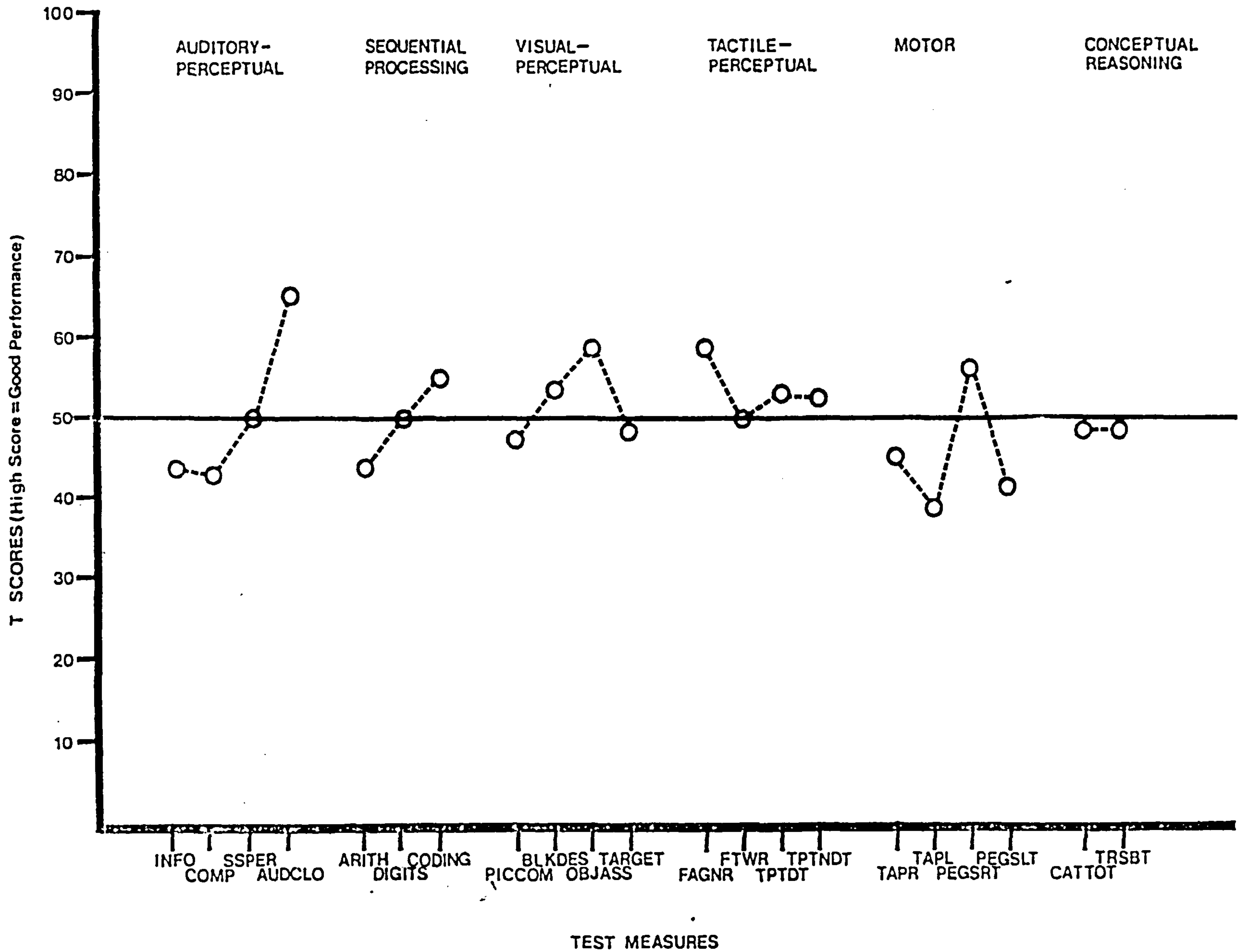

Figure 42. Plot of T score means for Cluster 6 of group average solution for dextral sample.

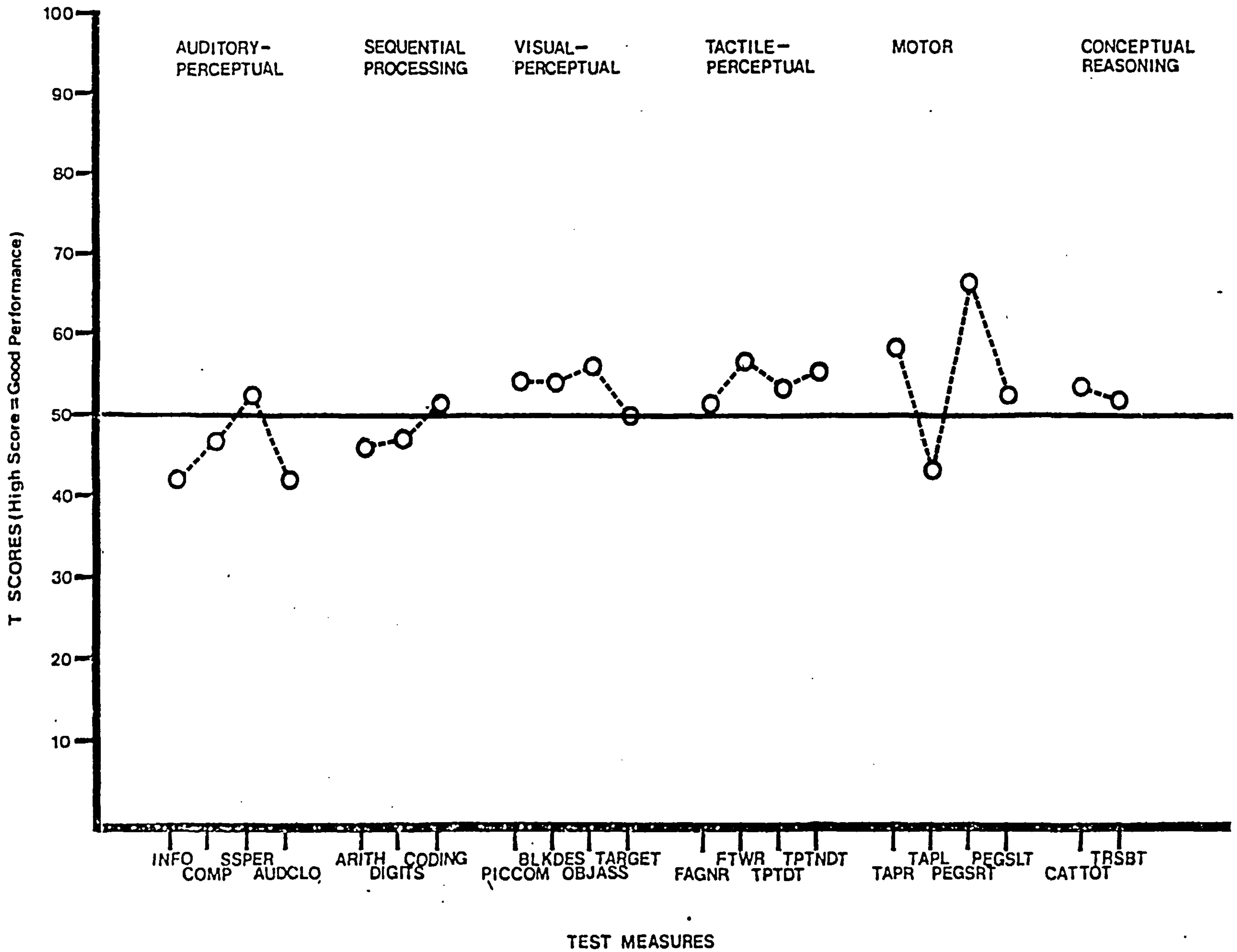

Figure 43. Plot of T score means for Cluster 7 of group average solution for dextral sample.

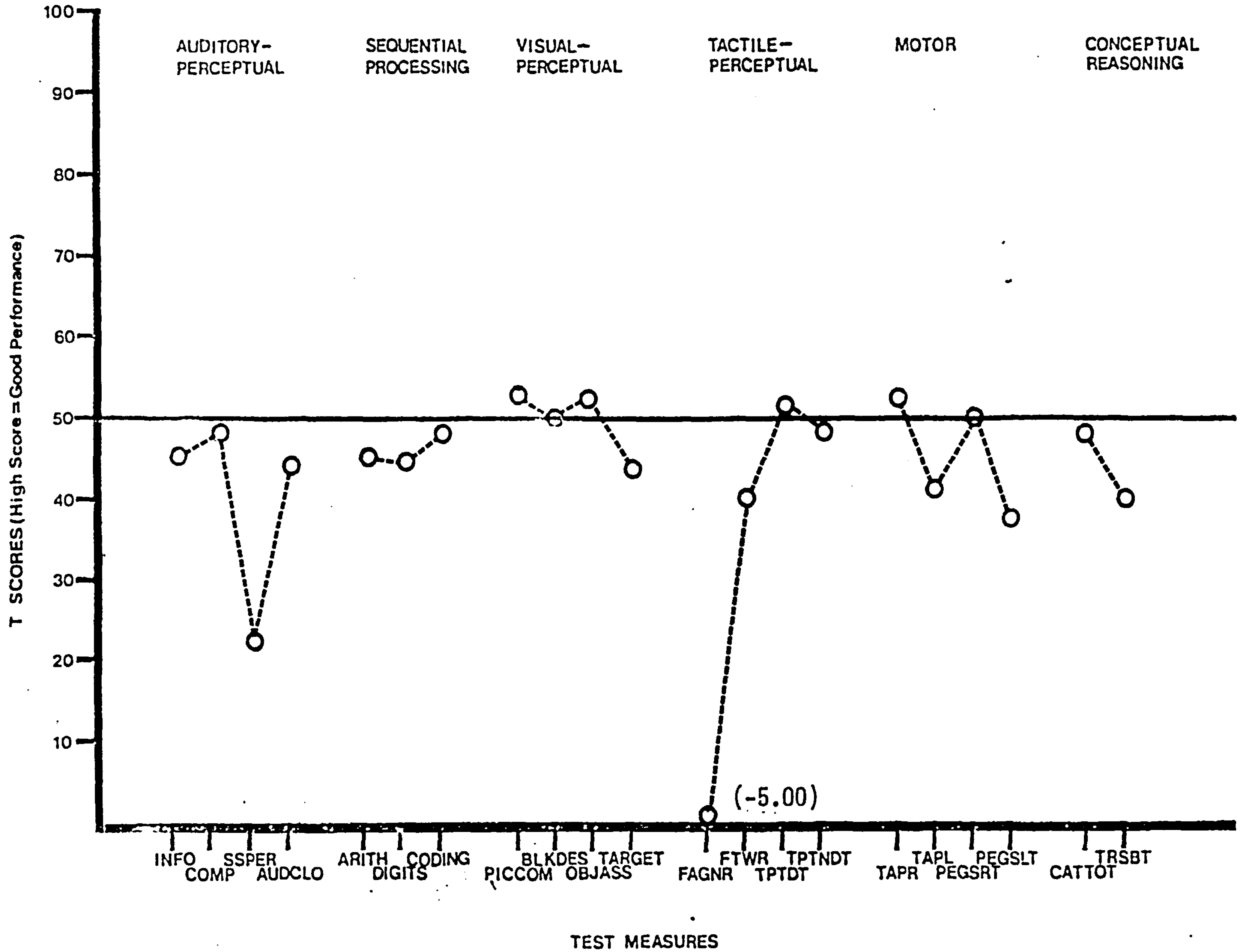

Figure 44. Plot of T score means for Cluster 1 of centroid sorting solution for dextral sample.

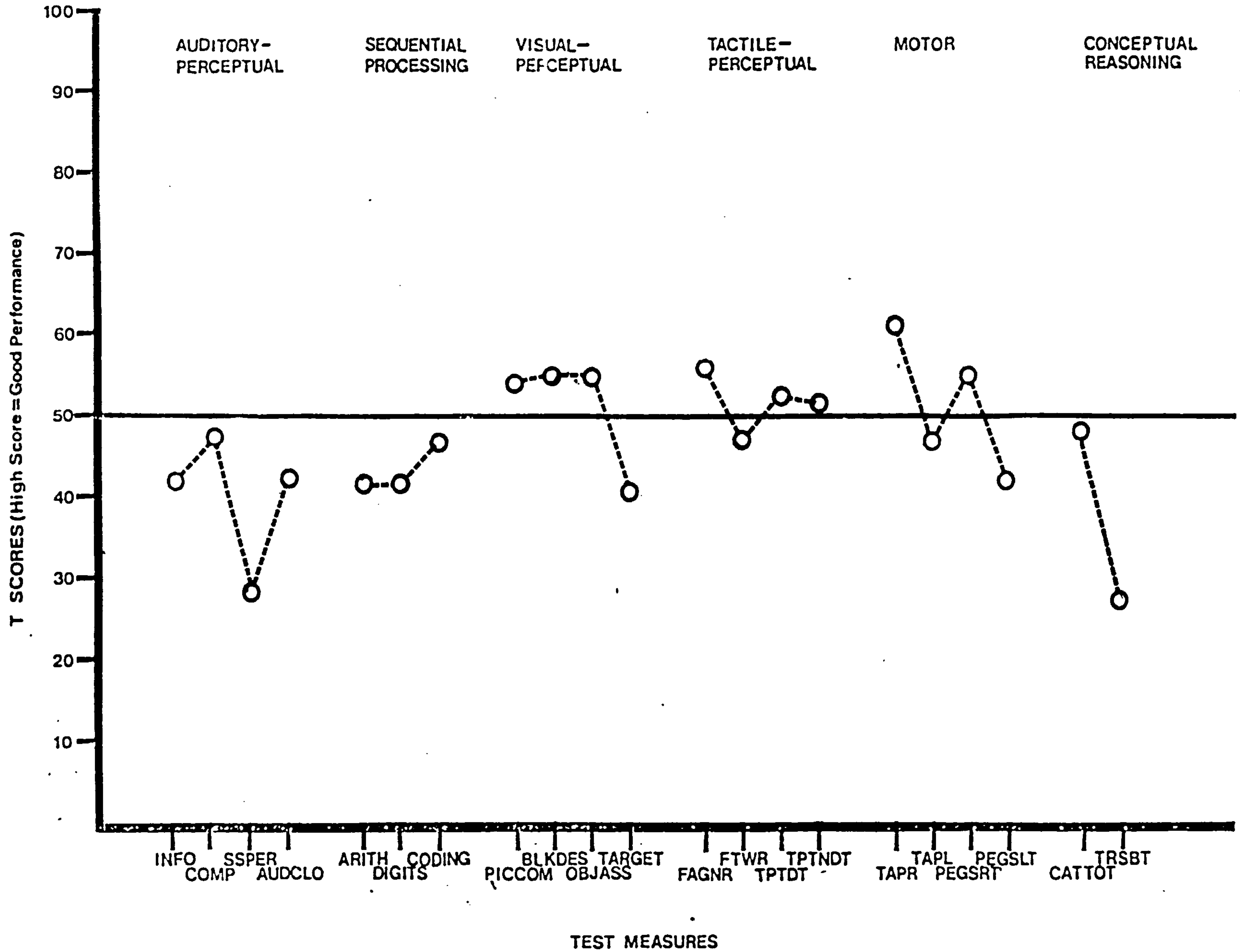

Figure 45. Plot T score means for Cluster 2 of centroid sorting solution for dextral sample.

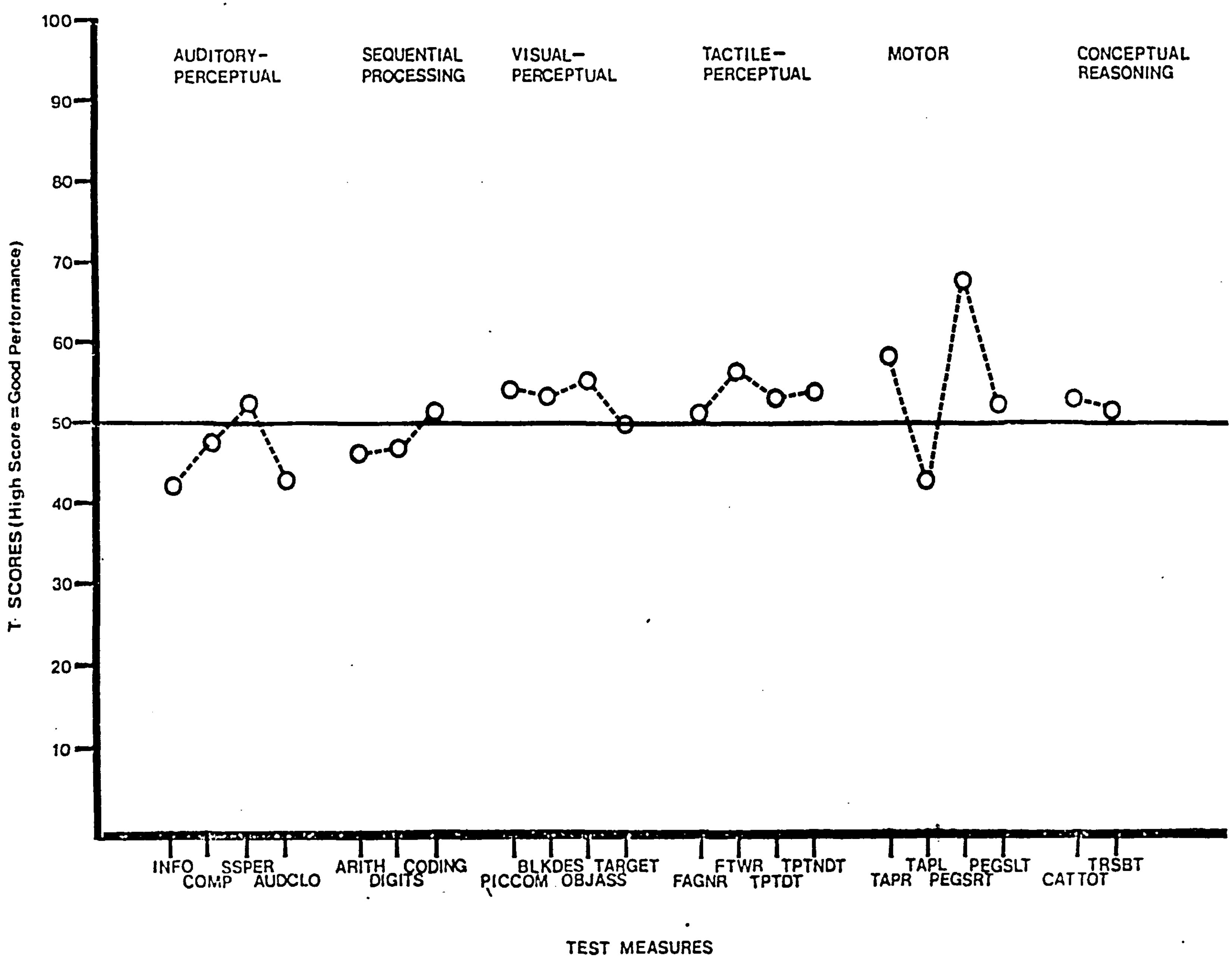

Figure 46. Plot of T score means for Cluster 3 of centroid sorting solution for dextral sample.

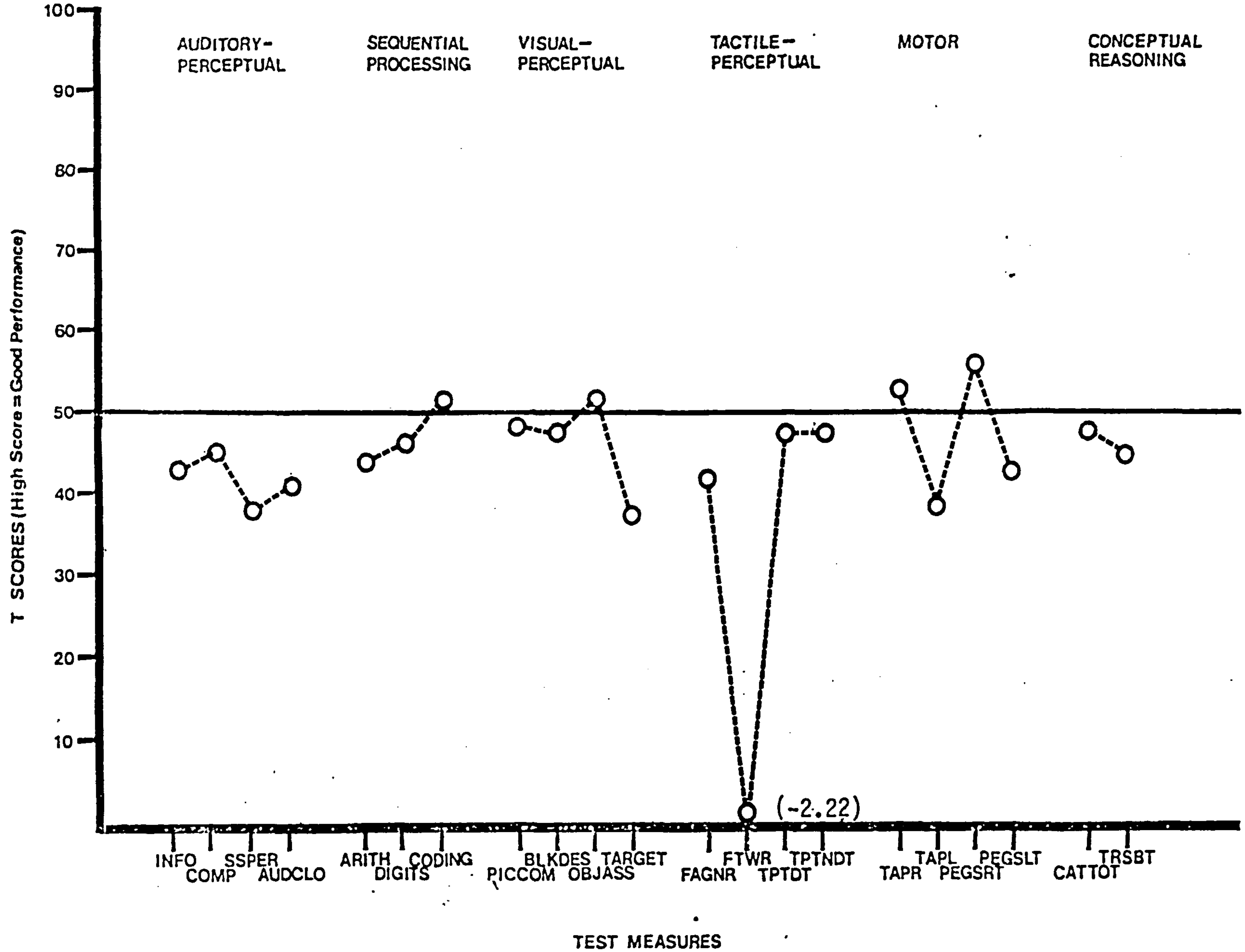

Figure 47. Plot of T score means for Cluster 4 of centroid sorting solution for dextral sample.

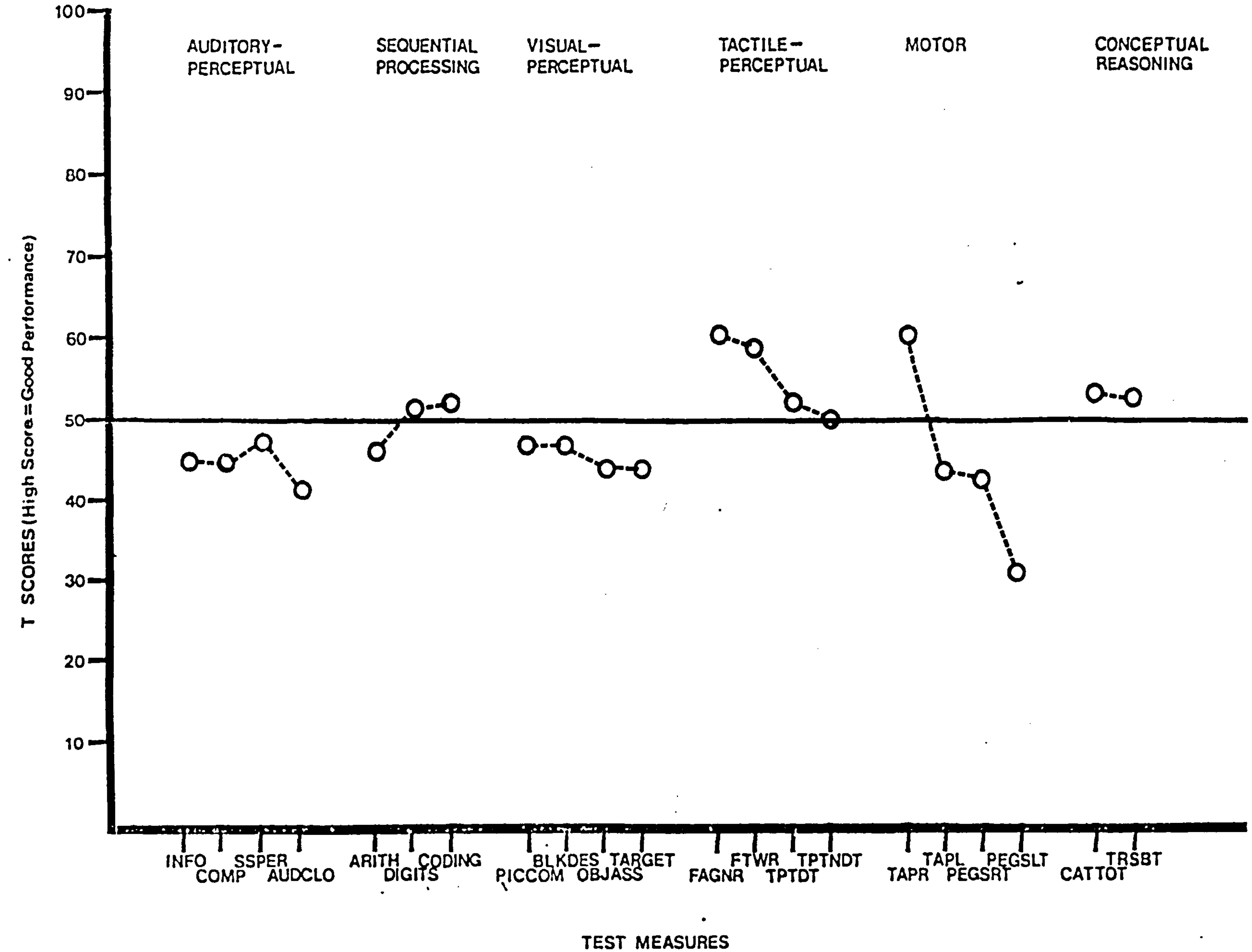

Figure 48. Plot of T score means for Cluster 5 of centroid sorting solution for dextral sample.

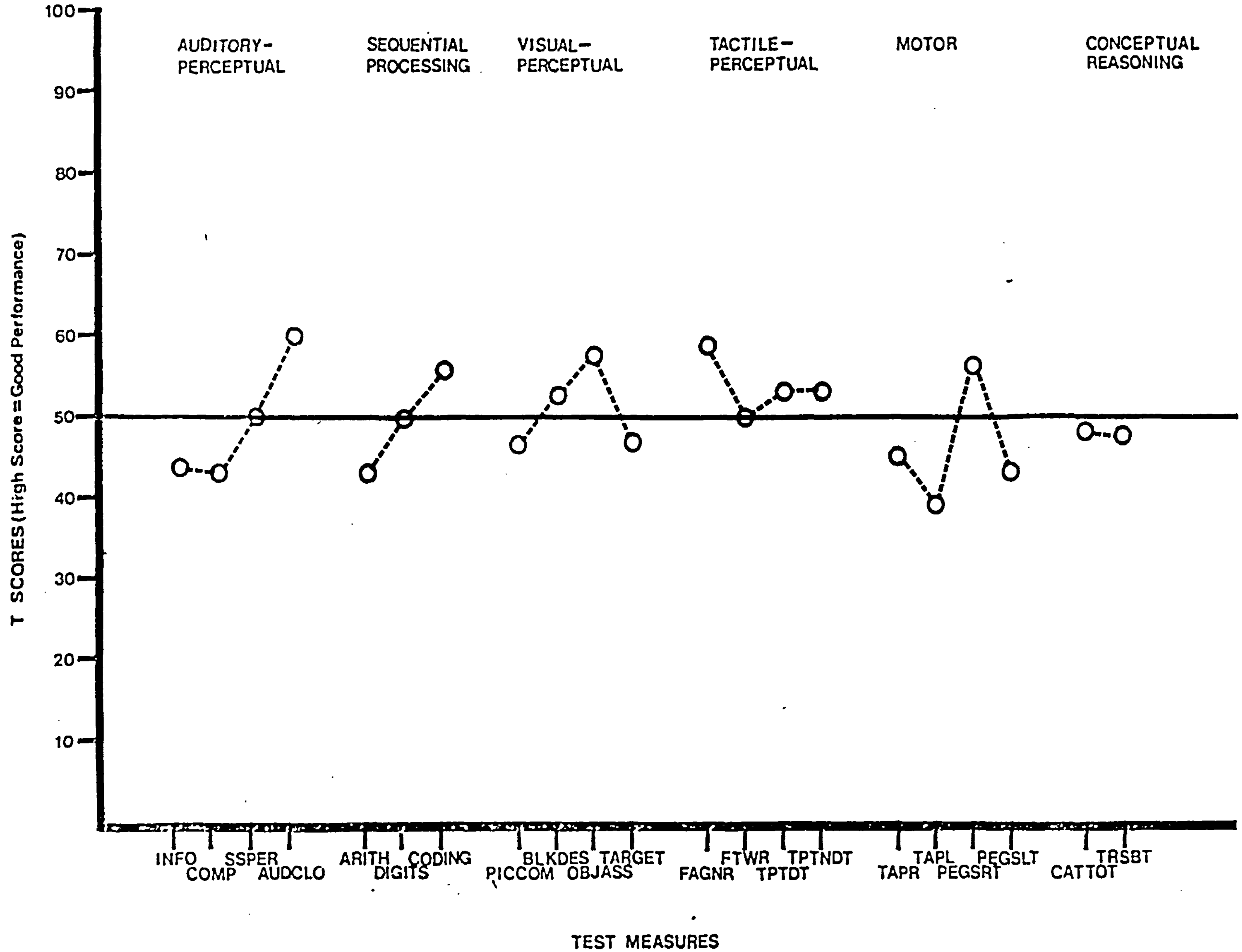

Figure 49. Plot of T score means for Cluster 6 of centroid sorting solution for dextral sample.

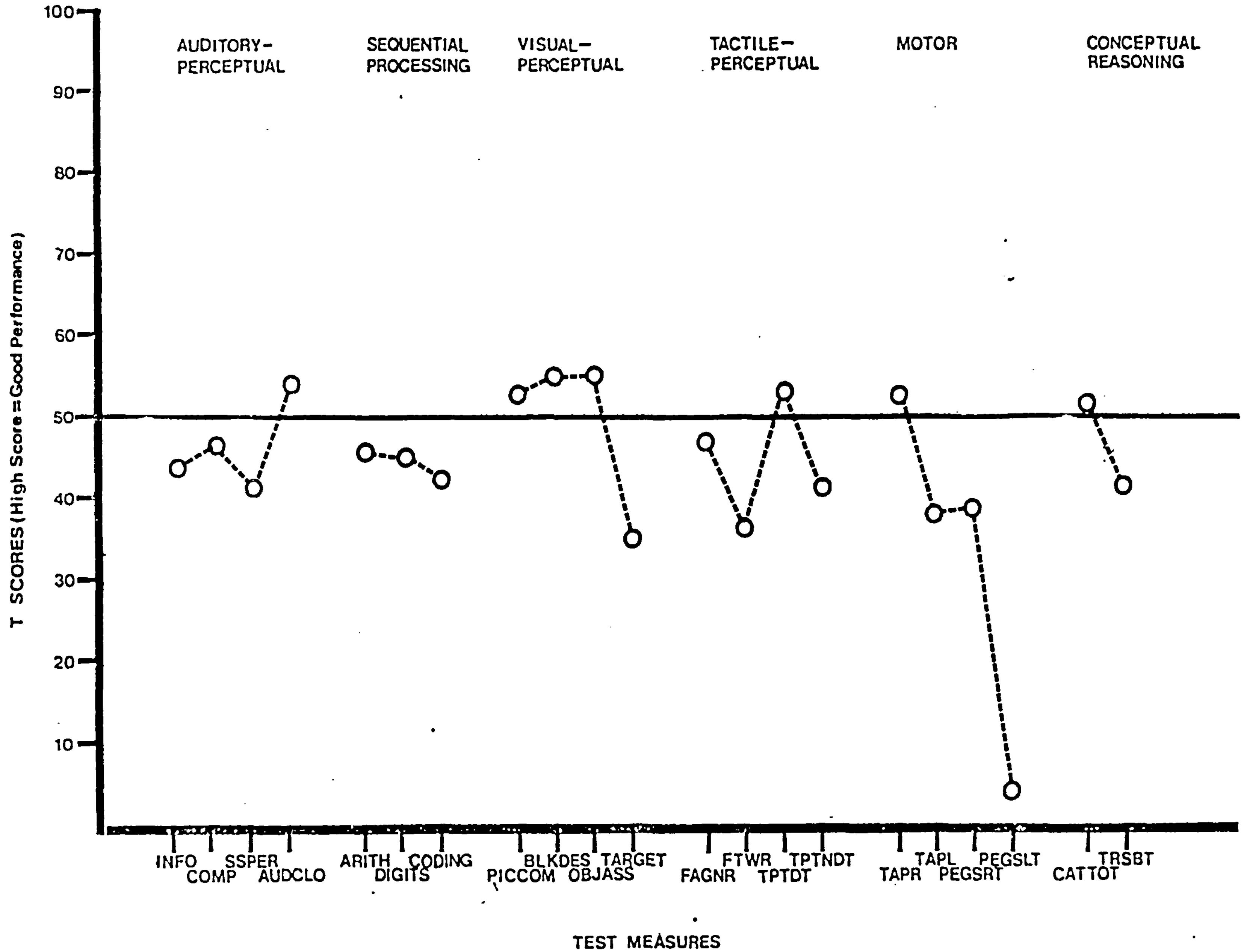

Figure 50. Plot of T score means for Cluster 7 of centroid sorting solution for dextral sample.

TABLE 36

Pearson Product Moment Correlation Coefficients for
Sinistral and Dextral Q Factors and Cluster Groups

	Sinistral Factors							*Dextral Factors*							*Sinistral Clusters*			
	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4
Sinistral Factors																		
1	1.00	.02	.20	.06	.03	.34	-.01	-.01	.94	.12	-.12	.03	-.22	-.16	.99	.09	.09	.15
2		1.00	.08	.16	.16	.11	.28	.84	.26	.07	.01	.55	.46	.37	.06	.14	.97	.12
3			1.00	-.16	.14	.30	-.19	.08	.18	.84	-.04	.41	-.01	-.00	.25	.04	.03	.99
4				1.00	.29	-.08	-.11	.21	.07	.11	.20	.11	.16	-.08	.05	.94	.05	-.19
5					1.00	.29	.19	.07	.02	.13	.13	.52	.49	.01	.08	.44	.25	.11
6						1.00	-.02	-.01	.31	-.01	.13	.66	-.30	.06	.41	.03	.19	.33
7							1.00	.19	.13	-.06	.21	.30	.46	.55	-.01	-.06	.41	-.15
Dextral Factors																		
1								1.00	.26	.25	.14	.48	.47	.42	.01	.13	.81	.11
2									1.00	.17	-.06	.17	-.03	-.04	.93	.06	.29	.13
3										1.00	.11	.33	.26	.19	.14	.27	-.01	.83
4											1.00	.21	.24	.33	-.11	.24	.01	.04
5												1.00	.32	.36	.10	.23	.60	.43
6													1.00	.36	-.23	.25	.49	.01
7														1.00	-.14	.04	.41	.10
Sinistral Clusters																		
1															1.00	.09	.12	.19
2																1.00	.05	.01
3																	1.00	.05
4																		1.00

TABLE 36 (cont'd)

	Dextral Group Average Clusters							Dextral Centroid Sorting Clusters						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Sinistral Factors														
1	-.02	.93	-.07	.24	-.12	-.21	.04	.93	-.05	.04	.22	-.4-	-.25	.09
2	..23	.28	.80	.06	.21	.18	.20	.28	.79	.21	.08	.22	.17	.24
3	.17	.20	.30	.92	.07	.05	-.06	.20	.32	-.05	.92	-.32	.03	.29
4	.76	.10	.03	-.20	.33	.23	-.42	.10	.03	-.44	-.23	.48	.18	.72
5	.22	.03	.29	.06	.25	.67	.05	.03	.33	.06	.05	-.10	.67	.32
6	-.03	.29	.39	.07	.29	-.16	.07	.29	.44	.10	.09	-.21	-.13	.05
7	.00	.08	.38	-.12	.14	.21	.68	.08	.38	.66	-.12	.27	.23	-.02
Dextral Factors														
1	.46	.33	.80	.18	.21	.21	.28	.33	.76	.29	.19	.44	.19	.43
2	.10	.99	.17	.26	-.08	-.17	.21	.99	.17	.21	.24	-.23	-.20	.18
3	.53	.20	.31	.92	.14	.28	.07	.20	.29	.06	.91	.07	.23	.60
4	.37	-.08	.19	.00	.92	.24	.44	.-.08	.21	.43	.02	.56	.27	.42
5	.38	.18	.86	.26	.43	.22	.28	.18	.90	.30	.27	.13	.22	.43
6	.38	-.01	.46	.12	.23	.75	.48	-.01	.45	.47	.11	.29	.75	.40
7	.20	-.05	.58	.10	.32	.32	.68	-.04	.55	.67	.12	.55	.33	.23
Sinistral Clusters														
1	-.02	.92	-.01	.26	-.09	-.20	.05	.92	.01	.05	.24	-.41	-.24	.10
2	.79	.07	.08	-.04	.40	.41	-.34	.07	.10	-.35	-.07	.40	.35	.80
3	.14	.35	.83	.01	.17	.20	.35	.35	.82	.36	.02	.15	.19	.16
4	.16	.15	.35	.91	.15	.08	.01	.15	.36	.02	.92	-.24	.07	.28

TABLE 36 (cont'd)

	Dextral Group Average Clusters							Dextral Centroid Sorting Clusters						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Dextral Group Average Clusters														
1	1.00	.12	.36	-.19	.45	.40	-.06	.12	.35	-.07	.17	.64	.34	.97
2		1.00	.21	.29	-.09	-.15	.18	1.00	.21	.18	.27	-.23	-.19	.21
3			1.00	.26	.34	.21	.44	.21	.99	.46	.28	.31	.20	.36
4				1.00	.01	.14	.11	.29	.25	.11	.99	-.20	-.20	.30
5					1.00	.28	.29	-.08	.38	.28	.03	.50	.50	.54
6						1.00	.20	-.15	.22	.19	.12	.19	.19	.45
7							1.00	.18	.44	.99	.13	.24	.24	-.04
Dextral Centroid Sorting Clusters														
1								1.00	.21	.18	.27	-.23	-.19	.21
2									1.00	.45	.27	.26	.22	.37
3										1.00	.13	.21	.23	-.05
4											1.00	-.19	.10	.27
5												1.00	.21	.49
6													1.00	.38
7														1.00

and will be commented upon further within the subsequent discussion on validation of the right-handed cluster results. Intercorrelations for Cluster 5 of both the group average relocate and centroid sorting relocate solutions were rather low. The highest correlation for Cluster 5 of the group average relocate results occurred with Cluster 7 of the centroid sorting relocate solution (r=0.54). Cluster 5 of the centroid sorting relocate solution correlated highest (r=0.64) with Cluster 1 of the group average relocate solution.

One final note on the group average relocate and centroid sorting relocate cluster comparisons. Since inter-correlations were so high between the group average relocate and centroid sorting relocate solutions, only the former results were compared against the left- and right-handed factor profiles generated by the Q technique, and the left-handed cluster profiles derived from cluster analysis. The only exception to this was in regard to Cluster 5 of both the group average relocate and centroid sorting relocate solutions, where rather low inter-correlations were seen between these and other dextral clusters.

From Table 36, it was ascertained that Cluster 2 of the group average relocate solution for the dextral sample correlated highest with Factor 2 from the dextral sample (r=0.99), with Factor 1 from the sinistral sample (r=0.93), and with Cluster 1 from the sinistral sample (r=0.92). These values would suggest that the pattern of mean scores for these profiles were quite similar. Cluster 3 of the group average relocate solution for the dextral sample correlated highest with Factor 5 from the dextral sample (r=0.86), with Factor 1 from the dextral sample (r=0.83), with Factor 2 from the sinistral sample (r=0.80), and with Cluster 3 from the sinistral sample (r=0.83), indicating a high degree of similarity in the pattern of scores for these profiles. Cluster 4 of the group average solution for the dextral sample correlated highest with Factor 3 from the dextral sample (r=0.92), with Factor 3 from the sinistral sample (r=0.92), and with Cluster 4 from the sinistral sample (r=0.91). These values would indicate that the pattern of mean _T_ scores for these profiles were quite similar as well. The profiles of performances associated with these factors and clusters, as well as the correlation coefficients between factors and clusters were interpreted as evidence to validate the existence of three highly similar subtypes of left- and right-handed children.

The following intercorrelation values were obtained for the remaining dextral group average relocate clusters. Cluster 1 from this sample correlated highest with Cluster 2 from the sinistral sample (r=0.79), and with Factor 4 from the sinistral sample (r=0.76). The similarities in these profiles may represent another similar subgroup of left- and right-handed children. Cluster 6 from the group average relocate solution for the dextral sample correlated highest with Factor 6 from the dextral sample (r=0.75), and with Factor 5 from the sinistral sample (r=0.67). Again, these profiles may well represent another similar subgroup of sinistral and dextral children, despite the fact that Factor 5 from the left-handed sample included only a total of six children. Cluster 7 from the group average relocate solution for the dextral sample correlated at a 0.68 level with both Factor 7 from the dextral sample and Factor 7 from the sinistral sample. Finally, there was a high correlation (r=0.92) between Cluster 5 from the group average relocate solution and Factor 4 from the dextral sample, suggesting that these profiles may represent a separate right-handed subgroup. However, cluster 5 from the dextral group average relocate solution was the group that failed to exhibit any significant correlation values with any of the centroid sorting relocate clusters. Thus, this cluster was only replicable across one clustering method. Intercorrelations between Cluster 5 from the dextral centroid sorting solution and the remaining clusters and Q factors were all fairly low.

The results of a misclassification analysis used to compare the cluster and factor analytic solutions derived from the right-handed data set are summarized in Table 37. A total of thirty-five children (30% of the total sample) classified together by the Q technique of factor analysis were not classified together by the group average method of cluster analysis, leaving 81 subjects (70% of the data set) that were classified into the same groups. Agreement between the centroid sorting method and the Q technique was slightly lower, with a total of forty subjects (35% of the sample) misclassified, and 76 of the children (65% of the data set) classified together.

TABLE 37

Number of Right-Handed Children from Each of the _Q_ Type Factors Misclassified by Cluster Analytic Methods

Cluster Analysis Method	*n* of Clusters	Q Factors 1 (*n*=20)	2 (*n*=26)	3 (*n*=18)	4 (*n*=11)	5 (*n*=18)	6 (*n*=8)	7 (*n*=15)	Total Misclassifications (*n*=116)
Group Average	7	7	3	6	3	4	4	8	35
Centroid Sorting	7	10	3	7	4	2	5	9	40

Validation of Right-Handed Clusters

Following the recommendation that a good solution should reappear under different clustering methods (Everitt 1974; Morris et. al., 1981), the results of the group average relocate and centroid sorting relocate procedures were compared. An analysis of the membership assignments within clusters revealed almost perfect agreement between the two methods. More specifically, the results showed that less than 5% of the subjects were placed into a different cluster for the seven-cluster solution. The extremely high correlation coefficients presented in Table 36 between the clusters generated from each method attests to the high degree of similarity between the two clustering solutions as well.

A split-sample design was again employed as a second validation procedure (i.e., the right-handed data set was randomly divided into two subsamples, and each half was clustered independently). The hierarchical trees obtained by applying the group average and centroid sorting methods to the two dextral subsamples are shown in Figures 51 to 54. Visual inspection of these figures indicated that both data sets were clearly structured. The clustering coefficients derived through the application of the group average and centroid sorting methods to the two subsamples are listed in Table 38, and graphs of these data are shown in Figures 55 to 58. In three out of four instances, a search for precipitous changes on these plots failed to reveal one acceptable or terminal solution. In the remaining case (Figure 58), inspection of the graph suggested that a three-cluster solution was

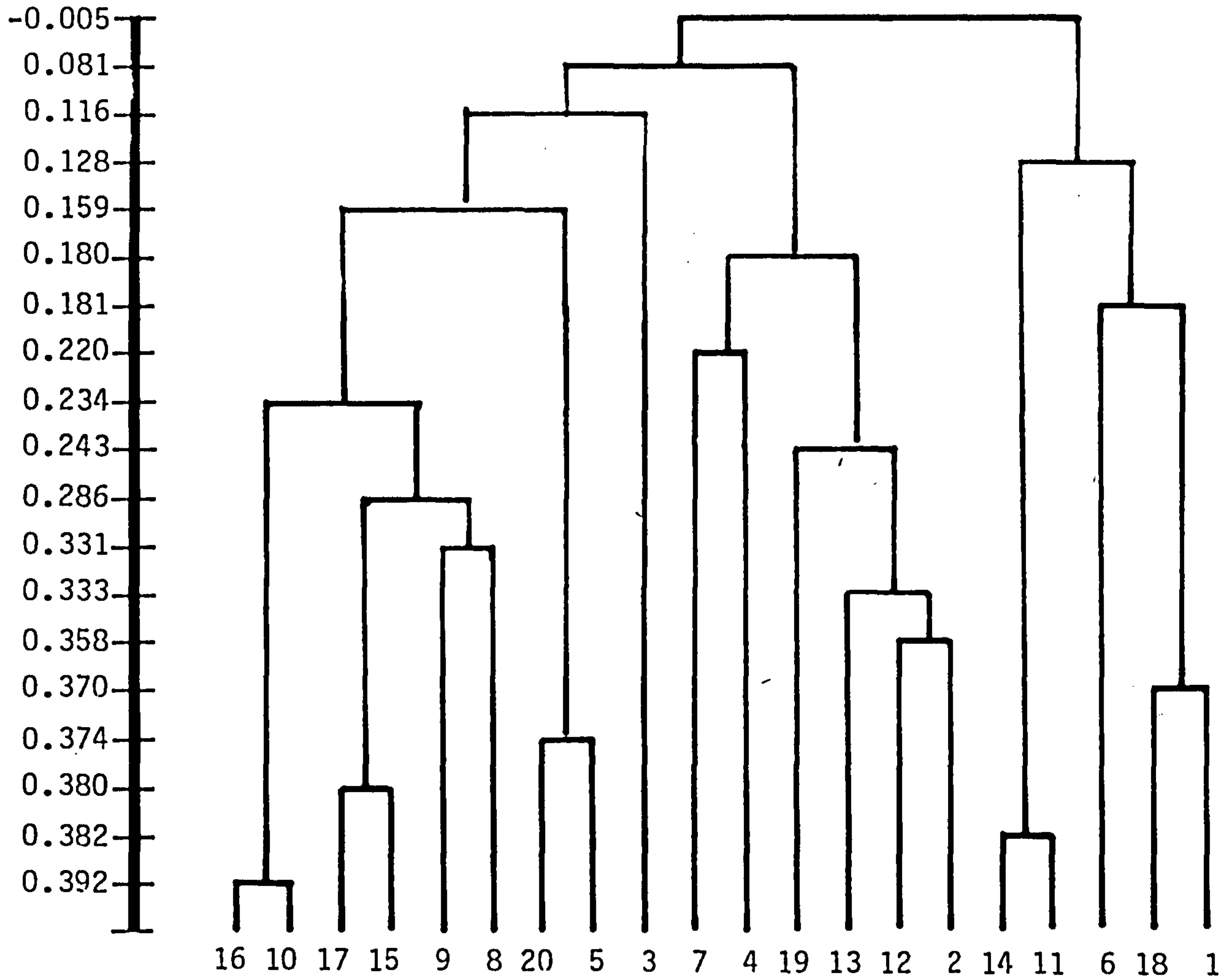

Figure 51. Split sample validation hierarchical tree using group average on dextral subsample 1.

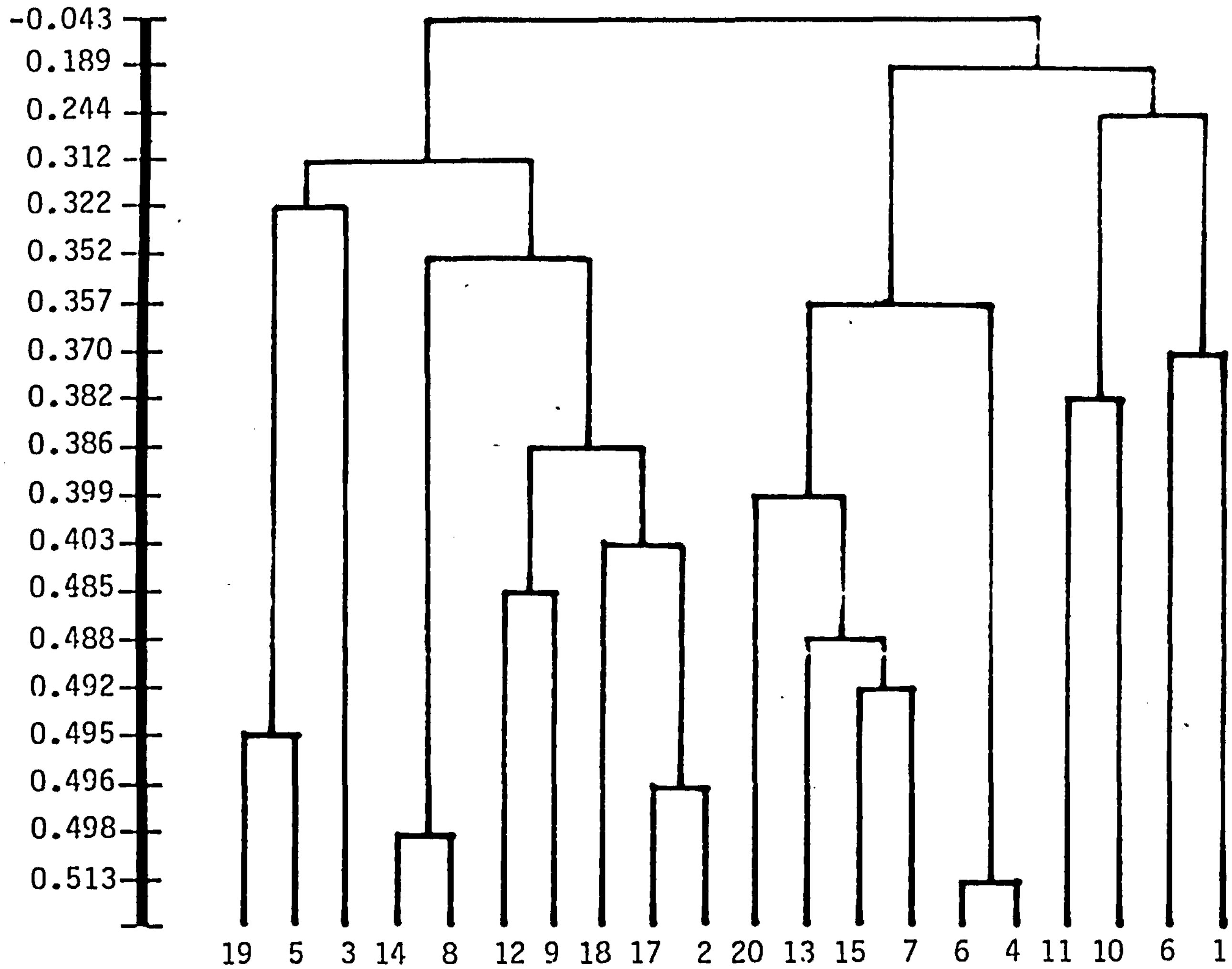

Figure 52. Split sample validation hierarchical tree using centroid sorting on dextral subsample 1.

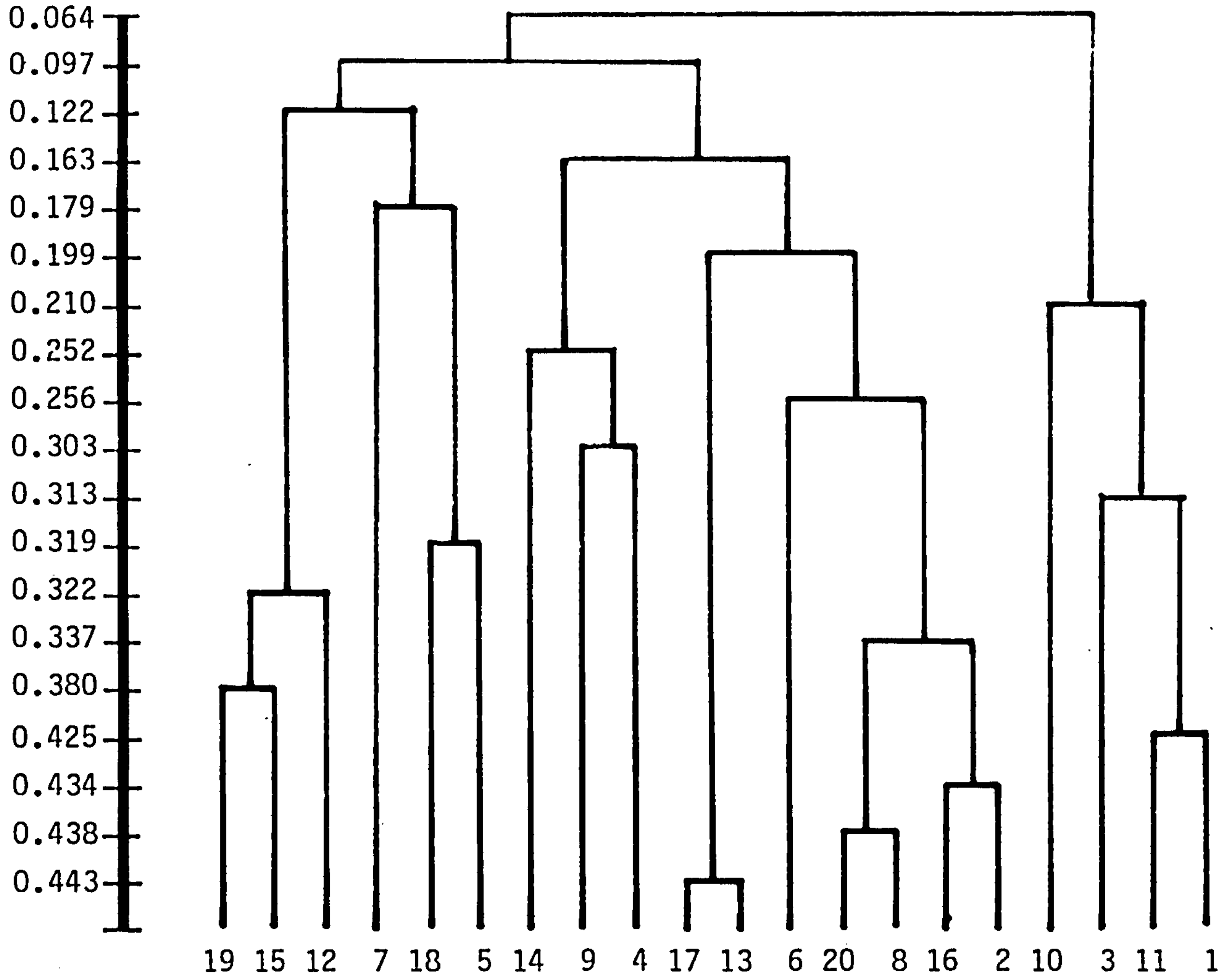

Figure 53. Split sample validation hierarchical tree using group average on dextral subsample 2.

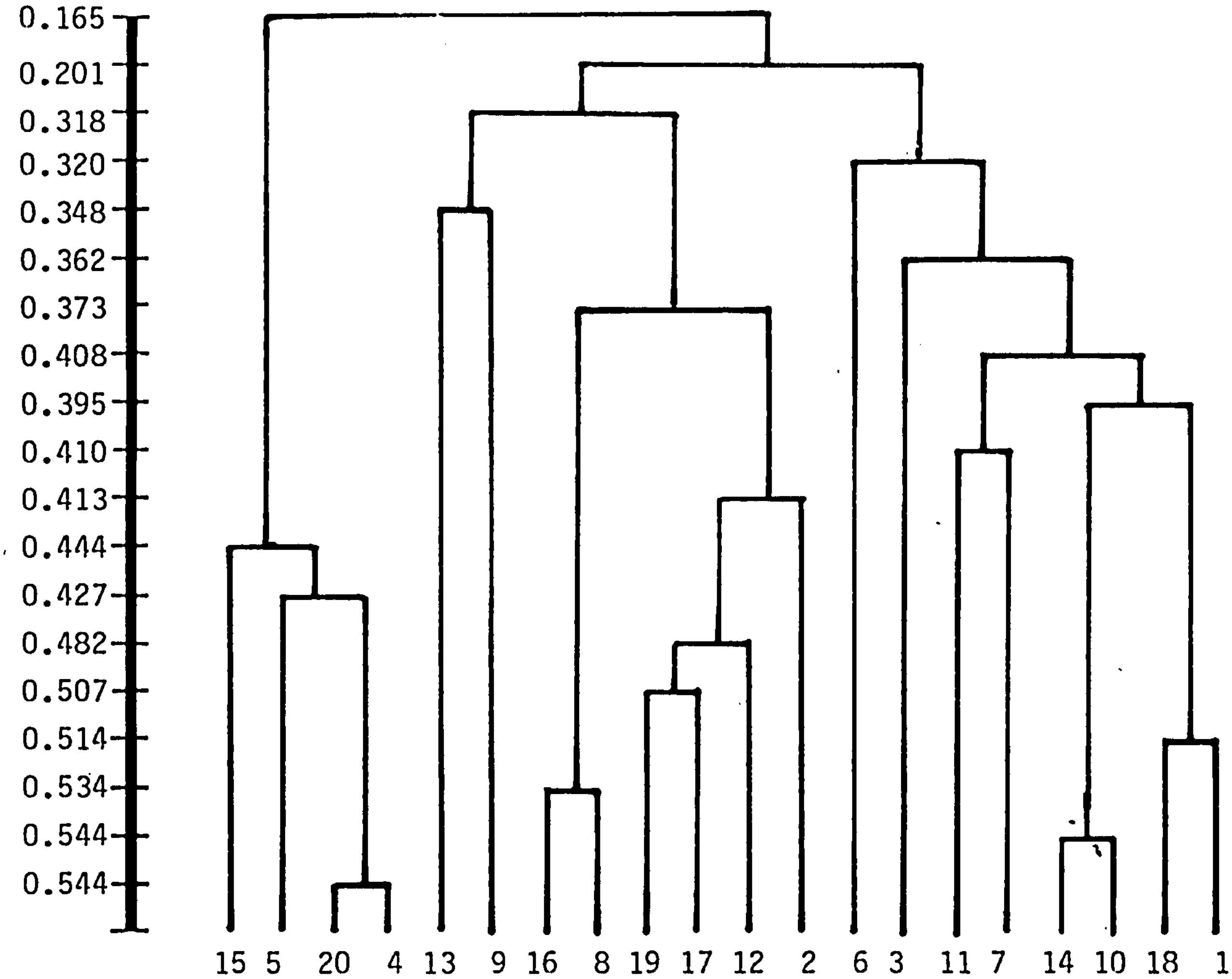

Figure 54. Split sample validation hierarchical tree using centroid sorting on dextral subsample 2.

TABLE 38

Split Design Validation Clustering Coefficients of Group Average and Centroid Sorting Hierarchical Agglomerative Methods Applied to Two Dextral Subsamples

	Subsample 1		Subsample 2	
n of Clusters	Group Average	Centroid Sorting	Group Average	Centroid Sorting
10	.243	.386	.303	.410
9	.234	.382	.256	.395
8	.220	.370	.252	.408
7	.181	.357	.210	.373
6	.180	.352	.199	.362
5	.159	.322	.179	.348
4	.128	.312	.163	.320
3	.116	.244	.122	.318
2	.081	.189	.097	.201
1	-.005	-.043	.064	.165

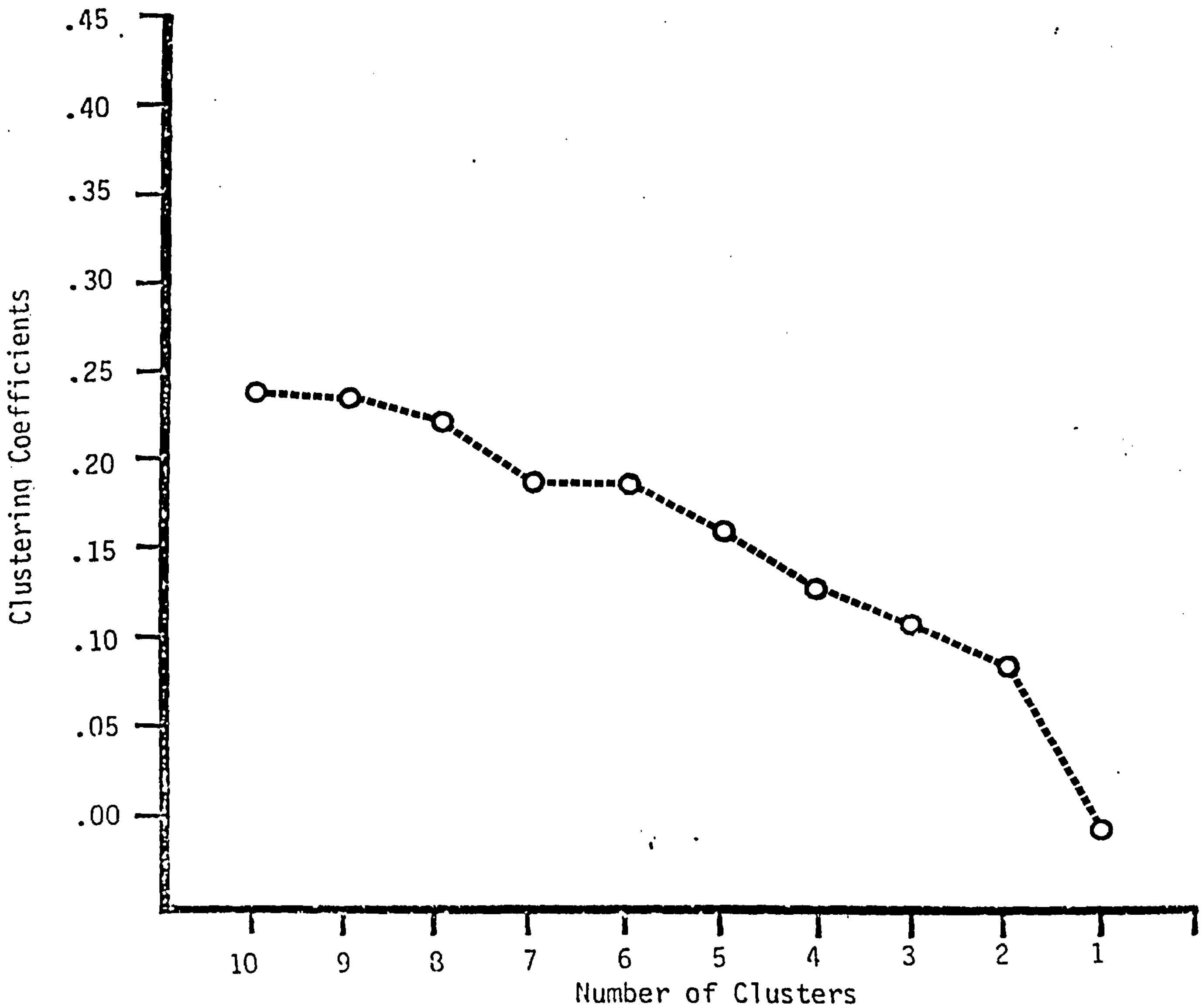

Figure 55. Plot of group average hierarchical clustering coefficients for split sample validation procedure using dextral subsample 1.

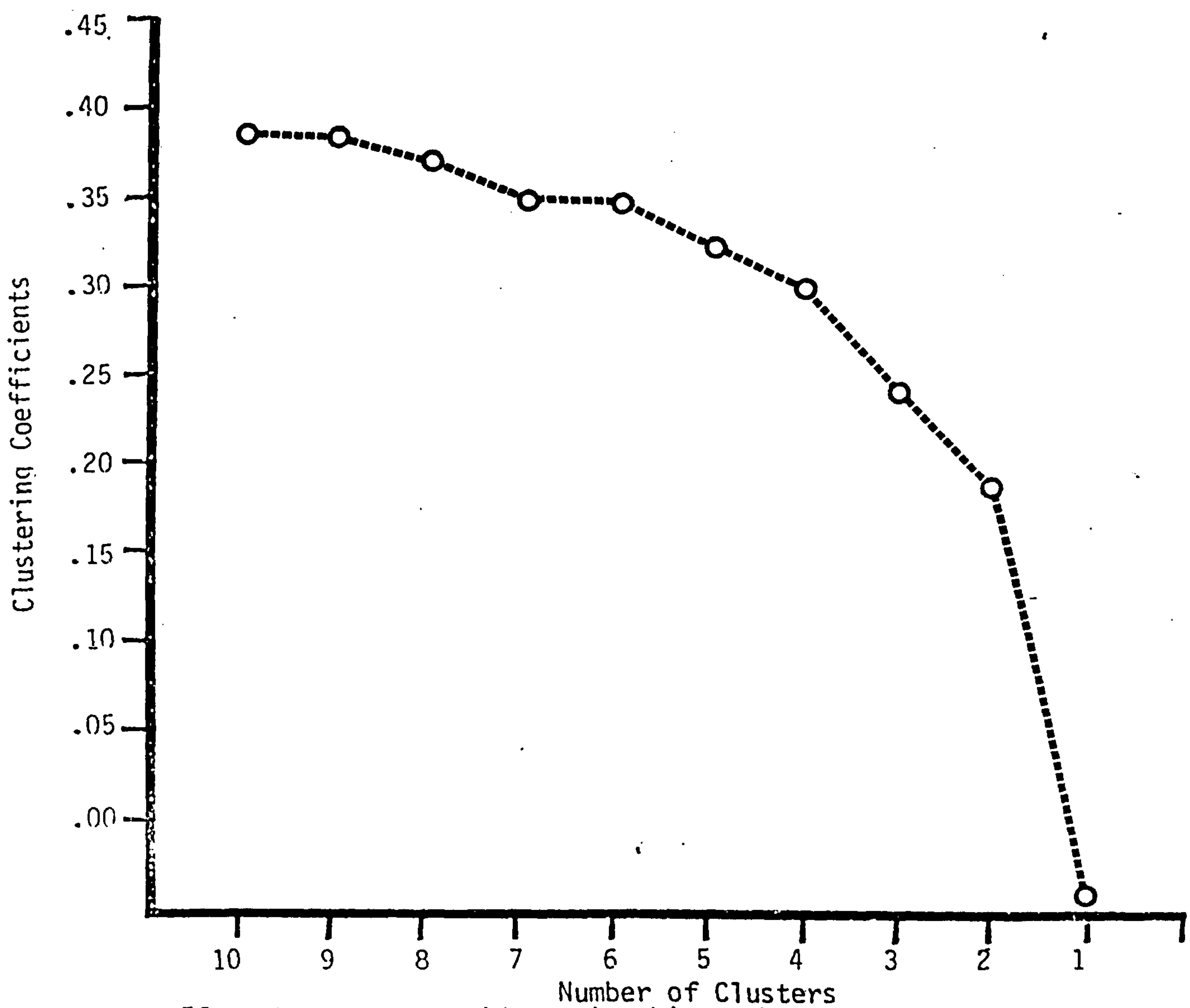

Figure 56. Plot of centroid sorting hierarchical clustering coefficients for split sample validation procedure using dextral subsample 1.

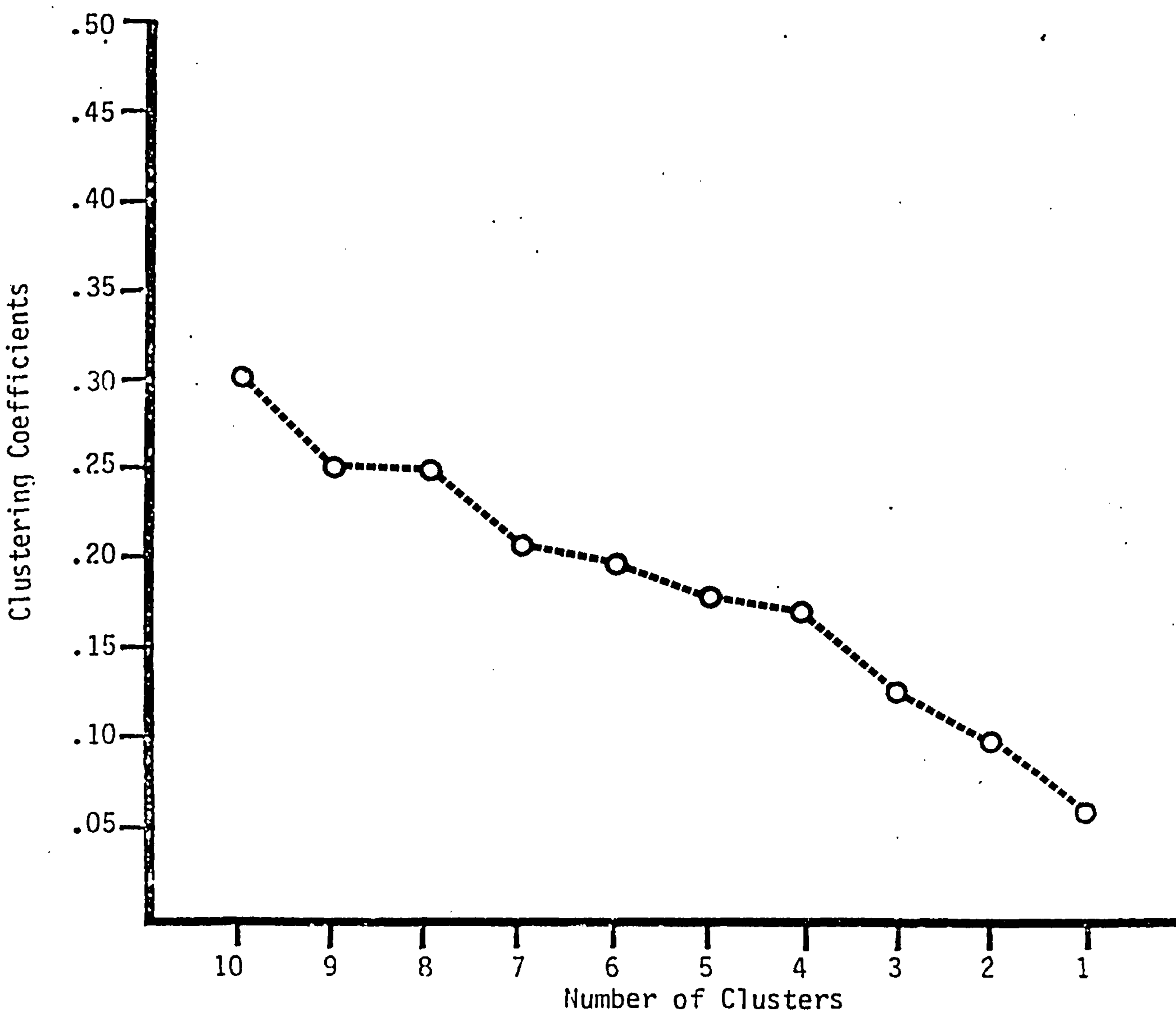

Figure 57. Plot of group average hierarchical clustering coefficients for split sample validation procedure using dextral subsample 2.

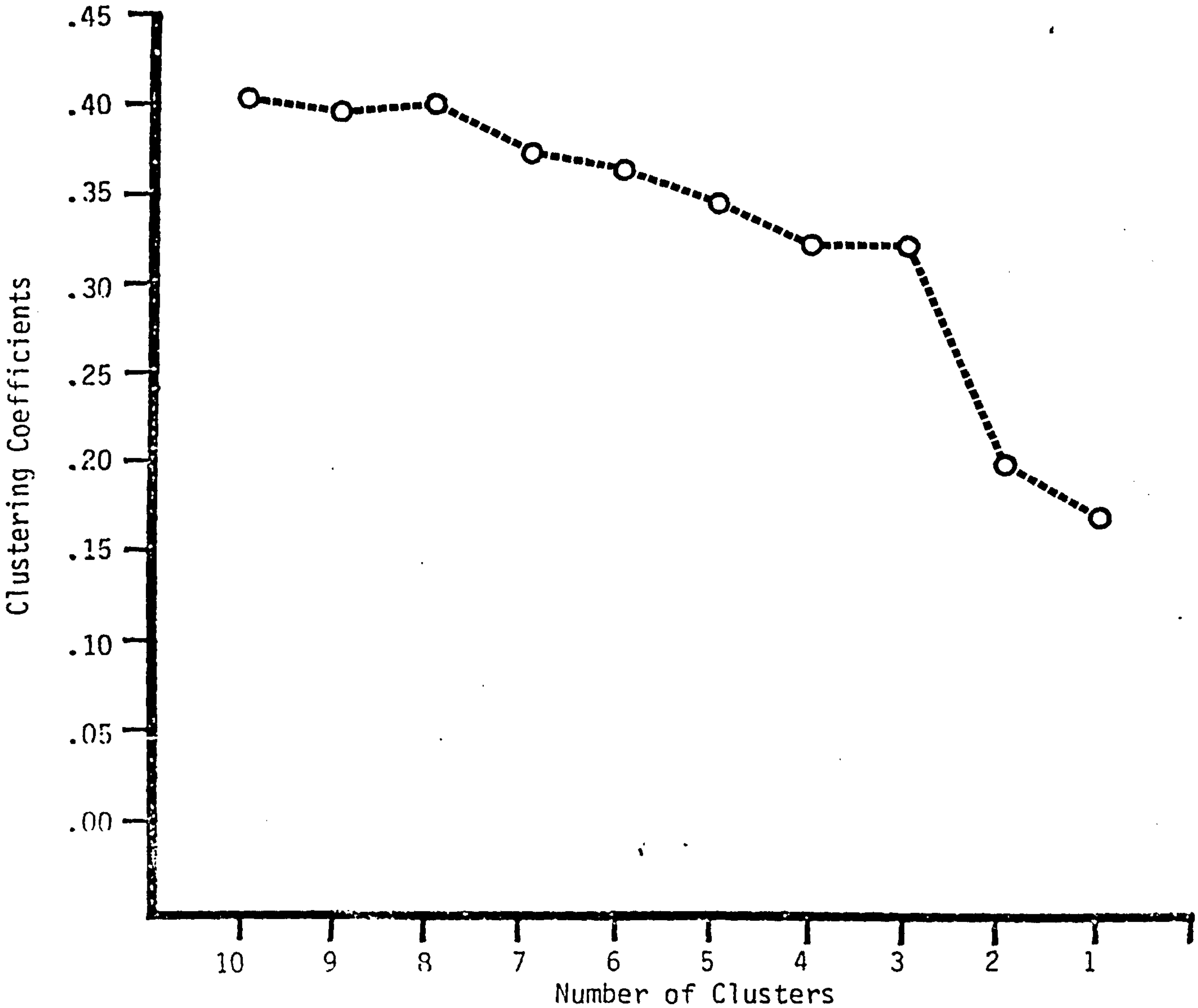

Figure 58. Plot of centroid sorting hierarchical clustering coefficients for split sample validation procedure using dextral subsample 2.

plausible. From Table 38 and Figures 55 to 58, it was clear that several different cluster solutions were possible. However, to be able to adequately assess the number of subjects who changed from their original clusters, a seven-cluster result was chosen as the terminal solution for both subsample data sets.

The final cluster membership distributions for the seven-cluster solutions for each subsample following the application of a iterative relocation procedure to both are provided in Tables 39 and 40. For subsample 1, identical seven-cluster solutions were derived from the group average and centroid sorting results following iterative partitioning of both. Cluster sizes for this sample were 14, 14, 11, 6, 18, 16 and 2 subjects. On the other hand, the iterative relocate results for the seven-cluster solutions of the group average and centroid sorting methods applied to Subsample 2 varied slightly. In the case of the former, clusters consisted of 16, 26, 4, 11, 6, 4 and 13 children, whereas the latter method generated cluster membership totals of 24, 4, 8, 11, 17, 8 and 8 subjects.

Next, the results of the split-sample validation procedure was compared against the standard solution by means of misclassification analysis. Table 41 indicates that for subsample 1 there were a total of 13 children who changed from their original clusters. This was equivalent to 16% of subsample 1. In the case of subsample 2 (Table 42), the group average relocate method resulted in 30 misclassifications (38% of the sample) whereas the centroid sorting relocate procedure misclassified 22 children, equivalent to 27% of subsample 2. In total, less than 30% of the subjects, using any

TABLE 39

Number of Right-Handed Children in Each Cluster for 8, 7, 6, 5, 4, 3 and 2 Relocate Cluster Results for Subsample 1 of the Split Sample Validation Procedure

Cluster Analysis Method	Clusters 1	7	6	5	4	3	2
Group Average							
1	18	14	14	18	23	45	43
2	14	14	19	17	13	15	38
3	11	11	11	12	20	21	
4	5	6	19	19	25		
5	17	18	16	15			
6	5	16	2				
7	9	2					
8	2						
Centroid Sorting							
1	18	14	14	18	23	45	43
2	9	11	11	12	13	15	38
3	11	14	19	17	20	21	
4	14	18	19	19	25		
5	17	16	16	15			
6	5	6	2				
7	5	2					
8	2						

TABLE 40

Number of Right-Handed Children in Each Cluster
for 8, 7, 6, 5, 4, 3 and 2 Relocate Cluster Results
for Subsample 2 of the Split Sample Validation Procedure

Cluster Analysis Method	Clusters						
	8	7	6	5	4	3	2
Group Average							
1	14	16	17	18	18	20	25
2	21	26	27	26	29	38	55
3	12	4	11	11	20	22	
4	4	11	6	13	13		
5	9	6	5	12			
6	5	4	14				
7	4	13					
8	11						
Centroid Sorting							
1	23	24	24	24	29	38	55
2	4	4	7	18	20	20	25
3	8	8	9	13	18	22	
4	11	11	14	18	13		
5	17	17	18	7			
6	6	8	8				
7	3	8					
8	8						

TABLE 41

Number of Right-Handed Children in Subsample 1 from Each of the Cluster Groups Misclassified by the Split Sample Validation Procedure

Cluster Analysis Method	n of Clusters	Clusters 1 (n=14)	2 (n=14)	3 (n=11)	4 (n=6)	5 (n=18)	6 (n=16)	7 (n=2)	Total Misclassifications (n=81)	% Sample
Group Average	7	1	3	0	3	2	3	1	13	16%
Centroid Sorting	7	1	3	0	3	2	3	1	13	16%

TABLE 42

Number of Right-Handed Children in Subsample 2 from Each of the Cluster Groups Misclassified by the Split Sample Validation Procedure

Cluster Analysis Method	*n* of Clusters	Clusters							Total Misclassifications	% Sample
		1	2	3	4	5	6	7		
n		(16)	(26)	(4)	(11)	(6)	(4)	(13)	*n* = 80	
Group Average	7	5	5	1	6	5	1	7	30	38%
n		(24)	(4)	(8)	(11)	(17)	(8)	(8)	*n* = 80	
Centroid Sorting	7	1	1	5	6	6	2	1	22	27%

TABLE 43

Composition of Left-Handed Subjects for Hand Preference, Hand Proficiency, and Familial Handedness Variables for Each Q-Factor and Cluster Grouping

	Q Factors				Clusters			
	1	2	3	4	1	2	3	4
Variable	(n=41)	(n=26)	(n=19)	(n=9)	(n=49)	(n=26)	(n=51)	(n=35)
Hand Preference								
Pure	19	19	13	6	23	15	27	21
Mixed	22	7	6	3	26	11	24	14
Hand Proficiency								
Congruous	21	11	7	2	26	9	17	12
Incongrous	7	3	5	3	7	9	12	8
Mixed	13	12	7	4	16	8	22	15
Familial Sinistrality								
Positive	19	4	8	6	25	13	15	12
Negative	17	18	7	3	19	10	30	16
No Data	5	4	4	0	5	3	6	7

N.B. The four cluster solution listed on this table represents the results of both the Group Average and Centroid Sorting Method, since identical solutions were generated from each.

TABLE 44

Comparison of Right-Handed Subjects for Familial Handedness Variable for Each Q Factor and Cluster Grouping

	Familial Sinistrality		
Method	Positive	Negative	No Data
Q Type			
1	12	8	0
2	11	15	0
3	9	9	0
4	3	8	0
5	5	13	0
6	5	3	0
7	3	12	0
Group Average			
1	10	12	0
2	15	15	0
3	12	29	0
4	10	10	1
5	3	9	0
6	5	5	0
7	9	12	2
Centroid Sorting			
1	15	15	0
2	12	28	0
3	10	11	1
4	9	11	2
5	4	11	0
6	4	5	0
7	10	11	2

of the methods, changed from their original clusters.

Finally, the _T_ score means and standard deviations of variables used in the split-sample design for each subsample cluster are shown in Appendix H. Graphic illustrations of the mean _T_ scores for each variable for the clusters derived in split-samples 1 and 2 are also included in Appendix H. In most cases, visual inspection of these graphs revealed a high degree of similarity between profile characteristics of the solutions derived from split-samples 1 and 2 and the results obtained from clustering the entire sample together. Again, the most notable differences in cluster patterns occurred in subsample clusters of small size.

Chi-Square Analyses

The distribution of scores for the hand preference, hand proficiency, and familial handedness variables for each _Q_ type factor and cluster analytic group were compared against their respective hypothetical distributions, and a measure of agreement or conformity (χ^2) was generated for each. Tables 43 and 44 summarize the subgroup composition for each Q factor and cluster subgroup across the hand preference, hand proficiency, and familial handedness variables. In sum, for each sinistral Q factor and cluster grouping (Table 45), only the set of scores for the familial handedness variable within Factor 2 was found to deviate significantly from the respective hypothetical distribution ($p < .05$). However, the lack of any significant differences between distributions on this variable within other subgroups

TABLE 45

Summary of Goodness-of-Fit χ^2 Values for the Hand Preference, Hand Proficiency, and Familial Handedness Variables for Each Sinistral Q Factor and Cluster Grouping

	Q Factors				Clusters			
Variable	1	2	3	4	1	2	3	4
Hand Preference	0.61	3.14*	1.32	0.11	0.51	0.04	0.00	0.26
Hand Proficiency	2.56	2.00	0.38	1.83	3.47	2.00	0.74	0.60
Familial Handedness	0.45	7.78**	2.44	2.25	2.12	0.69	2.21	1.09

* $p < .10$ ** $p < .05$

N.B. Following the recommendation outlined in Yamane (1967), χ^2 values for cases involving only one degree of freedom (i.e., Hand Preference) were computed using Yates' correction for continuity.

found to be highly similar to sinistral Factor 2 (i.e., sinistral Cluster 3, dextral Factor 1, dextral group average Cluster 3, and dextral centroid sorting Cluster 2), suggesting that this may have been an isolated finding. The hand preference distribution within sinistral Factor 2 was also found to be significant at $p < .10$. Again, however, this finding was thought to be rather meaningless.

Table 46 summarizes the Goodness-of-Fit Chi-Square values for the familial handedness variable for each dextral Q factor and cluster grouping. All of the values on this table were found to be statistically nonsignificant.

In sum, the results of these series of analyses would seem to indicate that subgroups cannot be differentiated from one another on the basis of hand preference, hand proficiency, and familial handedness composition. That is to say, there were no particular subgroups that exhibited either an unusually large or small number of congruent, incongruent or mixed-proficient left-handers, pure or mixed-preference left-handers, or subjects with mostly sinistral or dextral family members.

TABLE 46

Summary of Goodness-of-Fit χ^2 Values for the Familial Handedness Variable for Each Dextral Q Factor and Cluster Grouping

Factor or Cluster	χ^2 Value
Q Type	
1	3.82
2	0.00
3	1.67
4	1.47
5	2.47
6	2.13
7	2.50
Group Average	
1	0.29
2	1.99
3	4.57
4	0.83
5	1.37
6	0.42
7	1.13
Centroid Sorting	
1	1.99
2	3.09
3	1.42
4	0.31
5	1.11
6	0.00
7	0.42

CHAPTER IV

DISCUSSION

This study had a two-fold purpose. First, an attempt was made to investigate systematically, isolate and report on the adaptive similarities and differences between left- and right-handed learning disabled children based on a multivariate quantitative taxonomic analysis of their performances on a battery of neuropsychological measures. A systematic study of the typology of cognitive impairment associated with learning disabilities in these two particular groups of children originated from the burgeoning documented evidence suggesting that handedness and the organization of higher cognitive abilities are to some extent correlated with each other. The second aim of the investigation was to offer some evidence to show that similar subtypes could be generated in a reliable fashion through the application of different classification techniques.. It was felt that a reliable taxonomy of learning disabilities could offer potentially useful information regarding the remedial management of such children.

The performance measurements collected on an equivalent number of left- amd right-handed children referred to the neuropsychological service of an urban children's clinic because of learning, behavioural or perceptual handicaps were classified statistically by several multivariate procedures. Initial application of the Q technique of factor analysis to each handedness sample independently generated seven factors for each data set. Three factors from each target sample were highly correlated with each other. For the left-handed sample, one other fairly meaningful factor emerged, while the remaining three factors exhibited membership assignments that were interpreted to be of inconsequential magnitude. On the other hand, for the right-handers, a sizeable number of children were classified into each of the remaining factors. These findings suggest the following: (1) certain similar subtypes would appear to exist for left- and right-handed learning disabled children, and (2) left-handers appear to constitute a much more homogeneous population in regard to their performances on a battery of neuropsychologic measures than a similar group of right-handers. Subsequent application of several cluster algorithms to the same data sets resulted in classification solutions that were in perfect agreement with the Q factors for the left-handed sample, and solutions that were in fairly close agreement for the right-handed group of children. This finding suggests that subgroups generated by means of one multivariate statistical procedure could be reliably detected through the application of several other classification methods as well.

In this chapter, a more detailed and comprehensive discussion of the findings outlined above are preceded by a section on some methodological considerations of the study. Next, characteristics of the subgroups identified are described, and comparisons are made to other subtypes reported in the literature. Included here is some discussion on the reliability and stability of the isolated subgroups. Finally, the implications of the findings as they relate to the issue of handedness are addressed in some detail, including their obvious assessment and diagnostic considerations. Directions for future research are also provided.

Methodological Considerations

The present investigation compared the adaptive ability profiles between independent groups of left- and right-handed subjects who were selected from a *clinical* rather than from a *normal* population of school-age children. Undougtedly, quite different sets of conclusions regarding the relation between handedness and neuropsychological ability structure may be drawn from the two population samples, one based on the normal population of school children and one based on children referred to clinics for learning difficulties. It is within the latter type of sample, in particular, where anomalies of laterality (i.e., a higher incidence of sinistrality or mixed-handedness) are sometimes, but not always, detected. In a review of over 3500 clinic cases from which the samples in this study were drawn, approximately 14% were found to exhibit sinistral tendencies, a sizeable increase in the incidence of left-handedness reported in the general population.

Other clinically-affected samples - for example those exhibiting psychometric intelligence values outside of the range utilized within this investigation (i.e., below 85) - may demonstrate very different patterns of cognitive abilities and deficits as a function of preferred handedness. The findings from this study should not be construed as representative, therefore, of a general typology of cognitive strengths and weaknesses associated with lateral hand preference patterns *per se*. Instead, they should be viewed within the context of the limitations imposed by sampling considerations.

Despite similar mean WRAT Reading, Spelling and Arithmetic centile scores between the two handedness samples (see Table 3), no attempt was made in this study to match the groups on the basis of an academic achievement criterion. However, an analysis of the WRAT subtest performance patterns within each handedness sample (see Table 4) indicated that the between-group composition was quite similar. Nevertheless, some variability was noted in the distributions of scores, suggesting that the populations differed to some degree on this dimension. This may be one reason for the differences witnessed in regard to the number of interpretable groups (i.e., factors or clusters) generated for each handedness sample by the multivariate procedures.

As mentioned earlier, a number of methodological issues surround the use of cluster analysis. The selection of variables, the choice of similarity measure, the determination of the clustering method, and the procedure for estimating the number of clusters within the data must be clearly defined. Moreover, adequate evidence of a cluster solutions validity should be provided as well. Each of these considerations can affect the derived subtype structure.

In most clustering attempts there generally exists the problem of deciding on how many variables are appropriate for study. In turn, these input measures should fulfill the obvious requisite that they be relevant to the classification being sought. To minimize test redundancy and to maximize cluster interpretability, it is generally desireable to seek to reduce the number of input variables. In many accounts of clustering, measurements that have been amassed on a sizeable number of variables are reduced through principal components analysis. The first few principal component scores are then used as input variables to the clustering procedure. However, in the present study variables were duplicated from those utilized in the factor analyses. These variables were originally selected on the bases of a 'rational grouping' procedure and were, in turn, checked against the results of a formalized R type analysis of the complete test battery. T score matrices of these variables were then analyzed by the different clustering algorithms. Everitt (1974) suggests that similar classifications should emerge by using either the first few principal component scores or the complete set of data, provided the data is well structured. On the other hand, widely divergent solutions may be derived when the groups are not as clearly defined within the data set. In the present study, applying clustering algorithms to the raw data may have produced solutions quite different from those obtainable if the data derived from the raw data (i.e., factor scores) had been used as input to the clustering method.

Since this study was interested in elucidating the similarities and differences in adaptive ability profile shapes between left- and right-handed learning disabled children, correlation coefficients were calculated between individuals. On the contrary, distance measures are felt to be a more appropriate metric when one is interested in the similarity of the average profile levels. That is, two profiles may exhibit very similar patterns of performance, but be quite far apart in level of performance. These two different ways of defining similarity between subjects can result in different, yet clinically meaningful, interpretations.

It is not uncommon in clustering problems to find that a single set of scores analyzed by several different techniques may result in entirely different solutions or groupings of the data. Despite the fact that several clustering algorithms were utilized in the present study (in an attempt to lessen the possibility of accepting spurious or misleading solutions), other types of group structure may have emerged through the application of different clustering techniques. Indeed, the clustering algorithms utilized in the present investigation were chosen somewhat arbitrarily and there is no reason to believe that the results derived from them are the only types of structure present in the data.

As pointed out earlier, a persistent problem in cluster analysis is the difficulty of deciding as to the correct number of groups to consider for a given set of data. A review of both mappings of the data (i.e., hierarchical trees) and clustering coefficient results provided some idea of the number of clusters suitable for representation of the data matrices in the current study. However, inspection of these two sets of results did not always provide an unequivocal answer to this question. In fact, in several cases a range of clustering solutions appeared to be quite plausible, and decisions regarding the appropriate number of groups to consider were usually made on a highly subjective basis. It is clear that a host of interpretations or judgements could have eventuated in regard to the subtype structure existing within the data had an examination been made of other partitioning results.

Finally, the application of validation procedures helps to buttress the existence of "real" subgroups within the data. The Q type solutions generated in this study were validated by the clustering results and these findings, in turn, were validated through the application of a split-sample procedure to the data set. However, given the fact that different clustering techniques could likely give different solutions, validation becomes especially important. In this regard, several other alternative ways of validating the clustering results derived in this study could have been employed as well (e.g., altering the input data matrix through the omission or deletion of variables, or demonstrating that clusters have predictive value with respect to variables not included in the original clustering procedure).

One final note on this issue. The ultimate test of a factor or clustering solutions validity would seem to lie in its usefulness and meaningfulness from a clinical point of view. That is to say, are the characteristics of the derived subgroup interpretable, and are they reasonably consonant with those that one would expect to find within the data. The features and characteristics of the derived subtypes are outlined in the next section. Upon inspection of these descriptions, it will become clear that the subgroup compositions reflect cognitive ability profiles that can indeed be associated with learning problems in a viable and predictable fashion.

Description of Subtypes

The profiles of test performance associated with the derived factors and clusters, the correlation values between clusters and factors, and the results of the misclassification analyses were interpreted to define three highly similar and reliable subtypes of left- and right-handed learning disabled children. In addition, four other interpretable, but less well-defined subgroups emerged. In this section, subgroup composites are described, and comparisons are made to other subgroups reported in the literature.

Type I

This group is composed of children who constituted Factor 1 (n = 41) and Cluster 1 (n = 49) from the left-handed sample, and Factor 2 (n = 26), group average Cluster 2 (n = 30) and centroid sorting Cluster 1 (n = 30) from the right-handed sample. A graphic illustration of this subtype is depicted in Figure 59. Since the factor and cluster intercorrelations were so remarkably high within this group (i.e., r = 0.92 or above), a composite of all mean T score profiles (i.e., Figures 3, 21, 11, 38 and 44) is presented in Figure 59. The dashes on this figure as well as on two subsequent graphs represent the various independent factor and cluster T score means for each variable.

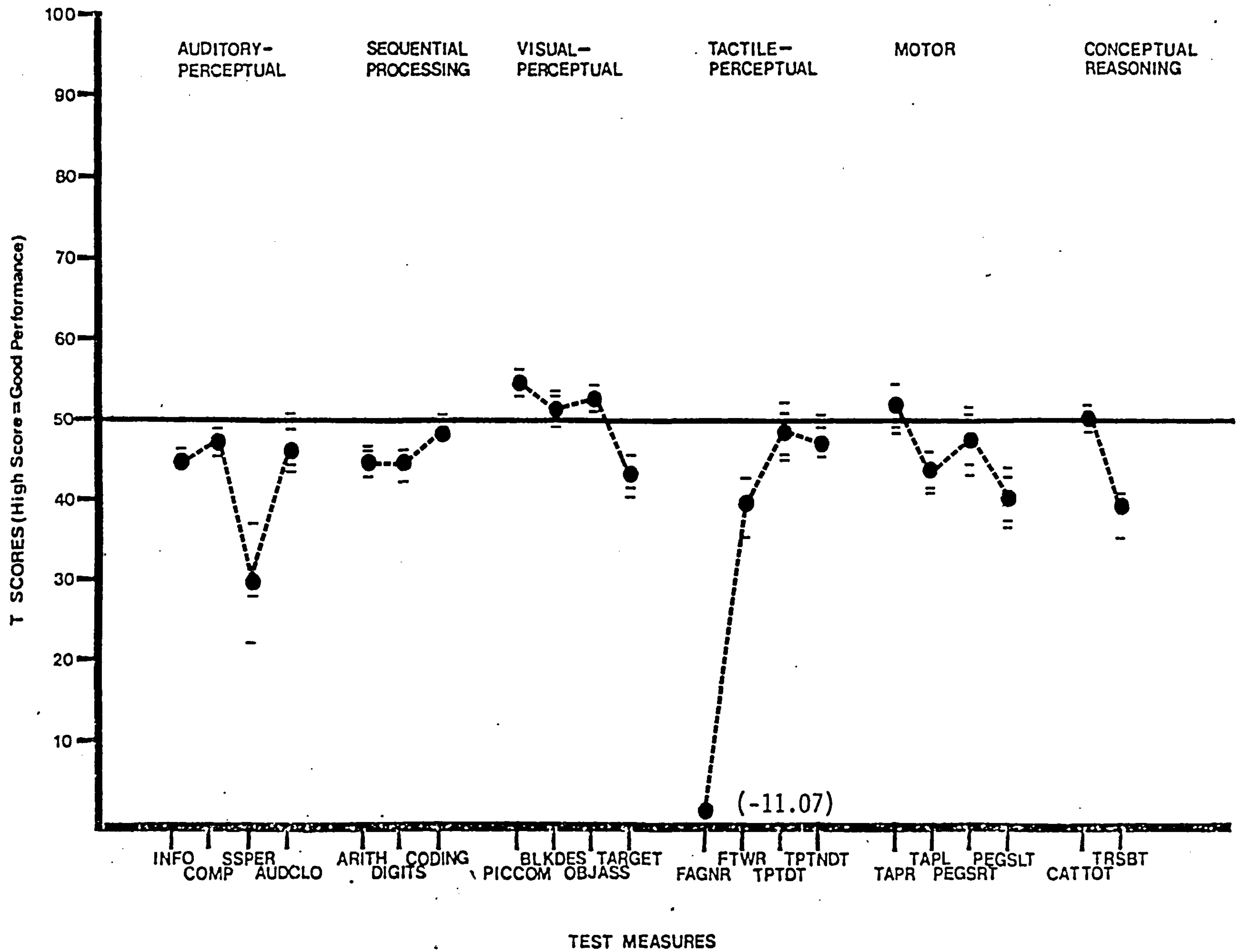

Figure 59. Type I.

Children in this group exhibited the following profile characteristics: (1) poor performances on several auditory-linguistic and sequential processing types of tasks involving phoneme-grapheme matching, sound-blending, general fund of information, "mental" numerical reasoning, and immediate recall for sequences of digits; (2) roughly normal performances on a task intended to determine understanding of social conventionality and social judgment (as assessed through a person's verbal reports), and on an associative learning task involving speed and accuracy of symbolic transcription; (3) age-appropriate or better performances on tasks intended to assess appreciation for visual-spatial relationships, and involving visual perceptual skill participation; (4) Well developed motor manipulatory and tactually-guided problem-solving ability, as well as adequate non-verbal reasoning skills with visually- or spatially-presented stimuli; (5) some difficulties remembering sequences of visual stimuli, and performing visual sequencing types of tasks involving symbolic shifting; (6) haptic deficiencies involving mild right-sided finger dysgraphesthesia, and marked right-sided finger agnosia; and (7) normally developed simple motor speed and fine finger dexterity with the right hand, but reduced motoric celerity and manipulative dexterity with the upper left extremity. In sum, *Type I* children were distinguished by the presence of a normally developed visual information processing system, rather good non-verbal problem-solving capabilities, some mild auditory information processing deficits and pronounced haptic deficiencies, especially tactile finger localization. Moreover, *Type I* children exhibited a mean WISC PIQ that exceeded the mean VIQ, and mean WRAT Reading, Spelling and Arithmetic scores that were all below the 30th centile.

The test profile for *Type I* is strikingly similar to the tactile finger localization group (Subtype A) of Fisk and Rourke (1979). Subtype A in that investigation was derived from a Q type multivariate correlational analysis conducted on a sample of 264 right-handed learning disabled children. *Type I* also bears some relation to the group of children of the Satz, Friel & Rudegair (1974) study who encountered problems identifying simple tactile stimulations delivered to the fingers, and to the haptic disturbance group (Type 2) of Petrauskas and Rourke (1979). Both of these investigations utilized exclusively populations of dextral subjects as well.

The patterns of adaptive deficiencies exhibited by the Subtype A subjects of Fisk and Rourke (1979) and the Type 2 subjects of Petrauskas & Rourke (1979) were interpreted by both sets of authors to be reflective of compromised brain functioning and tended to raise some question regarding the functional integrity of the posterior portions of the left cerebral hemisphere. It is hypothesized that a similar area of compromised brain functioning exists in *Type I* children of the current study.

Type II

This group is composed of children who constituted Factor 2 (n = 26) and Cluster 3 (n ≐ 51) from the left-handed sample, and Factor 1 (n = 20), group average cluster 3 (n = 41) and centroid sorting Cluster 2 (n = 40) from the right-handed sample. Figure

60 is a graphic representation of *Type II*. Again, this figure represents a compositive of all mean T score profiles constituting this subgroup (i.e., Figures 3, 23, 10, 39 and 45).

The *Type II* profile was characterized by the following: (1) clear impairment on some auditory-verbal and psycholinguistic tasks involving the associating of sounds and symbols, assessing of general knowledge (as is normally acquired through everyday activities), "mental" numerical reasoning, and amnestic skill participation (e.g., immediate memory for series of numbers) as well as some mild difficulty blending sounds to form words; (2) relatively better but slightly depressed performances on a test intended to assess understanding of social conventionality and social judgment, and on a task requiring the associating of symbols to their appropriate numerical counterparts; (3) well developed visual-perceptual and spatial visualization abilities; (4) some difficulty reproducing graphically sequences of visual stimuli, and negotiating visual-spatial arrays on the basis of numerical and alphabetical sequences; (5) age-appropriate tactile- and kinesthetic-perceptual skills, including well developed nonverbal tactually-guided problem-solving abilities; (6) adequate performance on a task involving inductive and deductive reasoning with visually- or spatially-presented stimuli; and (7) normally developed simple motor speed bilaterally, and fine manipulative dexterity with the right hand, but fine finger dexterity deficits with the left hand. In sum, *Type II* children manifested well-developed visual and tactile information processing systems, appeared to be good problem-

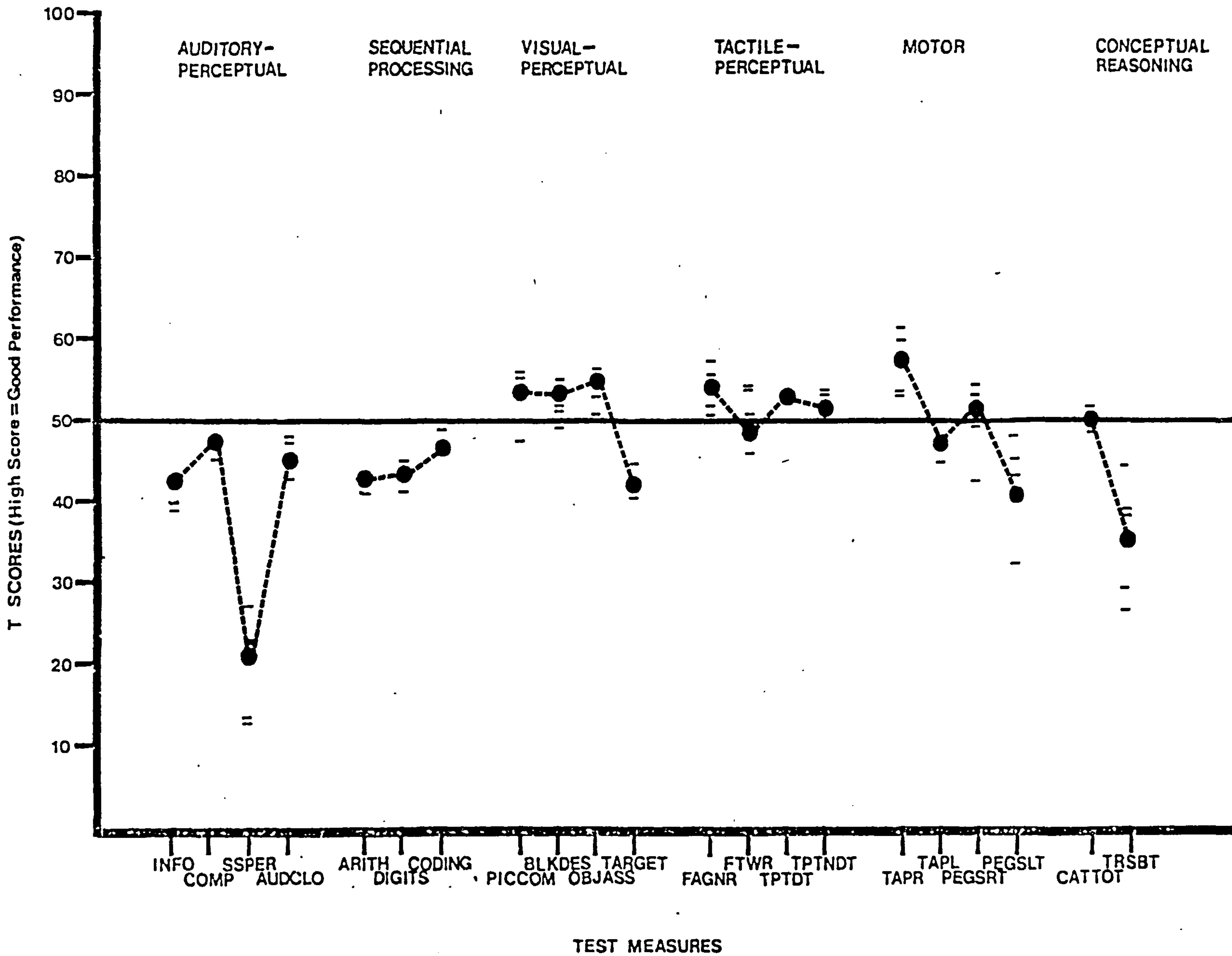

Figure 60. Type II.

solving strategists, and presented with reasonably well-developed simple and more complex psychomotor skills. Conversely, they exhibited clear weaknesses in their ability to process information of an auditory linguistic nature and demonstrated some verbal coding or labelling deficiencies. Children in this group were also seen to exhibit the largest mean WISC low VIQ-high PIQ discrepancy, and mean WRAT Reading, Spelling and Arithmetic subtest performances were all well below the 30th centile ranking.

These children bear a striking resemblance to the poor auditory-verbal processing group (Subtype B) of Fisk and Rourke (1979), and to the language disturbance group (Type I) of Petruaskas and Rourke (1979). They also seem most similar to the language disorder groups of Kinsbourne and Warrington (1963) and Mattis et al., (1975), and the sound-symbol integration deficiency group (i.e., dysphonetic dyslexia) of Boder (1973). Again, all of these investigators employed samples of right-handed children.

The functional intergrity of some of those abilities normally thought to be subserved by the temporal region of the left cerebral hemisphere was hypothesized by both Fisk and Rourke (1979) as well as by Petrauskas and Rourke (1979) as being somewhat compromised in their Subtype B and Type I children, respectively. A similar area of dysfunction is likely to be present in *Type II* children of the present study.

Type III

Included in this group are children who constituted Factor 3 (n = 19) and Cluster 4 (n = 35) from the left-handed sample, and Factor 3 (n = 18), group average Cluster 4 (n = 21) and centroid sorting Cluster 4 (n = 22) from the right-handed sample. Once again, the test profile for this group is plotted in terms of a composite of all mean T score patterns (i.e., Figures 5, 24, 12, 40 and 47) in Figure 61.

Visual inspection of the profile for *Type II* children revealed the following characteristics: (1) some auditory-verbal processing weaknesses involving a limited acquisition of general information, deficient sound-symbol matching skills, poor sound blending abilities, and somewhat underdeveloped "mental" numerical reasoning skills; immediate recall for short bursts of non-redundant auditory-verbal information (e.g., sequences of digits) as well as understanding of social conventionality and social judgment were both mildly impaired; an associative learning task involving speed and accuracy of symbolic transcription was performed in an age-appropriate manner; (2) normally developed visual-perceptual, perceptual organizational and visual-spatial skills; (3) poor performance on one visual-spatial sequential memory task; (4) mild finger agnosia and pronounced finger dysraphesthesia with the upper right extremity; average and below-average tactually-guided problem-solving capabilities with the dominant and nondominant hands, respectively; (5) normally developed simple motor speed and speeded eye-hand coordination with the right hand, but clearly impaired skills within these areas with the left hand; and (6) slightly impoverished nonverbal reasoning capabilities, and clear difficulties performing visual sequencing tasks

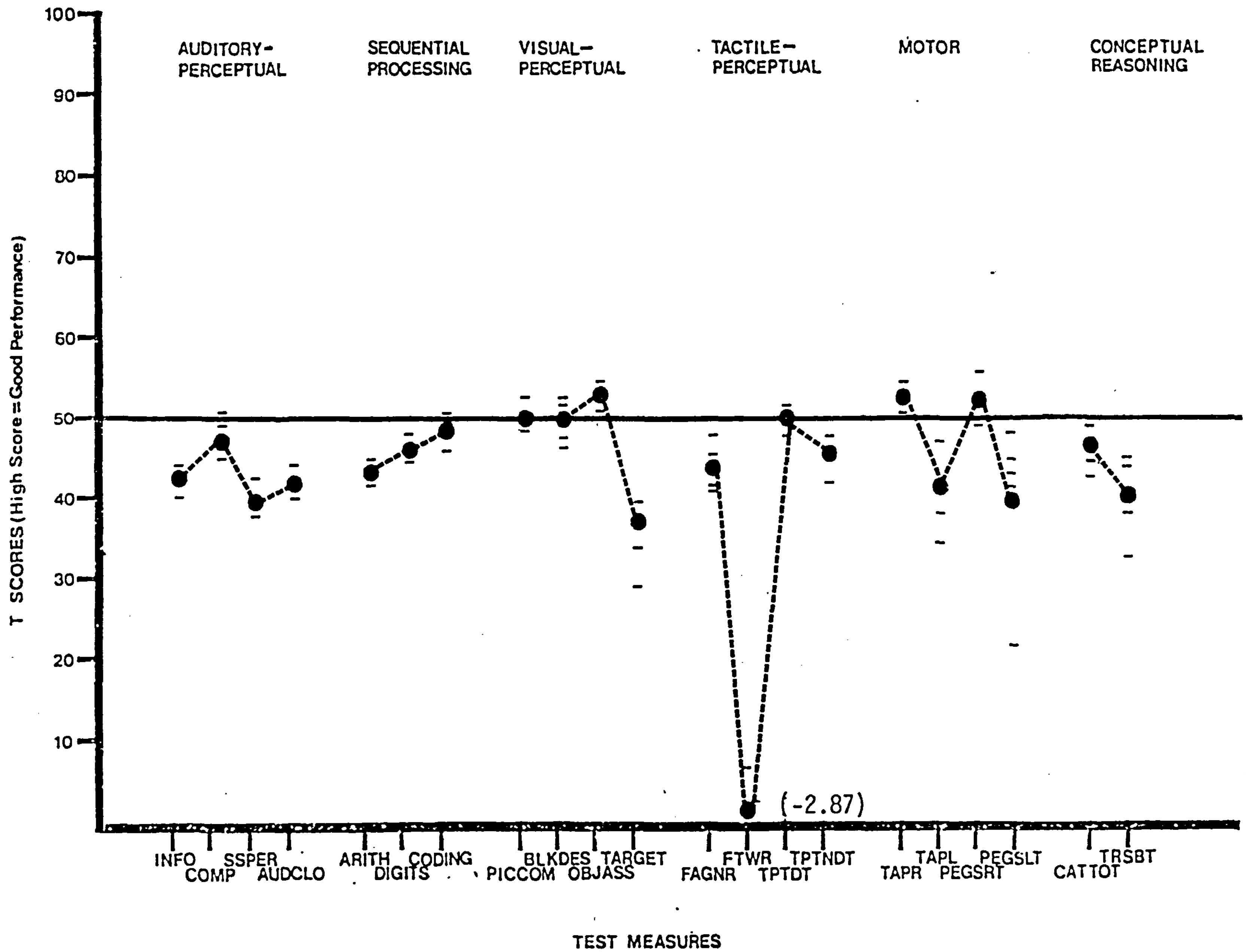

Figure 61. Type III.

involving symbolic shifting. Children in this group seemed to possess a reasonably well-developed visual-information processing system, and normally developed simple motor skills and motor manipulatory problem-solving abilities with the upper right extremity. On the contrary, children in this subgroup could be described as having some poor auditory-verbal and psycholinguistic skills, mild right-sided finger recognition deficits, and pronouned haptic deficiencies involving the detection of numbers written on the fingertips of the right hand. For *Type III* children, mean WISC PIQ exceeded VIQ, and mean WRAT Reading, Spelling and Arithmetic subtest scores were all below the 30th centile ranking. However, one of the members of this group (Cluster 4 from the sinistral sample) exhibited a WRAT subtest performance pattern of Reading above the 30th centile level, while both Spelling and Arithmetic were below this value.

The adaptive profile which characterized the *Type III* children was quite similar to the fingertip number writing deficit group (Subtype C) of Fisk and Rourke (1979). In fact, *Type III* children exhibited the highest mean age (12.59) of all of the groups, a finding consonant with the fact that Subtype C only emerged in the two oldest age-based samples (i.e., 11 to 12 years and 13 to 14 years) of the Fisk and Rourke investigation.

The preceding three groups of children appeared to be the most reliable subtypes, having been generated across all possible factor and clustering procedures. Four other less reliable (in the sense of having been only partially replicated) subgroups of learning disabled children emerged. A brief description of each of these is provided below.

Type IV

This group is composed of Factor 4 (n = 9) and Cluster 2 (n = 26) from the left-handed sample, and group average Cluster 1 (n = 24) and centroid sorting Cluster 7 (n = 23) from the right-handed sample. A comparable group did not appear to exist within the dextral factor structure.

Visual inspection of Figures 6, 22, 37 and 50 revealed that *Type IV* children were characterized by a slight reduction in general fund of information, and mild phoneme-grapheme matching skill deficiencies; a well developed understanding of social conventionality, and exceptionally good sound blending skills; mildly impaired arithmetic reasoning, auditory-verbal amnestic skills, and symbolic transcribing capabilities; a relatively good visual information processing system; mildly impaired performances on immediate memory for visual sequences, and on a visual sequencing task requiring the ability to shift "mental" set; normally developed right hand tactile finger localization, and dominant hand tactually-guided problem-solving skills; mild right-sided finger dysgraphesthesia, and weak tactually-guided behaviour with the non-dominant extremity; adequate nonverbal reasoning abilities; average and mildly deficient simple motor speeds with the right and left hands, respectively; and bilateral fine finger dexterity deficits, somewhat moreso with the left hand. The distinguishing feature of *Type IV* children centered around deficiencies in fine eye-hand coordination under speeded conditions. Children in this group were more apt to exhibit a very small WISC VIQ-PIQ discrepancy or, in some cases, a higher VIQ-lower PIQ pattern. Reading performance on the WRAT was more likely to exceed the 30th centile, while both Spelling and Arithmetic subtest scores were below this value.

This particular group bears some resemblance to Type 3 of Petrauskas and Rourke (1979), and is similar in some ways to the dyscoordination group of Mattis et al. (1975).

Type V

Included in this group are children who constituted Factor 5 (n = 6) from the left-handed sample, and Factor 6 (n = 8), group average Cluster 6 (n = 10) and centroid sorting Cluster 6 (n = 9) from the right-handed sample. However, intercorrelations between left- and right-handers within this group were rather low, whereas comparisons amongst the dextral sample yielded higher, more reliable intercorrelations. Thus, it would appear that this type may constitute an independent right-handed subgroup.

Examination of Figures 15, 42 and 49 suggested that *Type V* children are characterized by the following: (1) inconsistent performance on auditory-linguistic tasks involving understanding of social conventionality, phoneme-grapheme matching, and sound blending, while both general fund of information and arithmetic reasoning were consistently depressed; performances on immediate recall for digits and on an associative learning task involving speed and accuracy of symbolic transcription were roughly age-appropriate;

(2) normally developed visual and tactile perceptual information processing systems; (3) good nonverbal problem-solving skills, as well as the ability to moderate performances when the task required conceptual shifting; and (4) mildly and moderately deficient simple motor speeds with the right and left hands, respectively; average and mildly impaired fine manipulative skills with the dominant and non-dominant hands, respectively. These subjects also exhibited a fairly appreciable low VIQ-PIQ discrepancy on the WISC. While their WRAT subtest performance patterns were somewhat inconsistent, there was a trend for Reading to be somewhat higher than either Spelling or Arithmetic.

Type VI

This group contains children who constituted sinistral Factor 7 (n = 5), dextral Factor 7 (n = 15), dextral group average Cluster 7 (n = 23) and dextral centroid sorting Cluster 3 (n = 22).

While there was some degree of visual similarity between factor and cluster plots within this group (see Figures 16, 43, 46 and 9), most intercorrelation values were rather low. This would suggest that this type is the most unreliable. Briefly, however, with the exception of some inconsistency amongst performances within the auditory-linguistic and sequential processing realms, most neuropsychological adaptive skill areas yielded age-appropriate or better levels of performance. A low VIQ-high PIQ discrepancy of fairly large magnitude was exhibited by these children as well.

Type VII

This final group is composed of children who constituted Factor 4 (n = 11) and group average Cluster 5 (n = 12) from the right-handed sample. *Type VII* would appear to represent another independent right-handed subgroup, despite the fact that it did not emerge during the centroid sorting clustering procedure.

Inspection of Figures 13 and 41 suggested that *Type VII* children were characterized by some mild auditory perceptual deficiencies involving a reduced store of general information, under-developed sound-blending skills, and a somewhat limited under-standing of social conventionality; "mental" numerical reasoning skills and auditory-verbal amnestic abilities that were roughly normal, while performance on the Coding subtest was mildly deficient; well-developed visual and haptic information processing systems; good nonverbal reasoning capabilities; inconsistent performances on visual-sequencing tasks requiring symbolic shifting; normally developed simple motor speed and speeded fine eye-hand coordination with the upper right extremity, while performances with the left hand within these same areas were clearly deficient; and pronounced difficulties in immediate memory for sequences of visual stimuli. The distinguishing feature of *Type VII* children centered around deficiencies on the Target Test, a finding that may be reflective of a compromised ability in these children to apply verbal coding or labelling strategies efficiently. This group exhibited a minimal VIQ-PIQ discrepancy on the WISC. It should also be noted that this type obtained mean WRAT Arithmetic scores that were below the 30th centile level, while both Reading and Spelling scores were above this value.

Evaluation of Expectations

Hypothesis 1 suggested that different patterns of adaptive strengths and weaknesses may emerge in left- and right-handed learning disabled children as a function of manifest differences in specific patterns of cerebral organization that have been posited to exist between the handedness groups. This expectation was clearly not supported. In fact, the sorts of adaptive deficiencies exhibited by the group of left-handed children who were encountering learning problems in the present study were found to be remarkably similar to the types of cognitive deficiencies seen in a comparable group of right-handed age-mates included in the investigation, as well as to several other dextral learning disabled subgroups reported in the literature. However, the results of the quantitative classification analyses did suggest that the left-handers as a group appeared to constitute a more homogeneous population in regard to their patterns of performance on the battery of neuropsychological measures administered than did the similar group of right-handed children.

Failure to confirm the expectation that there are disparaties associated with sinistrality in regard to adaptive ability structure may be reflective of the problems in identification or the difficulty in constructing a workable definition of sinistrality (i.e., on what basis is preferred handedness determined?). In the current study, name-writing hand was chosen as an initial index of hand dominance. Left-handers identified on this basis were then examined more closely to determine their demonstrated hand proficiency on two skilled manual dexterity tasks: simple motor speed, and speeded fine eye-hand coordination. Neither one of these considerations appeared to influence the patterns of performance seen within the population of children assessed. Perhaps different methods of handedness determination (or classification) would reveal measurable differences between dextral and sinistral learning disabled children (Roszkowski, Snelbecker, & Sacks, 1981). In addition, a closer examination of hand, foot and eye dominance may eventuate in findings that are consistent with ability differences as a function of lateral preference patterns (Dean et al., 1981).

Hypotheses 2 and 3 dealt with two issues, one focussing on the importance of an individual's familial handedness history and one focussing on the significance of degree or intensity of an individual's left-handedness. Both of these factors have been posited as possessing predictive value in terms of being able to distinguish between sinistrals with different patterns of hemispheric specialization. In the present study, it was felt that if these particular variables were related to cerebral laterality, then the multivariate classification methods should generate subgroups that have members who report mostly sinistral or mostly dextral biological relatives and/or subtypes that exhibit a membership composition reflective of different measurable variations in consistency and degree of hand usage across a variety of manipulative and behavioural tasks. Neither of these expectations was supported by the data. That is to say, the results of a series of nonparametric analyses indicated that subgroups could not be distinguished from one another on the basis of hand preference, hand proficiency and familial handedness composition.

The meaningfulness of the familial sinistrality findings, in particular, can be challenged quite easily. There were at least two problems in obtaining an accurate assessment of familial handedness tendencies. First, since this study tended to regard familial sinistrality as positive if at least one parent or sibling was left-handed, a large number of "false positives" could have been easily reported. For instance, 60% of the left- and 65% of the right-handed sample were considered to be familial sinistral subjects based on a single sibling criterion (see Table 2). However, included within these values were several very young siblings reported as exhibiting a left-sided preference despite the likelihood that hand dominance had not yet been clearly established in these children. Moreover, Bishop (1980) has recently suggested that family size may be an important factor to consider when assessing familial sinistrality. According to Bishop, the problem is that the a priori probability that an individual will have a sinistral relative increases with the number of relatives he has. Thus, adopting a single parent or sibling criterion could possibly confound the effects of familial sinistrality and family size.

Finally, it has been demonstrated rather convincingly that subgroups generated by means of one multivariate statistical procedure can be reliably detected through the application of several other classification methods as well. Indeed, Q type and cluster analyses solutions were in perfect agreement for the left-handed sample of children, while solutions remained fairly well-defined across taxonomic procedures for the right-handed data set. These findings along with the success Doehring and his associates (1979) have experienced in their application of multiple classification methods confirms the usefulness and suitability of these instruments for providing a reliable taxonomy of learning disabilities.

Implications

One purpose of this study was to isolate and define systematically the sorts of adaptive similarities and dissimilarities that may exist between left- and right-handed learning disabled children. Toward this end a multivariate quantitative taxonomic procedure was used to delineate distinct subgroups of children who had been encountering learning problems. Secondly, an attempt was made to validate the existence of subtypes by assessing their preservation across different classification methods.

Several conclusions or generalizations can be drawn from the results of the study.

(1) Left- and right-handed children with learning problems would appear to exhibit very similar adaptive ability profiles. The classification analyses suggested the presence of at least

three highly similar subtypes of learning disabled children within two age-equivalent handedness-based samples. In turn, the subgroups were found to bear a striking resemblance to other dextral subtypes reported in the research literature (Boder, 1973; Fisk & Rourke, 1979; Mattis et al., 1979; Petrauskas & Rourke, 1979; Satz et al., 1974). While these findings support the notion that learning disabled children constitute a heterogeneous group in regard to their adaptive ability structures (Benton, 1975; Rourke, 1978a, 1978b, 1981a, 1981b, 1981c; Vernon, 1977), it would appear that handedness *per se* may not be an especially important consideration in the search for *types* of ability differences in learning disabled children. This finding would appear to be in agreement with several studies that have reported the absence of any significant ability differences between left- and right-handed individuals (Annett & Turner, 1974; Hardyck, Petrinovich & Goldman, 1976; Kocel, 1977), but seems to be at odds with other studies that have reported the existence of information processing differences between the handedness groups (Bakker, 1972; Schevill, 1980).

(2) To aid in subtype interpretability, the independent factor and cluster graphs that madeup each of the *Type I*, *Type II* and *Type III* children were combined and an overall mean T score illustration was provided for each group. However, it was interesting to note that closer visual inspection of the independent factor and cluster profiles within each group revealed one feature that distinguished sinistral and dextral children. In all cases,

dextrals exhibited a clearly better right hand than left hand performance on the two psychomotor tasks (i.e., Finger Tapping and Grooved Pegboard), whereas sinistrals were found to demonstrate a smaller between-hand discrepancy. Most of the difference between the two handedness groups on this dimension occurred within the right-handed performances where dextrals were clearly more proficient with the use of this extremity. Left-handed performances were usually quite similar between the two samples. The differences seen on tasks of a motoric nature could suggest one of two alternative states of affairs. First, within the group of left-handers, the left-handed performances on skilled motor tasks could reflect some "shift" in handedness as a consequence of having sustained some degree of left hemispheric dysfunction. This would imply that the sinistral tendencies seen in these children are a manifestation of brain pathology, a view expounded upon by a number of investigators (Annett, 1964; Bakan, 1971, 1977; Satz, 1972, 1973). However, this possibility seems rather remote since there was little evidence to suggest that left-handers in this study encountered any particular difficulties with their right hand that would have caused them to engage the use of their left hand as the dominant extremity (i.e., Finger Tapping and Grooved Pegboard scores were usually within an age-approriate range with the right hand). A second more parsimonious possibility is that the motor performances within the ability repertoires of both handedness groups represent the results of social conditioning and practice (Collins, 1970, 1975). That is, perhaps sinistrals exhibit a smaller between-hand discrepancy because they are natural left-handers who have been actively taught to use their right hand as a result of social and cultural influences. The same social conditioning in natural right-handers, of course, would result in a larger difference score between the extremities.

(3) The results of this study should not be construed as suggesting that left-handedness and its associated characteristics are unworthy of further exploration. Indeed, the results of studies of lesion-produced deficits and right-left auditory and visual perceptual asymmetries have provided a source of strong support for a relation between handedness and cerebral organization, despite the lack of consistent agreement amongst researchers within the area. The discrepancy between these findings and the current results invites further study into the relation between handedness, adaptive ability structure, and performance on visual half-field, dichotic listening, or dichotic monitoring types of tasks.

(4) Related to (3) above, an obvious research direction to pursue is to obtain some further information on the possible neurological determinants underlying the different subtype structures. Neurophysiological investigations involving visual or auditory evoked potentials would seem to be especially valuable in this regard (Hughes, 1978).

(5) An *internal* validation method (e.g., split-sample replication) was employed in the present study to determine the stability and usefulness of the clustering solutions. As an alternative, it would be of interest to see whether one subtype can be distinguishable from other subtypes on a wide variety of measures

and attributes not included in the initial classification process (i.e., *externally* validating the derived solutions). For example, subtype differences across such variables as academic achievement level (WRAT Reading, Spelling and Arithmetic), presence of learning problems among other family members, prevalence and/or type of birth complication, or birth order could be assessed through the application of parametric (MANOVA, ANOVA) or nonparametric (Chi-Square) statistical methods.

(6) The clarification and differentiation of the quality of cognitive impairment associated with learning difficulties has obvious remedial management implications. Since one important therapeutic objective is to promote academic remedial programmes tailored to the individual's specific cognitive strengths and weaknesses, identification of the "patterning" of adaptive skill deficits becomes especially important. Indeed, clinical experience has suggested that a remedial management intervention that fails to "fit" the adaptive ability makeup of the child can, in effect, be counterproductive in respect to the acquisition of basic academic-related skills, with consequent (often negative) impact on personality development.

(7) Finally, there has been a persistent tendency to attribute a variety of behavioural deficits to sinistrality. Researchers continue to argue for an association between deficit and left-handedness, despite the burgeoning amount of evidence to disclaim any significant link between cognitive deficiency and handedness. Moreover, it is probably not too presumptuous to hypothesize that

the tendency to believe that sinistrality is a sign of possible deficit likely pervades much of the clinical practice as well. At least in regard to the clinical populations studied within the confines of this investigation, the results would suggest that left-handedness more often times than not should be viewed as a "red herring", not worthy of the pathognomonic importance attributed to it.

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APPENDIX A

Parent Questionnaire

QUESTIONNAIRE

Date ______________________

Child

NAME ______________ AGE ______ DATE OF BIRTH ____________

SEX ______ EDUCATION ____________ SCHOOL ____________

Father

Name ______________ Age ______ Date of Birth ____________

Country of Birth ____________ Education ________ Occupation ________

Handedness (please underline) RIGHT LEFT

Mother

Name ______________ Age ______ Date of Birth ____________

Country of Birth ____________ Education ________ Occupation ________

Handedness (please underline) RIGHT LEFT

Religion ______________________________

Language Spoken in Home ______________________________

Family Doctor's Name ______________________________

Is child adopted? ______________________________

Is child presently on medication? ______ Kind? ______________

For what reason? ______________________________

Number of Children ______________

This child's position in birth order ______________

CHILDREN'S NAMES

						(Handedness 'underline')	
(1)	______________	Age	______	Grade	________	RIGHT	LEFT
(2)	______________	Age	______	Grade	________	RIGHT	LEFT
(3)	______________	Age	______	Grade	________	RIGHT	LEFT

(cont'd on next page)

(Handedness ' underline')

(4)	______	Age	______	Grade	______	RIGHT	LEFT
(5)	______	Age	______	Grade	______	RIGHT	LEFT
(6)	______	Age	______	Grade	______	RIGHT	LEFT
(7)	______	Age	______	Grade	______	RIGHT	LEFT
(8)	______	Age	______	Grade	______	RIGHT	LEFT
(9)	______	Age	______	Grade	______	RIGHT	LEFT
(10)	______	Age	______	Grade	______	RIGHT	LEFT

[illegible] of person filling out this information ______________________

Relationship to child ______________________

Please make a complete description of your child's difficulties including the reason why your child was referred to this unit.

____

____

____

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Does your child wear glasses? ______________________

If so, for what reason? ______________________

Is he wearing glasses during the administration of these tests?

____

Please answer the following questions as fully as possible. If there is not enough room, use the back of the page.

1.	Birth weight Comment			2.	Premature (Underline) If yes, how many days premature? Comment	Yes	No
3.	Difficulty at birth If yes, please comment	Yes	No	4.	Respirator used Comment	Yes	No
5.	Anemia or jaundice Comment	Yes	No	6.	Meningitis If yes, what age? Comment	Yes	No
7.	Polio If yes, what age?____ Comment	Yes	No	8.	Diabetes Age? ________ Comment	Yes	No
9.	High Blood Pressure Age? ________ Comment	Yes	No	10.	Heart Disease Age? ________ Comment	Yes	No
11.	Rheumatic Fever Age? ________ Comment	Yes	No	12.	Chorea Age? ________ Comment	Yes	No
13.	Scarlet Fever Age? ________ Comment	Yes	No	14.	Measles Age? ________ Comment	Yes	No

15. Abnormal movements, sensations Yes No
Age? ______

16. Other Illnesses

17. High Fever (over 104) Yes No
Length of fever ______
Age? ______
Comment

18. Headaches Yes No
Frequency ______
Age? ______
Comment

19. Coma Yes No
Duration? ______
Cause? ______
Age? ______
Comment ______

20. Dizziness Yes No
Frequency? ______
Age? ______
Comment

21. Long periods of nausea Yes No
Age? ______
Comment

22. Overcome by gas Yes No
Length of time overcome
Age? ______
Comment

23. Partially drowned Yes No
Age? ______
Comment

24. Dazed or unconscious from sport, fight, fall struck by object, automobile accident. Yes No
Duration ______
Age? ______
Comment

25. Epilepsy or convulsions Yes No
Type ______
Frequency ______
Controlled with drugs Yes No
Comments

26. Exposed to High Voltage Yes No
Age? ______
Comment

27. Sun Stroke Yes No
Age? ______
Comment

28. Foot, Arm, Hand, Wrist Injuries Yes No
Age? ______
Comments

PLEASE ANSWER ALL QUESTIONS	No	Yes-A Little Bit	Yes Very Much	Remarks
During Meals				
29. Up and Down at table	___	___	___	___
30. Interrupts without regard	___	___	___	___
31. Wriggling	___	___	___	___
32. Fiddles with things	___	___	___	___
33. Talks excessively	___	___	___	___
B. Television				
34. Gets up and down during program	___	___	___	___
35. Wriggles	___	___	___	___
36. Manipulates objects or body	___	___	___	___
37. Talks incessantly	___	___	___	___
38. Interrupts	___	___	___	___
C. Doing Home-Work				
39. Gets up and down	___	___	___	___
40. Wriggles	___	___	___	___
41. Manipulates objects or body	___	___	___	___
42. Talks incessantly	___	___	___	___
43. Requires adult supervision or attendance	___	___	___	___
D. Play				
44. Is unable to play	___	___	___	___
45. Inability for quiet play	___	___	___	___
46. Constantly changing activity	___	___	___	___
47. Seeks parental attention	___	___	___	___
48. Talks excessively	___	___	___	___
49. Disrupts other's play	___	___	___	___
E. Sleep				
50. Has difficulty settling down for sleep	___	___	___	___
51. Inadequate amount of sleep	___	___	___	___
52. Is restless during sleep	___	___	___	___

		No	Yes—A Little Bit	Yes Very Much	Remarks
F.	Behaviour Away From Home (Except School)				
	53. Is restless during travel				
	54. Is restless during shopping (includes touching everything)				
	55. Is restless during church, movies				
	56. Is restless during visiting friends, relatives, etc.				
G.	School Behaviour				
	57. Up and down				
	58. Fidgets, wriggles, touches				
	59. Interrupts teacher or other children excessively				
	60. Constantly seeks teacher's attention				
	TOTAL SCORE				

PLEASE ANSWER ALL QUESTIONS

	No	Yes—A Little Bit	Yes Very Much	Remarks
61. Thumb sucking				
62. Restlessness, inability to sit still				
63. Attention-seeking, "show-off" behaviour				
64. Skin Allergy				
65. Doesn't know how to have fun; behaves like a little adult.				
66. Self-consciousness; easily embarrased				
67. Headaches				
68. Disruptiveness; tendency to annoy and bother others.				
69. Feelings of inferiority				
70. Dizziness, vertigo				
71. Boisterousness, rowdiness				
72. Crying over minor annoyances and hurts				
73. Preoccupation; "in a world of his own".				
74. Shyness, Bashfulness				
75. Social withdrawal, preference for solitary activities.				
76. Dislike for school				
77. Jealousy over attention paid to other children				
78. Difficulty in bowel control, soiling				
79. Short attention span				
80. Prefers to play with younger children				
81. Lack of self-confidence				
82. Inattentiveness to what others say				

		No	Yes—A Little Bit	Yes Very Much	Remarks
83.	Easily flustered and confused				
84.	Lack of interest in environment, generally "bored" attitude				
85.	Fighting				
86.	Nausea, vomiting				
87.	Temper, tantrums				
88.	Reticence, secretiveness				
89.	Truancy from school				
90.	Hypersensitivity; feelings easily hurt				
91.	Laziness in school and in performance of other tasks.				
92.	Anxiety, chronic general fearfullness				
93.	Irresponsibility, undependability				
94.	Excessive daydreaming				
95.	Masturbation				
96.	Hay fever and/or asthma				
97.	Tension, inability to relax				
98.	Disobedience, difficulty in disciplinary control				
99.	Depression, chronic sadness				
100.	Unco-operativeness in group situations				
101.	Aloofness, social reserve				
102.	Passivity, suggestibility, easily led by others				
103.	Clumsiness, awkwardness, poor muscular co-ordination				
104.	Stuttering				
105.	Hyperactivity; always on the go".				
106.	Distractibility				
107.	Destructiveness in regard to his own and/others'property.				
108.	Negativism, tendency to do the opposite of what is required.				
109.	Impertinence, sauciness				
110.	Sluggishness, lethargy				
111.	Drowsiness				
112.	Profane language, swearing, cursing				
113.	Prefers to play with older children				
114.	Nervousness, jitteriness, jumpiness; easily startled.				
115.	Irritability; hot-tempered, easily aroused to anger				
116.	Eneuresis, bed-wetting				
117.	Stomach-aches, abdominal pain				
118.	Specific fears, e.g., of dogs, of the dark.				
119.	Seizures				
120.	Bizarre content of thought				
121.	Fluctuating performance				

		No	Yes-A Little Bit	Yes Very Much	Remarks
122.	Socially inept behaviour				
123.	Tics				
124.	Danger to self				
125.	Danger to others				
126.	Excessive talking				
	TOTAL SCORE				

Has your child received any of the following examinations? If so, who performed the examination and when was this completed?

Examinations	Physician/Agency	Date
Electroencephalogram (EEG)		
Neurological		
Hearing		
Vision		
Speech		
Psychology		
Social Work		
Psychiatric		

APPENDIX B

Description of Tests Included in the Neuropsychological Battery[1]

[1]Adapted from the description of tests distributed by the Department of Neuropsychology, Windsor Western Hospital Centre, Windsor, Ontario.

DESCRIPTION OF TESTS

TESTS ADMINISTERED TO ALL CHILDREN (AGES 5-15)

WECHSLER INTELLIGENCE SCALE FOR CHILDREN. (Wechsler, 1949)

Full Scale IQ. A composite score derived from the total scaled subtest scores. Indicative of overall "intellectual" functioning.

Verbal IQ. A composite score derived from the total scaled scores of six Verbal subtests. Indicative of overall "verbal" functioning.

Performance IQ. A composite score derived from the scaled scores of the five Performance subtests (excluding the Mazes test). Indicative of overall non-verbal, "visual-perceptual" functioning.

Verbal Subtests

Information. 30 questions. Involves elementary factual knowledge of history, geography, current events, literature, and general science. Score: number of items correct. Task Requirement: retrieval of acquired verbal information. Stimulus: spoken question of fact. Response: spoken answer.

Comprehension. 14 questions. Involves the ability to evaluate certain social and practical situations. Score: number of items correct. Task Requirement: evaluation of verbally formulated problem situations. Stimulus: spoken request for opinion. Response: spoken answer.

Arithmetic. 16 arithmetic problems of increasing difficulty. Score: number of problems correctly solved, with time credit. Task Requirement: arithmetic reasoning. Stimulus: spoken (first 13 items) or printed (last 3 items) question. Response: spoken answer.

Similarities. 16 pairs of words. The most essential semantically common characteristic of word pairs must be stated. Score: number correct. Task Requirement: verbal abstraction. Stimulus: spoken question. Response: spoken answer.

Vocabulary. 40 words. Spoken definition of words. Score: number of words correct. Task Requirement: verbal definition. Stimulus: spoken word. Response: spoken definition.

Digit Span. Repetition in forward order of three- to nine-digit numbers and repetition in reversed order of two- to eight-digit numbers. Score: simple total of forward and reversed digit span. Task requirement: short-term memory for digits. Stimulus: spoken numbers. Response: spoken numbers.

Performance Subtests

Picture Completion. 20 pictures of familiar objects, each with a part missing. The missing part is identified from simple line drawings.

Score: number of missing parts correctly identified. Task requirement: location of missing part on the basis of memory of the whole object. Stimulus: picture. Response: spoken name of missing part.

Picture Arrangement. 11 series of picture cards. Pictures are sequentially arranged to form a story. Score: total credits for speed and accuracy of arrangement. Task Requirement: manipulation of the order of picture cards to form the most probable sequence of events. Stimulus: pictures. Response: simple motor manipulation.

Block Design. 10 designs. Arrangement of coloured blocks to form designs which match those on printed cards. Score: total score for speed and accuracy of block placement. Task requirement: arrangement of blocks to match a printed design. Stimulus: printed geometric design. Response: manipulation and arrangement of blocks.

Object Assembly. 4 formboards (puzzles). Parts of each formboard are to be arranged to form a picture. Score: total score for speed and accuracy of assembly. Task Requirement: spatial arrangement of parts to form a meaningful whole. Stimulus: disarranged parts of picture. Response: complex manipulation and arrangement of parts.

Coding. 93 digits, preceded by a code which relates digits to symbols. Symbols are to be written below digits as rapidly as possible. Score: number of symbols correctly written within a fixed time. Task requirement: association of digits and symbols by direct visual identification or by short-term memorization. Stimulus: printed digits and symbols. Response: rapid co-ordination of visual identification with a complex writing response.

<u>PEABODY PICTURE VOCABULARY TEST FORM A.</u> (Dunn, 1965)

Picture Vocabulary, Oral Raw Score, Oral IQ. 150 sets of 4 line drawings, with which 150 words of increasing difficulty are to be associated. The words are those of Form A of the Peabody Vocabulary Test. Score: total correct picture-word associations. Task requirement: selection of picture most appropriately related to the spoken word. Stimulus: 4 visual pictures, 1 spoken word. Response: simple pointing response. Oral IQ is the transformation of the oral raw score to an IQ score on the basis of test norms.

<u>WIDE RANGE ACHIEVEMENT TEST.</u> (Jastak & Jastak, 1965)

Reading. Standardized test of oral word reading achievement. Score: centile score based on total number of words correctly read aloud. Task requirement: association of printed letters with spoken word. Stimulus: printed word. Response: spoken word.

Spelling. Standardized test of written spelling achievement. Score: centile score based on total number of words correctly spelled. Task requirement: written production of spoken word. Stimulus: spoken word. Response: written word.

Arithmetic. Standardized test of written arithmetic achievement. Score: centile score based on total number of correct solutions to progressively more difficult arithmetic problems. Task requirement: solution of arithmetic problems. Response: written answers.

OLDER CHILDREN'S BATTERY (AGES 9-15)

TESTS FOR SENSORY-PERCEPTUAL DISTURBANCES. (Reitan, 1965)

Tactile Perception

After determining S's ability (without vision) to perceive unilateral stimulation delivered to the right and left hand and face, unilateral stimulation is interspersed with simultaneous bilateral hand stimulation and simultaneous contralateral hand-face stimulation. The score is the number of errors for each hand and each side of the face under all conditions.

Auditory Perception

S is required to correctly identify (without vision) the ear to which an auditory stimulus is presented. The stimulus is produced by rubbing the fingers together lightly. Following this determination of S's ability to perceive unilateral stimulation, bilateral stimulation is interspersed with the unilateral stimulation. The score is the number of errors for each ear under all conditions.

Visual Perception

S is required to identify correctly slight finger movements presented in a confrontation manner to the visual fields. Stimulation is presented initially unilaterally and then simultaneous bilateral stimulation is interspersed with the unilateral trials. The score is the number of errors made within the quadrants of the visual fields.

Finger Agnosia

S is required to identify (without the aid of vision) the finger which has been touched. Each of the five fingers is stimulated four times in an unsystematic order. First the right hand and then the left hand is stimulated. The score is the number of errors made with each finger for each hand.

Finger-Tip Number Writing Perception

S is required to verbalize (without the aid of vision) which of the numbers 3, 4, 5 or 6 has been written on his finger tips. A different finger of the right hand is used for each trial until four trials had been given for each finger. The procedure is then repeated for the left hand. The score is the number of errors made with each finger for each hand.

Coin Recognition

S is required to identify, by tactile perception only, 1-, 5-, and 10-cent pieces placed in his right hand, then his left hand, and then each coin placed simultaneously in both hands. The order of presentation is unsystematic. The score is the number of errors made with each hand under each condition.

TARGET TEST. (Reitan, 1970)

S is required to make a delayed response in reproducing visual-spatial configurations of increasing complexity tapped out by the examiner. The score is the number of items out of 20 correctly reproduced.

SPEED OF VISUAL PERCEPTION. (Doehring, 1968) Underlining test

These tests are intended to assess speed and accuracy of visual discrimination for various kinds of verbal and nonverbal visual stimuli presented singly and in combination. In general, the visual stimulus becomes more verbal and more complex with each succeeding sub-test. The first and the last sub-tests involve the same task in order to permit assessment of practice effect. A short practice item is given for each sub-test.

1 Single Number. S is required to underline the number 4 each time it appears on a printed page containing a random sequence of 360 single numbers. An example of the number to be identified is printed at the top of the page. A short practice test is given. Score: total numbers correctly underlined minus total incorrectly underlined in 30 seconds. Task requirement: locating and underlining a particular number interspersed among other numbers. Stimulus: random sequences of printed numbers. Response: simple underlining response to identify single numbers.

2 Single Geometric Forms. S is required to underline a Greek cross with a pencil each time it appears in random sequence among a series of 235 geometric forms, including squares, stars, circles, triangles, etc. The forms are about ¼" in height. Score: total crosses underlined minus total errors in 30 seconds. Task requirements: as in previous sub-test, but for identification of a geometric form.

3 Single Nonsense Letter. A single nonsense letter is interspersed among 10 structurally similar nonsense letters in a random sequence of 126 letters. Score: total correct minus incorrect underlined letters. Task requirement: as in previous sub-test, but for identification of a nonsense letter.

4 Gestalt Figure. The figure to be identified is a diamond about 1-¼" in height containing a square which in turn contains a diamond. This figure

is interspersed among similar figures in a random sequence of 168 figures. Score: total correct minus incorrect underlined figures in 60 seconds. Task Requirement: as in previous sub-test, but for identification of a complex figure.

5 Single Letter. The letter "s" is interspersed among 360 randomized letters. Score: number underlined minus number of errors in 30 seconds. Task requirement: as in previous sub-test, but for a single letter.

6 Single Letter in Syllable Context. 162 four-letter nonsense syllables are presented, 47 of which contain the letter "e". S is required to underline each syllable containing "e". Score: total correct minus incorrect in 45 seconds. Task requirement: as in previous sub-test, but for a letter in syllable context.

7 Two Letters. The letters "b" and "m" are interspersed among 360 randomized letters. Score: number underlined minus number of errors in 45 seconds. Task requirement: as in previous sub-test, but for two letters.

8 Sequence of Geometric Forms. Four geometric forms (triangle, Greek cross, circle, crescent) are presented in various orders for a total of 65 "syllables". S is required to underline only the groups with the order triangle, cross, crescent, and circle. Score: total groups correctly underlined minus errors in 60 seconds. Task requirement: same as in previous sub-test, but for groups of geometric figures.

9 Four Letter Nonsense Syllable, Unpronounceable. S is required to underline a four-letter nonsense syllable (fsbm) interspersed among 146 four-letter nonsense syllables. All syllables are made up of consonants, which renders them unpronounceable. Score: total correct minus incorrect in 60 seconds. Task requirement: same as in previous sub-test, but for nonsense syllables.

10 Four Letter Nonsense Syllable, Pronounceable. This task is the same as in the previous sub-test except that it involves the identification of a pronounceable nonsense syllable (narp) instead of an unpronounceable nonsense syllable. This syllable is interspersed among other nonsense syllables made up of the letters n, a, r, p. The time limit is 60 seconds.

11 Four Letter Word. The word "spot" is interspersed among 146 four-letter syllables made up of the letters, s, p, o, t. Score: total correct minus incorrect in 60 seconds. Task requirement: same as in previous sub-test, but for a four-letter word.

12 Unspaced Four Letter Word. The word "spot" is interspersed among the letters s, p, o, t, in various orders, with no syllabic spacing. Score: total correct minus incorrect. Task requirement: same as in previous sub-test, but for an unspaced word.

13 Single Number. This task is exactly the same as that involved in the first sub-test except that the number to be underlined is 5 instead of 4.

TRAIL MAKING TEST. (Reitan & Heineman, 1968)

The Trail Making Test consists of two parts, A and B. In Trails A, S is required, under time pressure, to connect the numbers 1 to 15 arranged on a page. The requirements are essentially similar in Trails B except that it is necessary to alternate between the numeric and the alphabetic series. The scores recorded are the number of seconds required to finish each part plus the number of errors made on each part.

HALSTEAD-WEPMAN APHASIA SCREENING TEST. (Reitan & Heineman, 1968)

Naming (Dysnomia). Five items which require S to name familiar objects. Score: number of errors.

Spelling (Spelling Dyspraxia). S is required to spell orally three spoken words. Score: number of errors.

Writing (Dysgraphia). Two items. S is required to write a word and a sentence which are presented to him orally. Score: number of errors.

Enunciation (Dysarthria). Three items. S is required to repeat three increasingly complex words spoken to him by the examiner. Score: number of errors.

Reading (Dyslexia). Six items. S is required to read numbers, letters, and words. Score: number of errors.

Reproduction of Geometric Forms (Constructional Dyspraxia). Four items. S is required to copy a square, a triangle, a Greek cross, and a key. Score: number of errors.

Arithmetic (Dyscalculia). Two items. S is required to solve two problems: one subtraction (written) and one multiplication (oral). Score: number of errors.

Understanding Verbal Instructions (Auditory-Verbal Agnosia). Four items. S is required to demonstrate an understanding of four verbal items. Score: number of errors.

SEASHORE RHYTHM TEST. (Reitan & Heineman, 1968)

The Rhythm Test is a sub-test of the Seashore Tests of Musical Talent. S is required to differentiate between 30 pairs of rhythmic patterns which are sometimes the same and sometimes different. The score is the number of errors.

SPEECH SOUNDS PERCEPTION TEST. (Reitan & Heineman, 1968)

S is required to attend to 30 tape-recorded nonsense syllables and to select the correct response alternative from among three printed choices. The score is the number of sounds correctly identified.

AUDITORY CLOSURE. (Kass, 1964)

S is required to blend into words 23 progressively longer chains of sound elements presented on tape. The score is the number of words correctly identified.

SENTENCE MEMORY. (Benton, 1965)

S is required to repeat sentences of gradually increasing length (from 1 to 26 syllables). These are presented on a tape recorder. The score is the number of sentences correctly repeated.

VERBAL FLUENCY. (Strong)

S is required to name as many words as he can, within 60 seconds, which begin with the sound "P", as in pig. This is repeated with the sound "C" as in cake. The score is the mean number of correct words for the two trials.

TESTS FOR LATERAL DOMINANCE. (Harris, 1947; Miles, 1929)

Hand Preference. S is required to demonstrate the hand used to throw a ball, hammer a nail, cut with a knife, turn a doorknob, use scissors, use an eraser, and write his name. The number of tasks performed with each hand is recorded.

Eye Preference. S is required to demonstrate the manner in which he would look through a telescope and use a rifle. The eye used for each task is recorded. In addition, S is given the Miles ABC Test for Ocular Dominance, in which (without ordinarily realizing that he is doing so) he has to choose one eye or the other to look through a conical appartus to identify a visual stimulus. The eye chosen on each of 10 trials is recorded.

Foot Preference. S is asked to demonstrate the manner in which he would kick a football and step on a bug. The foot used on each trial is recorded.

RIGHT-LEFT AWARENESS. (Piaget, 1928)

Twenty-six items on increasing difficulty designed to assess right-left order and memory with respect to parts of the body and objects arranged before S. Score: number correct.

STRENGTH OF GRIP. (Reitan, 1966)

The Smedley Hand Dynamometer is used to measure strength of grip. S is required to squeeze the dynamometer three times with his dominant hand and three times with his nondominant hand, alternating between hands on each trial. The mean pressure which he exerts on the three trials is recorded (in kgs) for each hand.

WRITING SPEED. (Reitan, 1966)

S is required to write his name with a pencil as rapidly as possible first with his preferred hand and then with his non-preferred hand. The score is the time taken for each hand.

FINGER TAPPING. (Reitan, 1966); FOOT TAPPING. (Knights & Moule, 1967)

For finger tapping S uses alternately the index finger of the dominant hand and of the nondominant hand. S is given four trials of 10 seconds each for both hands. The foot tapping test employs the same principles and instructions, but this time S uses his feet, alternating between the dominant foot and the nondominant foot. Four trials of 10 seconds are given for each foot. The score for both finger and foot tapping is the average of the best three out four trials.

MAZE TEST. (Kløve, 1963; Knights & Moule, 1968)

S is required to run a stylus through a maze which has the blind alleys filled and is placed at a 70 degree angle (on the Tactual Performance Test stand). Three scores are obtained: the number of contacts with the side of the maze, the total amount of time during which the stylus contacts the side of the maze, and the speed (total time from start to finish). These are electrically recorded. There are two successive trials with the dominant hand followed by two successive trials with the nondominant hand. The scores are the totals for the two trials with the dominant hand and the two trials with the nondominant hand.

GRADUATE HOLES TEST. (Kløve, 1963; Knights & Moule, 1968)

S is required to fit a stylus into a series of progressively smaller holes. S is required to hold the stylus in the centre of the holes for a 10-second period without contacting the edge. Two scores are obtained: the number of contacts with the edge of the hole, and the duration of the contact. These are recorded electrically. The test is performed once with the right hand and once with the left hand.

GROOVED PEGBOARD TEST (Kløve, 1963; Knights & Moule, 1968)

S is required to fit keyhole-shaped pegs into similarly shaped holes on a 4-in. x 4-in. board beginning at the left side with the right hand and at the right side with the left hand. Ss are urged to fit all 25 pegs in as rapidly as possible. Ss perform one trial with the dominant hand followed by one trial with the nondominant hand. The scores obtained are the length of time required to complete the task with each hand and the total number of times the pegs are dropped with each hand.

TACTUAL PERFORMANCE TEST. (Reitan, 1966)

This test is Reitan's modification for children of the test developed by Halstead (1947). Halstead's test was based in turn, upon a modification of the Sequin-Goddard formboard. S is blindfolded and not permitted to see the formboard or blocks at any time. The formboard is placed in a vertical disposition at an angle of 70 degrees on a stand situated on a table immediately in front of S. S is to fit six blocks into the proper spaces with the dominant hand, then with the non-dominant hand, and a third time using both hands. After the board and blocks had been put out of sight, the blindfold is removed and S is required to draw a diagram of the board representing the blocks in their proper spaces. In all, six measures are obtained. S is scored for the time needed to place the blocks on the board with the dominant, the nondominant, and both hands. A fourth measure is the sum of the time taken with the right, left and both hands. The Memory component of this test is the number of blocks correctly reproduced in the drawing of the board; the Location component is the number of blocks correctly localized in the drawing.

HALSTEAD CATEGORY TEST. (Reitan & Heineman, 1968)

S is required to respond to 168 visual choice stimuli, mostly geometric forms. Within any series, only one principle applies. But, in successive sequences of trials, the abstraction of principles of numerosity, oddity, spatial position, and relative extent is required for successful responding. The score is the number of errors.

APPENDIX C

Factor Loadings of Subjects in the Left-Handed Sample

FACTOR ANALYSIS OF SINISTRALS

ROTATED FACTOR PATTERN

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5	FACTOR6	FACTOR7
537.1	0.57464	0.58264	0.08037	0.01868	0.12817	-0.16967	-0.27425
1137.1	-0.03546	-0.07894	0.31177	0.03995	0.53194	-0.48465	0.05613
2123.1	-0.09629	0.31624	0.16187	0.45978	-0.06074	-0.20243	0.11825
2191.1	-0.46394	0.18932	0.28763	0.20622	-0.31022	-0.04573	-0.36570
2197.1	0.67689	0.07932	0.16137	-0.02084	-0.29760	-0.09424	0.07168
2259.1	0.63014	0.27409	0.16721	-0.36104	-0.33453	0.02302	-0.07521
2260.1	0.23565	0.55291	0.23011	-0.11415	-0.07150	-0.35834	-0.24101
2307.1	0.86393	0.13114	0.16532	-0.19196	-0.04967	0.24473	0.05241
2431.1	0.35217	0.63910	0.15982	-0.02106	0.41771	0.33648	-0.06858
2472.1	-0.12002	0.17627	0.01614	-0.15945	0.35849	0.21700	0.15748
1011.1	0.42902	0.11360	-0.02152	-0.56001	-0.11553	0.12163	-0.07384
1045.1	-0.38489	0.04725	0.41425	0.34086	-0.12869	0.49257	-0.09890
1269.1	0.59449	0.01420	0.18812	0.05980	-0.41651	-0.03839	-0.08858
3583.1	0.04992	-0.16858	0.54112	0.23912	-0.24718	-0.02157	-0.15981
9.2	0.42298	-0.30383	0.72692	0.30117	0.04228	-0.22605	-0.13370
566.1	0.01067	0.13040	0.61331	-0.06544	-0.20309	0.04601	-0.32971
1236.1	0.73949	-0.08172	-0.13770	0.04372	0.37616	-0.28650	-0.12916
1258.1	0.00116	0.51979	0.55832	-0.20789	0.13257	0.09732	0.33727
1293.1	0.67783	0.31852	0.34123	-0.23871	-0.30807	0.05362	0.30863
1392.1	0.64090	-0.17268	-0.09498	0.38562	-0.36832	-0.13405	0.22318
1416.1	0.94545	0.03875	-0.06306	0.10463	0.15176	-0.04354	-0.12374
1569.1	0.23955	0.25948	-0.40307	-0.39873	-0.02329	-0.19530	0.59933
2454.8	0.55291	0.34429	0.05704	0.12581	0.31772	-0.55113	0.13212
3339.1	0.06093	0.01940	0.83574	-0.05960	0.15519	0.25930	0.06040
3600.1	0.93813	-0.19467	-0.13533	0.02044	0.02097	0.06638	-0.08331
516.1	0.61116	-0.23372	0.42210	-0.16177	-0.16667	-0.10862	-0.36636
657.1	0.49359	0.06429	0.26337	-0.27982	0.32032	0.56259	0.10898
852.1	0.52949	0.09834	0.05857	0.46768	0.31190	-0.19474	0.24233
1678.1	-0.03213	0.02715	0.04575	0.59405	0.35402	0.04405	-0.10438
1805.1	0.20200	-0.27015	0.33073	-0.33156	-0.14856	0.35339	0.11221
1809.1	0.00538	0.21132	-0.33530	0.56173	0.13887	-0.05045	0.11915
2032.1	-0.15380	0.04427	-0.06430	0.54065	-0.00934	0.34534	-0.07239
3629.1	0.92889	-0.19834	0.15284	-0.12364	-0.03603	0.09457	0.13656
235.2	0.20094	0.77486	-0.22183	0.06814	-0.04180	0.04567	0.10076
249.2	-0.02961	-0.11210	0.89604	0.13892	0.05903	0.07057	-0.13068
470.1	0.62597	0.14843	0.07937	0.21049	0.04671	0.42736	0.39211
488.1	0.49333	-0.26504	0.55931	-0.05592	0.15672	-0.37931	0.08806
548.1	0.56655	-0.08167	0.08240	0.74172	-0.17753	0.01013	0.19043
549.2	-0.02499	-0.17763	0.07546	0.05669	0.22264	0.09251	0.05286
918.1	-0.08811	0.78327	0.31266	-0.12401	0.16666	0.02658	0.24957
998.1	-0.17761	-0.07972	-0.39331	-0.52674	-0.19401	0.11337	0.41186
1147.2	-0.09983	0.14934	-0.24003	-0.03841	-0.05541	-0.02231	0.51002
1150.1	0.08695	0.17582	0.33717	0.40992	-0.22394	0.06636	-0.17718

1934.1	-0.00077	0.83188	0.07248	-0.37873	0.04320	-0.04206	0.22870
1994.1	0.83476	0.18278	-0.08976	-0.04483	-0.21244	0.11097	-0.10972
2261.1	0.30566	0.61520	0.07507	-0.29114	-0.36163	0.06613	-0.06569
2266.1	0.90239	0.06173	0.03076	-0.11724	0.27993	0.16631	-0.00031
2397.1	-0.16964	0.65328	0.17398	-0.00742	0.26763	0.42273	0.16248
2594.1	-0.05181	0.85051	-0.03384	-0.09101	-0.19062	0.20966	-0.01013
2912.1	-0.10899	0.46227	0.01976	0.16862	0.43550	0.12793	-0.55132
3225.1	0.19863	0.51290	-0.09065	-0.04940	-0.06507	0.33921	0.09314
3241.1	-0.12411	0.00753	0.81807	-0.21433	-0.16325	0.20110	-0.14105
3245.1	0.18964	0.27958	-0.02967	-0.47456	-0.12970	0.17725	0.00556
3304.1	-0.18501	0.12377	0.23194	-0.01348	-0.02952	-0.46696	-0.12065
3324.1	0.04879	0.10761	0.28484	0.11010	0.02121	-0.04196	0.63196
3340.1	0.65458	-0.37760	0.12321	0.10096	0.26673	-0.22428	-0.38893
3387.1	0.77951	0.03690	-0.04333	0.37022	-0.05900	0.16613	-0.10707
3388.1	-0.24582	0.59348	0.39715	0.34228	-0.10620	-0.12436	0.00037
3436.1	0.05326	0.07454	0.96450	0.00274	0.04243	-0.05923	0.02672
3440.1	0.20776	0.49609	0.70854	0.07554	-0.10092	-0.27639	0.07894
3489.1	0.03108	0.17564	-0.32759	-0.32581	0.12513	0.37399	0.04936
3515.1	-0.25943	0.68463	0.19493	-0.10157	-0.29855	-0.15543	0.11487
3533.1	-0.07247	0.55770	0.05676	0.26745	0.00167	0.50521	-0.02913
3555.1	0.05003	0.27957	0.03290	-0.59194	0.03435	0.37151	0.29888
3559.1	-0.05470	-0.03414	0.17993	0.31341	-0.00385	0.20265	-0.09388
3574.1	0.00425	0.34098	-0.01066	-0.52046	-0.05491	-0.04162	0.41445
3585.1	0.78688	0.05107	0.07921	0.20321	-0.42912	-0.16253	0.14457
3646.1	0.11828	0.40667	0.72588	0.17117	-0.03994	-0.02597	0.33461
9037.1	0.80926	0.21957	0.04356	-0.07777	0.15444	-0.28058	-0.26574
9037.2	0.73520	0.01657	0.62655	-0.02642	-0.09238	-0.17545	-0.07201

FACTOR ANALYSIS OF SINISTRALS

ROTATED FACTOR PATTERN

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5	FACTOR6	FACTOR7
9039.1	-0.03056	0.35181	0.78638	0.20200	0.04131	0.05343	0.12152
332.2	-0.05540	-0.07670	0.12267	0.60750	0.20490	0.24231	0.53316
1155.1	-0.30964	-0.07885	0.07867	0.05069	0.05349	0.53401	-0.48209
1316.1	0.83898	-0.21365	0.31091	-0.11606	-0.14829	0.08442	-0.02266
1320.1	-0.06041	0.02523	-0.14165	0.78832	-0.02380	0.10231	0.20766
496.1	0.50348	0.64821	-0.05969	-0.09033	-0.10124	-0.19370	-0.03730
506.1	0.51361	-0.09860	0.05224	0.19271	0.01701	0.19445	0.31968
1060.2	-0.19554	0.09858	-0.28804	-0.50071	0.03665	0.16473	0.61298
1130.1	0.84101	-0.05842	-0.15125	-0.08981	-0.06156	-0.01225	0.22180
1816.1	0.48203	0.08043	-0.23024	0.73222	0.34399	-0.12173	-0.05332
1817.2	-0.46026	-0.18070	0.18925	0.12732	0.23410	-0.00216	-0.42058
1836.1	-0.02814	0.09475	-0.10324	0.76901	0.40102	0.22251	0.14036
1884.1	0.01392	0.09570	-0.04334	0.14820	0.57485	-0.02139	0.45456
2094.1	0.27529	0.30982	0.27560	0.35539	0.47759	0.05831	0.07278
491.1	0.04214	0.28105	-0.09492	-0.67210	-0.03519	0.10722	-0.22432
3359.1	-0.05228	0.16470	-0.04777	-0.79165	0.09744	-0.03274	0.34479
2118.1	0.45978	0.60354	0.27953	-0.00842	0.17640	-0.19556	0.18943
2113.1	-0.20116	0.19902	-0.33433	-0.39973	0.45249	-0.18048	0.09367
1700.1	-0.13171	0.25124	-0.00455	0.12131	0.11359	0.01649	-0.01283
1702.1	0.02456	-0.07648	0.15326	-0.05053	0.12294	0.59557	-0.09091
2637.1	-0.02687	0.34993	0.60695	0.12700	0.29456	0.15776	-0.39914
2643.1	0.90466	0.03328	0.01323	-0.15070	-0.09936	-0.30275	0.12636
787.1	0.22637	-0.05130	0.13309	-0.08739	-0.11195	0.18615	-0.03975
1507.1	-0.21741	0.71321	0.02879	0.24201	-0.24793	-0.08204	-0.06445
2773.1	0.27524	0.49019	-0.19209	0.16451	0.26999	-0.38041	-0.45354
1696.1	0.51136	-0.01715	0.04905	0.20234	0.32696	-0.51760	-0.34678
808.2	0.08441	0.80163	0.13591	-0.18113	-0.26530	0.33038	0.00643
984.1	0.58124	0.05910	0.09968	0.38987	-0.00982	-0.36857	0.23625
2223.1	0.09850	0.91702	0.06629	-0.01464	-0.27168	-0.02651	0.06878
2217.1	0.87367	-0.08967	-0.10161	-0.00904	-0.05315	0.18885	0.06927
964.1	0.09286	0.54392	0.49648	-0.04390	-0.03403	-0.48566	0.26441
1951.1	0.27163	0.29205	-0.19441	0.83051	0.09985	-0.12657	0.14179
1958.1	0.58525	0.19796	-0.11051	0.03121	0.07752	-0.28770	0.25781
3016.1	0.02801	0.18759	0.40918	-0.11922	0.16435	0.10859	0.55609
1749.1	0.63438	0.49231	-0.22846	-0.17835	-0.23913	0.19607	0.05239
1730.1	-0.57291	0.09877	-0.23931	0.09758	0.44375	0.24177	0.05026
602.1	0.66381	0.31074	0.05414	-0.08466	0.30613	0.20260	-0.16278
1523.1	0.72869	0.06216	0.34237	0.02274	0.21175	-0.35336	0.06444
2060.1	-0.01602	0.34452	-0.08706	0.14580	0.03523	-0.39209	0.37660
1391.1	0.95279	-0.12644	-0.05461	-0.11057	-0.01793	-0.00134	0.04604
9048.1	0.10232	0.22945	0.34274	0.24747	-0.45290	-0.03454	0.20161
1456.1	-0.10121	0.16708	-0.28169	0.56572	-0.15915	0.22218	0.40869
1892.1	-0.06152	0.78398	-0.17793	0.13549	-0.03623	-0.41009	0.21636
2073.2	-0.00925	0.72773	-0.12432	0.40699	0.03914	-0.20100	-0.03878
1516.1	-0.18556	-0.39237	0.20998	0.20940	0.33325	-0.45532	0.25109
2823.1	-0.17335	0.12875	0.23365	-0.19994	-0.57899	0.17630	0.01230
2050.1	0.88212	0.01431	-0.10526	0.23412	0.15981	0.01624	-0.13678

9021.1	0.94780	0.17019	-0.05203	0.15402	-0.02258	-0.01429	0.02790
1619.1	-0.03593	0.47272	0.20264	-0.10696	-0.15647	-0.49737	0.14978
1886.2	0.62103	-0.39885	0.34170	0.23392	-0.21262	-0.06757	-0.17611
2693.1	-0.27759	0.67381	0.10268	0.24006	0.21683	0.23554	0.10202
1840.1	0.02837	0.81546	-0.04450	0.11953	-0.11916	0.01231	-0.00658
1586.1	-0.05814	0.81123	-0.07624	0.11668	0.19062	-0.44235	0.08136
2996.1	-0.05992	-0.05537	-0.06090	0.55126	0.28193	0.22215	-0.29358
2352.1	-0.15296	0.44228	-0.22125	0.51672	0.43927	-0.23495	0.09231
2485.1	-0.00811	-0.03288	0.11683	0.21259	0.58970	0.01331	-0.07085
509.2	0.06249	0.31315	0.77297	0.03630	0.24256	-0.02354	0.43526
2655.1	0.69701	0.00699	0.13525	-0.12907	0.30300	0.17410	-0.09685
2524.1	-0.03810	0.25979	0.50063	0.08520	0.28165	0.03349	0.41498
3034.1	-0.16325	0.31221	0.35602	0.41329	0.12571	0.39891	-0.10437
1175.1	0.42102	0.26102	0.28478	0.00142	0.10719	0.74038	0.22395
2223.2	0.56390	0.70781	-0.00733	-0.15599	-0.09753	-0.24413	0.08419
417.1	0.20390	0.38569	0.09991	-0.09052	0.54880	0.25778	0.19499
1367.1	0.51412	0.69406	0.08326	-0.17741	0.19306	0.14075	-0.03753
1369.1	0.30353	0.13602	0.36790	-0.33267	-0.01926	0.31939	0.03339
2174.1	0.29773	0.32570	-0.29494	0.08576	-0.48635	0.19511	0.16019
2079.1	0.87749	0.07401	-0.02398	-0.05054	-0.12484	-0.14302	-0.12950
2107.1	-0.02873	0.29169	0.40078	-0.22374	-0.39799	-0.44059	0.12261
2374.1	0.64294	0.43229	-0.19237	-0.04552	0.02570	-0.37510	-0.07318
2533.1	-0.04537	0.06563	0.16888	0.28897	-0.09352	-0.11857	-0.02364

ROTATED FACTOR PATTERN

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5	FACTOR6	FACTOR7
1221.1	0.61548	0.08391	0.18896	0.06867	0.56821	0.18206	-0.25190
2914.1	-0.08491	0.55804	-0.05464	-0.10703	0.55973	-0.17440	-0.07285
2807.1	0.32895	0.14292	0.42402	-0.17211	-0.50096	-0.00006	0.00348
2811.1	0.06238	0.79101	-0.08110	0.08035	0.25357	-0.32728	-0.10552
2812.1	0.28405	0.17651	0.10145	-0.22616	-0.24580	0.11663	-0.60079
2524.2	-0.03919	0.52665	-0.30327	0.02394	-0.36317	-0.03738	0.45514
3001.1	0.04082	0.57311	-0.09993	-0.28027	-0.00202	0.23944	-0.02335
1538.1	-0.13054	-0.15768	-0.07528	0.08465	0.76047	-0.00329	-0.19609
9019.1	-0.13625	0.58336	0.16869	-0.35096	0.19685	0.53570	0.20707
2577.1	0.89415	-0.03478	0.24186	-0.08105	0.07153	0.17331	-0.05504
2978.1	-0.13480	-0.14576	0.59060	-0.09586	0.09956	0.21958	-0.37825
3161.1	-0.28757	0.39838	0.39728	0.16070	0.10059	0.09841	-0.06067
3284.1	-0.01219	0.70019	0.04896	-0.25314	0.26375	0.29885	0.11168
3302.1	-0.14712	0.83724	0.19726	0.09238	0.04105	-0.03106	0.07571
9048.2	-0.03774	-0.01039	0.65129	-0.36098	-0.37722	0.00331	0.25081
2886.1	0.72993	-0.04872	0.00915	0.08342	0.49895	0.23936	-0.17436
2816.1	0.11799	-0.28847	0.86599	-0.05656	0.04079	-0.20622	-0.04729
2904.1	0.93699	-0.24225	-0.13924	0.04664	-0.04329	-0.03452	0.01176
2923.1	0.77690	-0.07630	0.00921	0.01524	0.03449	0.28516	0.43392
2964.1	0.22929	-0.07505	0.89604	-0.01149	-0.02467	-0.17064	-0.15263
2990.1	0.06684	-0.10332	0.65298	-0.31727	0.02000	0.44529	-0.05625

ORTHOGONAL TRANSFORMATION MATRIX

	1	2	3	4	5	6	7
1	0.94085	0.26023	0.20917	-0.00703	0.02092	-0.03953	0.03531
2	-0.29651	0.91961	0.16171	-0.05424	0.04854	0.05067	0.17994
3	0.14022	0.18728	-0.92181	0.16705	0.19118	-0.11511	0.13354
4	-0.05561	-0.01308	0.23995	0.80263	0.32121	-0.10659	-0.10906
5	0.03677	-0.03963	-0.01140	-0.31579	0.64702	0.63388	0.06660
6	0.05155	0.03687	-0.08690	0.46905	-0.51988	0.70339	0.05814
7	0.01097	0.20483	-0.12295	-0.07160	-0.00930	0.00379	-0.96374

VARIANCE EXPLAINED BY EACH FACTOR

FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5	FACTOR6	FACTOR7
31.962842	22.399162	16.812419	13.637580	12.051453	10.357029	9.019498

APPENDIX D

Factor Loadings of Subjects in the Right-Handed Sample

FACTOR ANALYSIS OF DEXTRALS

ROTATED FACTOR PATTERN

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5	FACTOR6	FACTOR7
532.1	-0.02218	-0.05121	-0.10994	0.25843	0.26478	0.59583	-0.05114
559.1	-0.13873	0.78771	0.06493	0.01156	0.08635	-0.00528	-0.24978
2154.1	0.70143	0.50266	-0.18690	0.35169	-0.07651	-0.03832	0.15417
2208.1	0.25290	-0.13867	-0.18407	0.69926	0.09522	0.22109	0.28731
2255.1	-0.27328	0.70657	-0.03240	0.07576	0.21685	0.28055	0.34152
2258.1	0.29982	0.54372	0.37839	0.10361	-0.02823	0.10758	0.03791
2433.1	0.00758	-0.07566	0.43623	0.02097	0.06593	-0.14957	-0.06823
2442.1	-0.17878	0.37654	0.23298	-0.06718	0.70041	0.38003	0.10656
3307.1	0.33813	0.03613	-0.22783	0.33757	0.18742	0.47059	0.46282
3318.1	0.91843	0.08734	0.18481	-0.00342	0.05993	0.09966	0.09859
3333.1	0.02813	0.40369	0.05372	-0.11224	0.07980	0.35908	0.40147
3401.1	0.13302	-0.26262	0.08830	0.21214	0.81861	-0.01047	-0.11380
3414.1	0.14514	-0.13125	-0.17908	0.75022	-0.09875	-0.03014	0.09039
3473.1	0.67540	0.17118	-0.05492	-0.29650	0.14639	-0.16579	0.27414
3494.1	0.13711	0.14683	0.30019	0.08538	0.67130	-0.08239	0.23984
546.1	0.13315	-0.49691	0.42551	0.07150	-0.16923	-0.07977	-0.25120
1117.3	0.25897	0.06137	0.45517	-0.14451	0.49820	0.36419	0.13386
1278.2	0.10614	0.11816	0.02013	0.01449	0.76383	0.18171	0.19394
2267.1	0.57479	-0.35777	-0.09917	0.12449	0.24774	-0.05058	0.43190
3291.1	-0.02297	0.59827	0.01389	0.11504	0.40616	-0.04007	-0.17396
3407.1	0.15176	-0.67000	-0.05240	0.09511	-0.12043	-0.10907	0.42453
954.1	0.04747	-0.16594	-0.24087	0.14284	0.05855	0.15102	0.52360
1088.1	0.60912	0.10058	0.06254	0.03638	0.56310	-0.13635	-0.06613
1230.1	0.31050	-0.43499	-0.04619	0.30616	0.15725	0.25773	0.03874
1276.1	0.22595	0.59649	-0.30279	0.11599	0.22838	0.33428	0.30367
1319.2	0.21409	0.13879	0.31195	0.08525	0.09210	0.42509	0.05589
1346.2	0.04890	0.10710	0.31343	0.69070	0.28301	0.32801	-0.13148
1480.1	-0.11399	-0.04066	0.37734	-0.02002	0.79276	-0.11034	-0.04545
1757.1	-0.00742	0.14267	0.94571	-0.18572	-0.03227	-0.04414	-0.15382
1926.1	0.40988	-0.05484	-0.29422	0.11145	0.63831	-0.07506	-0.01935
2451.1	0.50069	0.45629	0.53272	-0.00730	-0.29538	0.16651	-0.21597
3395.1	0.72879	0.19579	-0.03044	-0.16038	0.18319	0.31726	0.43407
631.1	-0.46067	0.19481	0.46640	0.34108	-0.27045	0.19333	0.02029
754.2	0.38962	0.00472	-0.17030	-0.16635	0.80114	0.17768	-0.02383
934.1	0.23034	0.88374	0.03487	0.04157	-0.00678	-0.05269	0.22611
1587.1	0.11119	0.12562	-0.16732	-0.06056	0.20720	0.38163	0.60922
1791.1	-0.05721	0.05181	0.34324	-0.19450	0.05280	0.55774	0.25314
1806.1	0.18010	-0.42432	-0.06707	0.22413	-0.13533	0.66582	0.15926
2026.1	0.15075	0.03105	0.86491	-0.28699	0.23579	0.25759	-0.06479
33.4	0.14219	-0.00165	0.37368	0.59445	0.23603	-0.40215	-0.04238
749.1	-0.00323	0.51853	0.03020	-0.09639	-0.34956	0.55879	-0.01698
752.1	-0.01481	-0.18733	0.22457	0.63393	0.15413	0.19127	0.10585
1232.1	0.67916	0.22349	0.24555	0.16627	0.30196	0.33242	-0.01735
1722.1	0.30219	-0.12041	0.58453	-0.14965	0.49746	0.16398	0.37448
2249.1	-0.03202	0.24248	0.01520	-0.23049	0.50101	0.63089	0.12717
2268.1	-0.19109	0.86544	-0.06701	-0.00487	0.14879	-0.15234	-0.25404

2290.1	0.36142	0.20551	0.14883	0.20744	-0.02007	0.63904	0.01703
2295.1	-0.34531	-0.13088	0.19794	0.04560	-0.00260	0.41374	0.44700
2560.1	-0.22260	-0.25582	-0.07237	0.46222	-0.16731	0.09620	-0.21513
2606.1	-0.24082	0.51618	0.64865	0.27036	0.03772	-0.37209	-0.03911
2623.1	0.64759	0.07139	0.68626	-0.03147	-0.05829	-0.09279	0.10524
9099.1	0.04196	-0.03561	0.92949	-0.09548	0.12610	-0.08511	0.13509
518.1	-0.29420	C.36092	-0.20970	0.58016	-0.22898	-0.34446	0.01162
568.2	0.04711	0.08607	0.03923	0.11059	0.23889	0.72477	0.26559
637.1	0.01985	-0.45465	0.04828	0.09094	0.07198	-0.23103	0.32777
1113.1	0.26664	0.61104	0.11971	0.06093	-0.14359	-0.10998	0.44855
1530.1	0.76690	-0.00682	0.11634	-0.28652	-0.02740	0.48854	-0.15000
1837.1	-0.16075	0.95316	0.06251	0.05225	-0.12120	-0.08710	-0.12812
1876.1	-0.03669	0.11877	0.55301	0.03751	0.25777	0.55362	0.18989
1989.1	0.28551	0.15600	-0.27718	-0.01652	0.36379	0.13254	0.59621
2458.1	0.49241	-0.15739	0.01158	0.06057	0.38283	0.30763	0.52495
2622.1	0.31233	0.61359	0.15516	-0.31288	0.35722	-0.22990	-0.13460
2659.2	0.66995	0.07121	0.63439	0.07249	0.01408	-0.01762	0.16720
2661.1	0.11184	0.97088	0.05745	-0.08814	0.00941	-0.07007	0.00216
373.2	0.02280	-0.27605	-0.25676	0.08536	-0.27670	-0.40121	-0.06016
515.1	-0.24633	0.92673	-0.00128	0.01940	-0.03447	-0.12317	-0.03030
531.1	-0.32377	-0.28355	-0.07646	0.53151	-0.16502	0.01035	0.13157
848.1	-0.13434	-0.02816	-0.10465	0.28166	0.50816	-0.40289	0.03380
3347.1	0.40304	-0.28882	0.54909	0.12148	0.21601	0.47778	0.27108
2111.1	-0.03762	-0.62451	-0.12299	0.38365	0.19822	0.38345	-0.29462

FACTOR ANALYSIS OF DEXTRALS

ROTATED FACTOR PATTERN

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5	FACTOR6	FACTOR7
1915.1	0.78760	-0.29267	-0.03339	0.13231	0.14703	-0.05068	-0.02444
3143.1	0.19622	0.16489	0.06930	0.67904	-0.06614	0.33091	-0.16828
2350.1	-0.14856	0.16074	0.12438	0.18437	-0.27802	0.42315	0.51527
2727.1	0.24015	0.26612	0.28187	-0.17160	0.60534	0.33918	0.14754
3102.1	0.42503	-0.30703	0.13966	0.27420	-0.10604	-0.22419	0.65908
194.2	0.18323	0.09976	0.68207	0.13522	-0.05371	0.07196	0.34764
1895.1	0.19963	0.03080	0.66746	-0.01683	-0.02227	0.44416	-0.27405
1945.1	0.04699	-0.12745	0.85635	-0.28250	-0.01573	0.26710	-0.07078
3021.1	0.16163	0.81751	0.34930	-0.08997	0.02634	-0.18793	0.19093
1752.1	0.00358	-0.20350	-0.14470	0.04290	-0.28069	0.45402	-0.05764
3274.1	0.44891	0.00456	0.06513	-0.19049	0.44801	0.53530	0.09513
1534.1	-0.21771	-0.05099	0.78649	-0.23785	-0.09397	0.29059	0.06193
2445.1	0.44453	-0.21414	0.13129	0.09794	0.64830	0.19392	0.24171
2067.1	0.21289	0.48317	0.46649	-0.06013	0.31926	-0.11688	-0.40749
1439.1	0.59691	0.71907	0.20495	0.07506	0.12151	-0.00921	0.12642
1443.1	0.15140	-0.06753	-0.45369	0.44698	0.10679	0.01879	0.10281
9024.1	-0.14575	0.82558	0.14375	-0.06655	-0.17062	-0.12940	0.32133
827.1	0.37783	0.57456	0.12067	-0.16478	0.28797	-0.43433	-0.10189
2360.1	0.81002	0.21899	0.00662	-0.06608	0.08885	0.37994	-0.01730
1077.1	-0.19418	0.26378	0.76155	0.32332	0.16955	0.08600	-0.08451
2099.1	0.28216	-0.10792	-0.33735	0.63823	0.08476	0.15753	0.31611
1591.1	0.30829	0.85289	0.18671	-0.23585	-0.11088	0.16299	-0.07431
1551.1	0.23482	0.88157	0.13317	0.18297	-0.04630	0.11466	-0.04433
1932.1	-0.24459	0.49804	-0.21561	0.34235	0.24127	-0.03019	-0.32216
1831.2	-0.15271	0.55432	-0.12922	-0.20594	0.22447	0.43261	0.03523
1682.1	-0.47240	-0.29673	0.55137	0.26632	-0.16931	0.29671	-0.08526
9007.2	0.03940	-0.23115	0.23856	-0.04756	0.01453	0.21360	0.68790
128.1	-0.00404	0.18091	0.89697	-0.03145	-0.02116	-0.11917	0.10171
149.2	-0.14501	-0.25015	-0.26737	0.56333	0.19765	-0.10548	0.06697
1572.1	0.51821	0.49234	0.15908	-0.03843	0.31116	0.30295	-0.36567
1580.1	0.17180	0.91549	-0.07555	-0.16801	-0.03884	0.17220	0.01744
1554.1	-0.10981	-0.03244	-0.30388	0.15869	0.26389	0.42762	0.17085
1774.1	0.53209	0.28283	0.10210	-0.25230	0.24705	-0.08705	-0.37813
1788.1	-0.12114	-0.03758	-0.18625	0.52603	-0.22138	0.30845	0.50608
2548.1	0.15547	-0.05741	0.42009	0.26623	-0.04477	0.29312	0.60391
2588.1	0.19565	0.80663	0.07011	-0.39996	0.06077	0.04271	-0.15512
2810.1	0.28704	-0.06564	0.79413	0.15287	0.15669	-0.04175	0.04751
2822.1	-0.10663	-0.04080	0.06110	0.15580	0.09498	0.08496	0.68390
2178.1	0.65218	-0.27965	0.01880	0.30460	0.22938	0.12645	0.41033
2171.1	0.47528	0.41595	0.10613	-0.11856	0.65816	0.04307	-0.12352
494.1	0.77595	0.15138	-0.22083	0.05043	0.00140	0.35740	0.11682
1016.1	0.67324	-0.31327	-0.13000	0.16044	0.24175	0.10516	0.02759
1362.1	0.05672	0.25290	0.93077	-0.11886	0.12906	-0.01627	-0.15354
1322.1	0.57715	0.47197	0.00956	-0.33103	0.17081	-0.08781	-0.25453
656.1	0.44859	-0.12275	0.44150	0.03231	0.25143	-0.46380	0.02303

728.1	-0.49869	-0.16813	0.59082	-0.08716	0.42500	-0.02109	0.03797
1748.2	0.68789	0.12756	0.39634	-0.32768	0.23675	0.18974	0.16584
495.1	0.16876	0.69884	0.01282	-0.18348	0.35816	0.14075	-0.34768
600.1	0.07762	0.61831	0.68194	-0.11003	0.11462	-0.12960	0.05383
626.2	0.14684	0.73014	0.59419	-0.09007	0.06467	0.16746	0.04082
632.1	0.49264	-0.27090	0.01843	-0.13423	0.20545	-0.33585	0.51383
887.0	-0.04158	-0.13208	-0.09979	0.68697	0.04605	-0.23935	0.31560
890.1	0.08608	0.05575	0.29965	-0.04423	0.74562	0.41147	0.10665
899.1	-0.01329	0.14104	0.08150	0.29307	0.15102	0.46065	0.35745
904.1	-0.30773	0.18049	0.72852	0.26060	0.09552	-0.31008	0.13735
971.1	0.44024	-0.31989	0.18846	0.23057	0.63187	-0.08245	0.14147
1201.1	0.15956	-0.43066	0.06725	0.21175	-0.36237	0.54798	-0.07781
2740.1	0.11058	0.08096	-0.14256	0.57028	0.52069	0.10304	-0.04523
30.1	-0.07468	0.61272	-0.09916	0.12865	0.35927	0.33329	0.30899
1564.1	-0.03757	0.95948	0.04087	-0.10953	-0.05070	-0.05744	-0.10144
762.1	0.03314	0.49952	-0.03470	0.17249	0.76309	0.15729	0.14811
2542.1	0.11733	-0.23815	0.33147	0.07858	0.33419	0.33373	0.07550
2435.1	0.55252	0.43675	0.41066	-0.01411	0.12602	0.41270	-0.26336
2531.1	0.10642	-0.04404	-0.05152	0.16611	0.30053	0.60450	-0.02931
1869.1	0.20335	0.08173	0.47714	0.18523	0.75719	-0.01513	0.05428
1981.1	0.63978	0.03956	-0.07412	0.22333	0.55726	0.00789	0.00962
1374.1	0.20365	0.12117	0.69400	-0.08156	0.27629	0.49129	0.21781
3125.1	0.12683	-0.09683	-0.21901	-0.02832	0.06911	-0.24307	0.55103
3134.1	0.57575	0.22849	0.00171	-0.20451	0.27270	0.21488	0.58329

FACTOR ANALYSIS OF DEXTRALS

ROTATED FACTOR PATTERN

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5	FACTOR6	FACTOR7
2082.1	0.12870	0.56874	0.44236	0.41953	-0.02739	0.11173	0.05885
1104.1	0.15511	-0.01207	0.31841	-0.14059	0.73929	-0.28128	0.24444
3193.1	0.11749	0.89008	-0.17051	0.04123	-0.08949	0.06741	0.04990
2956.1	0.09604	0.49004	0.16216	-0.14572	0.07152	0.07367	0.49421
2572.1	0.41798	0.24163	0.04343	0.21148	0.07362	-0.09389	0.64285
2579.1	0.63554	-0.24584	-0.13345	-0.01252	0.52103	-0.03565	0.07735
2757.1	0.04391	-0.55886	0.39369	0.10483	0.02236	-0.13219	0.58468
1451.1	0.35785	0.33202	0.54450	0.40899	0.32971	-0.00687	-0.16056
2556.1	0.63583	-0.47326	-0.04684	0.04492	-0.06004	-0.25161	0.19232
2022.1	0.42779	0.11807	-0.17853	0.08555	0.80182	0.17712	0.00512
498.1	0.66449	0.29617	0.14880	0.14848	0.41389	0.12937	0.27721
2155.1	0.70104	0.09516	-0.03734	0.33905	0.33819	-0.19110	0.27576
2225.1	0.12575	0.53336	0.03289	0.10267	0.70281	0.21762	-0.02233
604.2	0.03552	-0.00727	0.52991	0.72115	0.25305	0.03178	0.05892
2589.1	-0.02613	0.94902	0.00508	-0.03787	0.02294	0.01515	-0.08600
3127.1	0.15322	-0.07456	0.21892	-0.22676	0.38791	-0.07403	0.55344
3170.1	-0.14874	0.09185	0.05707	0.08497	0.23331	-0.46252	0.00118
3260.1	0.55070	-0.08961	0.13394	0.37180	-0.11891	0.04400	0.21035
3269.1	0.09467	-0.31227	-0.01593	0.40920	0.55892	-0.17573	0.16252
3073.1	-0.15216	-0.12823	0.68644	-0.21176	0.52292	0.27243	0.12291
3112.1	0.18577	0.18443	0.08379	0.32335	0.19844	0.13744	0.52532

ORTHOGONAL TRANSFORMATION MATRIX

	1	2	3	4	5	6	7
1	0.48992	0.54793	0.41840	-0.00141	0.45637	0.22826	0.15594
2	0.40233	-0.74626	-0.02806	0.23957	0.29601	0.16380	0.32954
3	0.33259	0.29860	-0.88557	0.07480	0.06660	0.00745	0.07683
4	-0.45361	0.16729	-0.04450	0.47470	-0.11051	0.62208	0.37381
5	0.41110	-0.04276	0.06762	-0.38303	-0.69959	0.42136	0.10443
6	0.21964	0.15181	0.17306	0.51034	-0.42414	-0.56093	0.37918
7	0.25395	-0.02909	0.05846	0.55183	-0.13465	0.20456	-0.75284

VARIANCE EXPLAINED BY EACH FACTOR

FACTOR1 FACTOR2 FACTOR3 FACTOR4 FACTOR5 FACTOR6 FACTOR7

APPENDIX E

Four-Cluster Classification Arrays produced by

Group Average, Centroid Sorting, Group Average Relocate,

Centroid Sorting Relocate, Group Average Relocate (Random) and

Centroid Sorting Relocate (Random)

Group Average

1	2	3	4	1	1	3	1	1	2	3	4	1	4	1	4	1	4	1	1
1	3	1	4	1	1	1	2	2	4	2	4	1	3	4	1	1	1	4	3
3	3	4	3	1	3	1	3	3	4	3	4	3	3	3	1	1	4	4	4
3	3	4	3	4	3	1	4	1	1	4	2	4	1	2	1	1	3	1	2
4	2	2	1	3	3	1	3	3	4	4	1	1	3	1	1	3	1	3	1
4	2	1	3	3	2	1	1	3	1	3	2	3	3	2	4	1	1	3	1
4	3	3	2	2	2	4	1	2	4	1	1	1	1	4	3	1	3	1	4
1	3	4	3	3	3	3	2	3	1	4	4	3	3	4	1	4	1	1	4
4																			

Group Average Relocate

1	6	2	6	1	1	3	1	3	3	1	6	1	6	6	6	1	3	1	1
1	3	1	6	1	1	1	2	2	6	2	2	1	3	6	1	6	2	2	3
3	3	2	3	1	3	1	3	3	3	3	6	3	6	6	1	1	3	6	6
3	3	3	3	2	3	1	6	1	1	6	2	6	1	2	3	1	3	1	2
6	2	2	2	3	3	3	3	2	6	6	1	1	3	3	1	3	1	3	1
3	2	1	6	1	2	1	1	3	1	6	2	3	3	2	6	1	1	3	1
3	3	3	2	2	2	6	1	6	2	1	3	3	3	6	3	1	6	1	2
1	3	6	3	1	3	3	2	3	1	6	6	3	3	6	1	6	1	1	6
6																			

Group Average Relocate (Random)

2	1	6	1	2	2	3	2	3	3	2	1	2	1	1	1	2	3	2	2
2	3	2	1	2	2	2	6	6	1	6	6	2	3	1	2	1	6	6	3
3	3	6	3	2	3	2	3	3	3	3	1	3	1	1	2	2	3	1	1
3	3	3	3	6	3	2	1	2	2	1	6	1	2	6	3	2	3	2	6
1	6	6	6	3	3	3	3	6	1	1	2	2	3	3	2	3	2	3	2
3	6	2	1	2	6	2	2	3	2	1	6	3	3	6	1	2	2	3	2
3	3	3	6	6	6	1	2	1	6	2	3	3	3	1	3	2	1	2	6
2	3	1	3	2	3	3	6	3	2	1	1	3	3	1	2	1	2	2	1
1																			

Centroid Sorting

1	2	3	3	5	5	1	5	1	2	1	1	5	3	3	3	5	3	5	5
5	1	5	3	5	5	5	2	2	3	2	3	5	1	3	5	5	5	2	1
1	1	3	1	5	5	5	1	1	1	1	3	1	2	1	5	5	3	3	3
1	1	3	1	3	1	5	3	5	5	3	2	3	5	2	1	5	1	5	2
2	2	5	5	1	1	5	1	3	3	3	5	5	1	1	5	1	5	1	5
3	2	5	1	5	2	5	5	1	5	1	2	1	1	2	3	5	5	1	5
3	1	1	2	2	2	3	5	5	3	5	1	5	1	5	1	5	1	1	2
5	1	3	1	1	1	1	2	1	5	3	3	1	1	3	5	3	5	5	3
3																			

Centroid Sorting Relocate

3	2	5	2	3	3	1	3	1	1	3	2	3	2	2	2	3	1	3	3
3	1	3	2	3	3	3	5	5	2	5	5	3	1	2	3	2	5	5	1
1	1	5	1	3	1	3	1	1	1	1	2	1	2	2	3	3	1	2	2
1	1	1	1	5	1	3	2	3	3	2	5	2	3	5	1	3	1	3	5
2	5	5	5	1	1	1	1	5	2	2	3	3	1	1	3	1	3	1	3
1	5	3	2	3	5	3	3	1	3	2	5	1	1	5	2	3	3	1	3
1	1	1	5	5	5	2	3	2	5	3	1	1	1	2	1	3	2	3	5
3	1	2	1	3	1	1	5	1	3	2	2	1	1	2	3	2	3	3	2
2																			

Centroid Sorting Relocate (Random)

2	1	6	1	2	2	3	2	3	3	2	1	2	1	1	1	2	3	2	2
2	3	2	1	2	2	2	6	6	1	6	6	2	3	1	2	1	6	6	3
3	3	6	3	2	3	2	3	3	3	3	1	3	1	1	2	2	3	1	1
3	3	3	3	6	3	2	1	2	2	1	6	1	2	6	3	2	3	2	6
1	6	6	6	3	3	3	3	6	1	1	2	2	3	3	2	3	2	3	2
3	6	2	1	2	6	2	2	3	2	1	6	3	3	6	1	2	2	3	2
3	3	3	6	6	6	1	2	1	6	2	3	3	3	1	3	2	1	2	6
2	3	1	3	2	3	3	6	3	2	1	1	3	3	1	2	1	2	2	1
1																			

N.B. Each number in row 1 of each of the classification arrays corresponds to subjects 1 through 20; row 2 corresponds to subjects 21 through 40; row 3 corresponds to subjects 41 through 60; row 4 corresponds to subjects 61 through 80; row 5 corresponds to subjects 81 through 100; row 6 corresponds to subjects 101 through 120; row 7 corresponds to subjects 121 through 140; row 8 corresponds to subjects 141 through 160; and row 9 to corresponds to subject 161. Subjects with identical numbers have been grouped into the same cluster.

APPENDIX F

Sinistral Split-Sample Validation Results

TABLE 1

T Score Means and Standard Deviations of Variables for Each Cluster Group for Sinistral Split Sample 1

Clusters

Cluster 1

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILE	29	2434.76206897	1607.30263517
INFO	29	42.29931034	6.30612567
COMP	29	45.63241379	8.68825507
SSPER	29	18.75689655	20.83622037
AUDCLO	29	48.29517241	14.82064454
ARITH	29	42.64344828	6.92246770
DIGITS	29	43.79413793	8.20060517
CODING	29	43.16137931	10.21927930
PICCOM	29	51.37931034	10.92871020
BLKDES	29	51.49448276	8.33677635
OBJASS	29	54.94241379	10.33637359
TARGET	29	36.00586207	12.65195002
FAGNR	29	47.58620690	15.71513656
FTWR	29	44.24068966	17.61381214
TPTOT	29	51.16862069	9.65217397
TPTNOT	29	49.09034483	10.36380290
TAPR	29	53.19379310	9.92621076
TAPL	29	49.59758621	11.91149225
PEGSRT	29	45.05724138	8.74782540
PEGSLT	29	44.56655172	8.35285079
CATTOT	29	48.99275862	9.18813764
TRSBT	29	40.20344828	18.29852829

Cluster 2

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILE	14	2083.02857143	735.91820870
INFO	14	45.71357143	7.21095065
COMP	14	52.61928571	10.71661289
SSPER	14	48.02357143	15.67098181
AUDCLO	14	63.16285714	13.78561984
ARITH	14	44.76142857	7.24588250
DIGITS	14	44.32214286	6.35161297
CODING	14	44.28642857	7.99879472
PICCOM	14	55.47642857	9.02195835
BLKDES	14	50.23357143	9.00646935
OBJASS	14	48.57142857	6.49921635
TARGET	14	46.05928571	8.00131284
FAGNR	14	44.57142857	21.08486255
FTWR	14	47.42857143	11.02141912
TPTOT	14	55.07714286	6.47805933
TPTNOT	14	50.49500000	13.45141843
TAPR	14	45.79857143	11.87908172
TAPL	14	40.50857143	12.41126774
PEGSRT	14	32.62357143	22.64544431
PEGSLT	14	28.79500000	22.21755777
CATTOT	14	50.69142857	9.75676874
TRSBT	14	43.65571429	12.39523207

Clusters

Cluster 3

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILE	31	2446.00967742	1977.67739842
INFO	31	43.44161290	6.23506541
COMP	31	44.30161290	8.95358852
SSPER	31	41.14000000	14.65142041
AUDCLO	31	48.28387097	17.00669862
ARITH	31	42.58064516	7.33877003
DIGITS	31	44.73000000	8.37942003
CODING	31	49.35451613	10.52006142
PICCOM	31	55.69903226	8.65832291
BLKDES	31	50.43032258	7.96955728
OBJASS	31	51.29129032	9.29587498
TARGET	31	37.59838710	13.87267725
FAGNR	31	0.58516129	32.01293737
FTWR	31	23.49032258	44.26152998
TPTOT	31	46.42838710	13.26215545
TPTNOT	31	47.12838710	12.86035260
TAPR	31	51.21645161	12.03710916
TAPL	31	46.17709677	15.31000614
PEGSRT	31	43.31774194	18.01602355
PEGSLT	31	42.58096774	19.37532182
CATTOT	31	51.38254839	8.70032281
TRSBT	31	41.95709677	17.38468966

Cluster 4

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILE	7	1808.27142857	1204.92869874
INFO	7	40.95285714	5.99845734
COMP	7	45.23857143	10.33899000
SSPER	7	50.85571429	6.19413125
AUDCLO	7	41.02285714	12.17109378
ARITH	7	42.[illegible]1000000	5.90869698
DIGITS	7	45.71285714	11.97488582
CODING	7	50.47428571	8.48291196
PICCOM	7	51.90571429	7.66521767
BLKDES	7	46.66571429	6.66750042
OBJASS	7	52.38000000	9.17237452
TARGET	7	56.62000000	2.79770739
FAGNR	7	54.00000000	0.00000000
FTWR	7	66.65571429	4.45090574
TPTOT	7	53.30285714	7.01054376
TPTNOT	7	57.27571429	6.47601435
TAPR	7	50.54571429	10.51997443
TAPL	7	46.66571429	9.77723522
PEGSRT	7	67.08428571	18.40610484
PEGSLT	7	58.64142857	11.44953919
CATTOT	7	55.53571429	8.03604351
TRSBT	7	45.03428571	7.40963980

N.B. The four cluster solution listed on this table represents the results of both the Group Average and Centroid Sorting Methods, since identical solutions were generated from each.

TABLE 2

_T_ Score Means and Standard Deviations of Variables for Each Cluster Group for Sinistral Split Sample 2

Clusters

Cluster 1

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILE	27	1992.94444444	1666.61569617
INFO	27	44.56740741	6.34753047
COMP	27	48.64148148	9.96796743
SSPER	27	37.09851852	16.79805225
AUDCLO	27	51.87555556	17.03220599
ARITH	27	43.70444444	7.00083475
DIGITS	27	45.43222222	9.87756367
CODING	27	47.16037037	9.94445515
PICCOM	27	54.44370370	8.72191499
BLKDES	27	51.43148148	8.23328570
OBJASS	27	52.09814815	8.43072861
TARGET	27	40.27592593	12.77754709
FAGNR	27	-6.21629630	37.66453261
FTWR	27	36.35703704	12.54611611
TPTOT	27	46.60407407	10.11328116
TPTNDT	27	44.62037037	13.96902824
TAPR	27	48.32000000	9.49262750
TAPL	27	43.32000000	12.63740145
PEGSRT	27	41.85888889	17.92220225
PEGSLT	27	42.72444444	16.74259385
CATTOT	27	50.69962963	9.23555774
TRSBT	27	29.32962963	32.26898326

Cluster 2

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILE	8	2070.23750000	515.06998952
INFO	8	42.08375000	4.69510973
COMP	8	48.33375000	5.03779412
SSPER	8	48.40000000	9.67851081
AUDCLO	8	42.74500000	11.4922[illegible]
ARITH	8	44.16750000	4.27265307
DIGITS	8	42.08250000	5.39262432
CODING	8	49.16750000	9.55443913
PICCOM	8	52.91750000	7.85619819
BLKDES	8	50.83375000	7.50719262
OBJASS	8	50.83250000	6.60747574
TARGET	8	44.71250000	14.53116429
FAGNR	8	51.00000000	11.85628224
FTWR	8	60.17375000	9.11726610
TPTDT	8	54.47500000	3.80781152
TPTNDT	8	54.38250000	8.99106735
TAPR	8	48.31000000	5.63006217
TAPL	8	49.15125000	6.62644149
PEGSRT	8	40.33875000	14.93028221
PEGSLT	8	44.70250000	6.07642929
CATTOT	8	51.68375000	7.83391516
TRSBT	8	45.97250000	4.75225586

TABLE 2 (cont'd)

Clusters

Cluster 3

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILE	23	2097.38695652	2291.82257490
INFO	23	44.34782609	6.06594964
COMP	23	50.29000000	9.68738449
SSPER	23	48.61565217	15.05820701
AUDCLO	23	48.78000000	14.80310164
ARITH	23	43.47869565	6.39326798
DIGITS	23	44.92739130	8.52080354
CODING	23	49.27565217	9.48006752
PICCOM	23	51.73913043	10.91179383
BLKDES	23	51.59347826	8.21903202
OBJASS	23	56.95608696	9.26044655
TARGET	23	34.79260870	16.03510388
FAGNR	23	55.04347826	9.10283802
FTWR	23	13.48739130	41.44317153
TPTDT	23	50.70608696	6.47651263
TPTNDT	23	42.58739130	23.11994539
TAPR	23	53.43695652	14.13572374
TAPL	23	48.55739130	14.01883675
PEGSRT	23	48.51652174	14.87142092
PEGSLT	23	42.86782609	12.58881031
CATTOT	23	43.41608696	9.55563981
TRSBT	23	34.25565217	21.03932375

Cluster 4

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILE	22	2595.97272727	1705.37845909
INFO	22	38.93863636	7.51624545
COMP	22	48.78727273	9.57134224
SSPER	22	20.[illegible]	22.20385601
AUDCLO	22	50.49181818	14.91733751
ARITH	22	42.12090909	6.55055498
DIGITS	22	44.39454545	9.61629457
CODING	22	48.33409091	8.89423498
PICCOM	22	56.21181818	8.98494860
BLKDES	22	55.00000000	6.95838035
OBJASS	22	56.21[illegible]1818	8.37666125
TARGET	22	50.03227273	7.59257716
FAGNR	22	51.54545455	15.38003428
FTWR	22	53.70181818	10.63135194
TPTDT	22	53.42590909	6.65352371
TPTNDT	22	52.19409091	7.18829847
TAPR	22	52.79363636	11.63726917
TAPL	22	46.90181818	10.47211292
PEGSRT	22	50.99909091	13.47980320
PEGSLT	22	49.81136364	11.28172618
CATTOT	22	51.12000000	8.47670196
TRSBT	22	39.15772727	21.13133037

N.B. The four cluster solution listed on this table represents the results of both the Group Average and Centroid Sorting Methods, since identical solutions were generated from each.

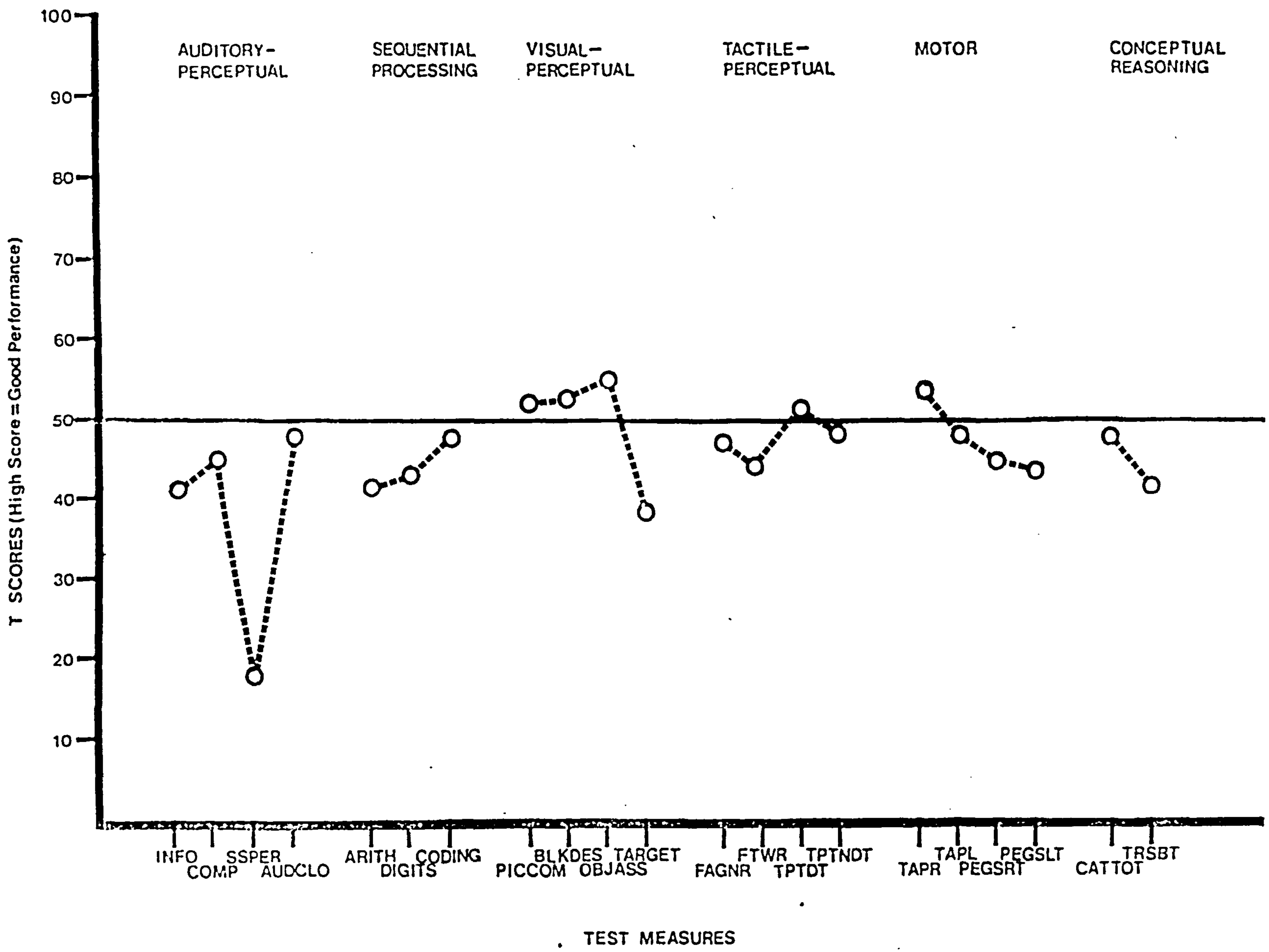

Figure 1. Plot of T score means for Cluster 1 of sinistral split sample 1.

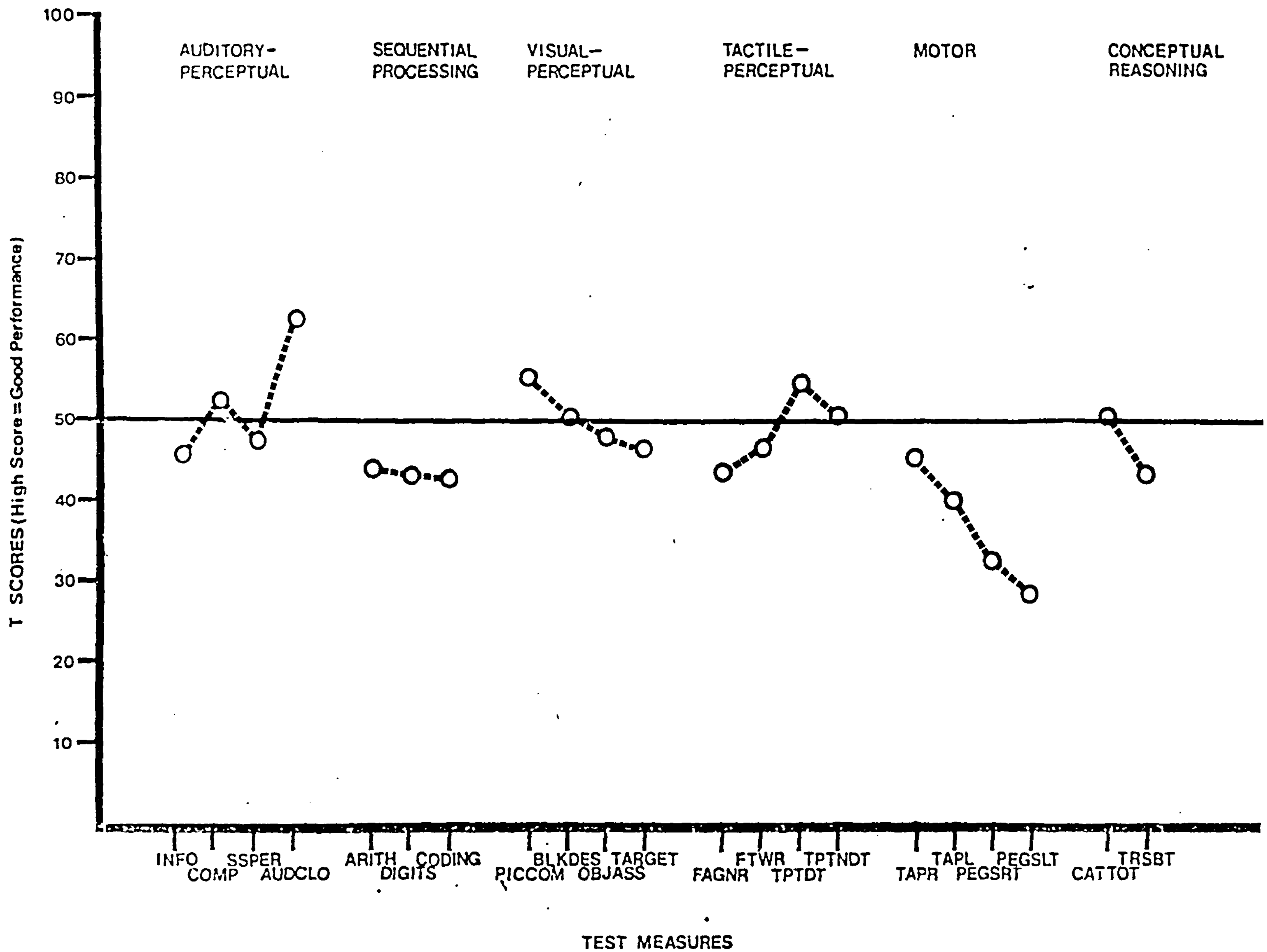

Figure 2. Plot of T score means for Cluster 2 of sinistral split sample 1.

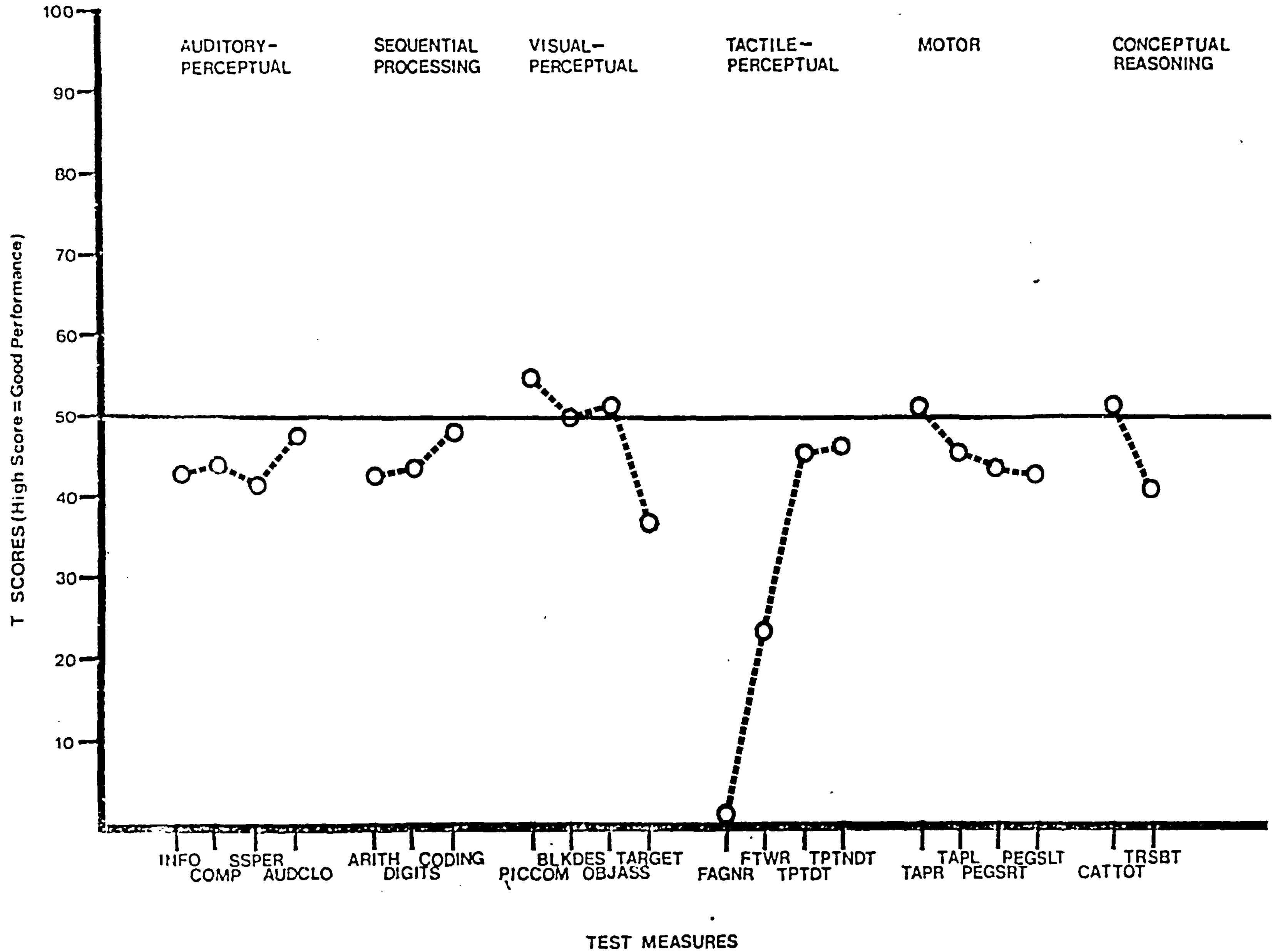

Figure 3 . Plot of T score means for Cluster 3 of sinistral split sample 1.

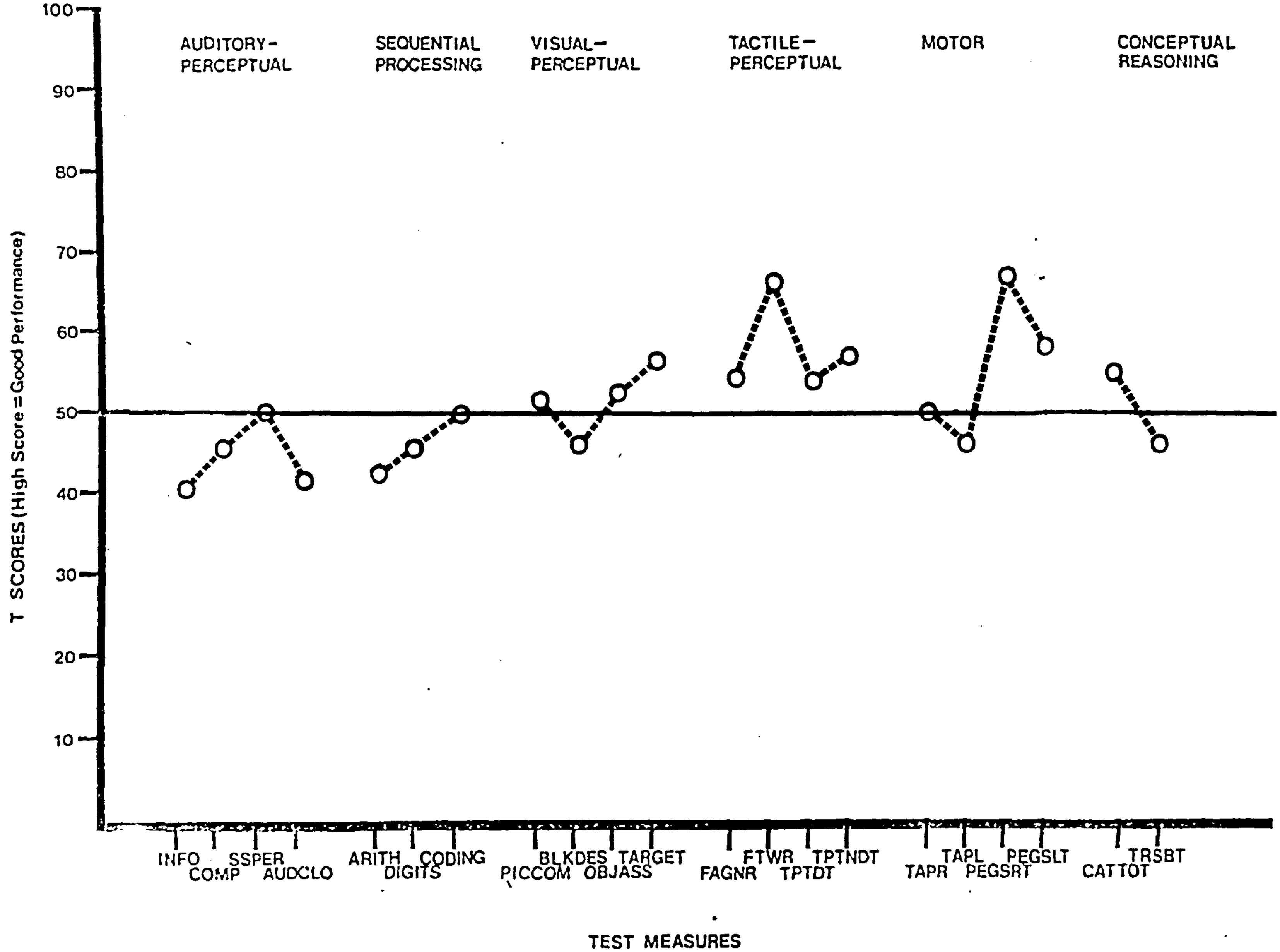

Figure 4. Plot of T score means for Cluster 4 of sinistral split sample 1.

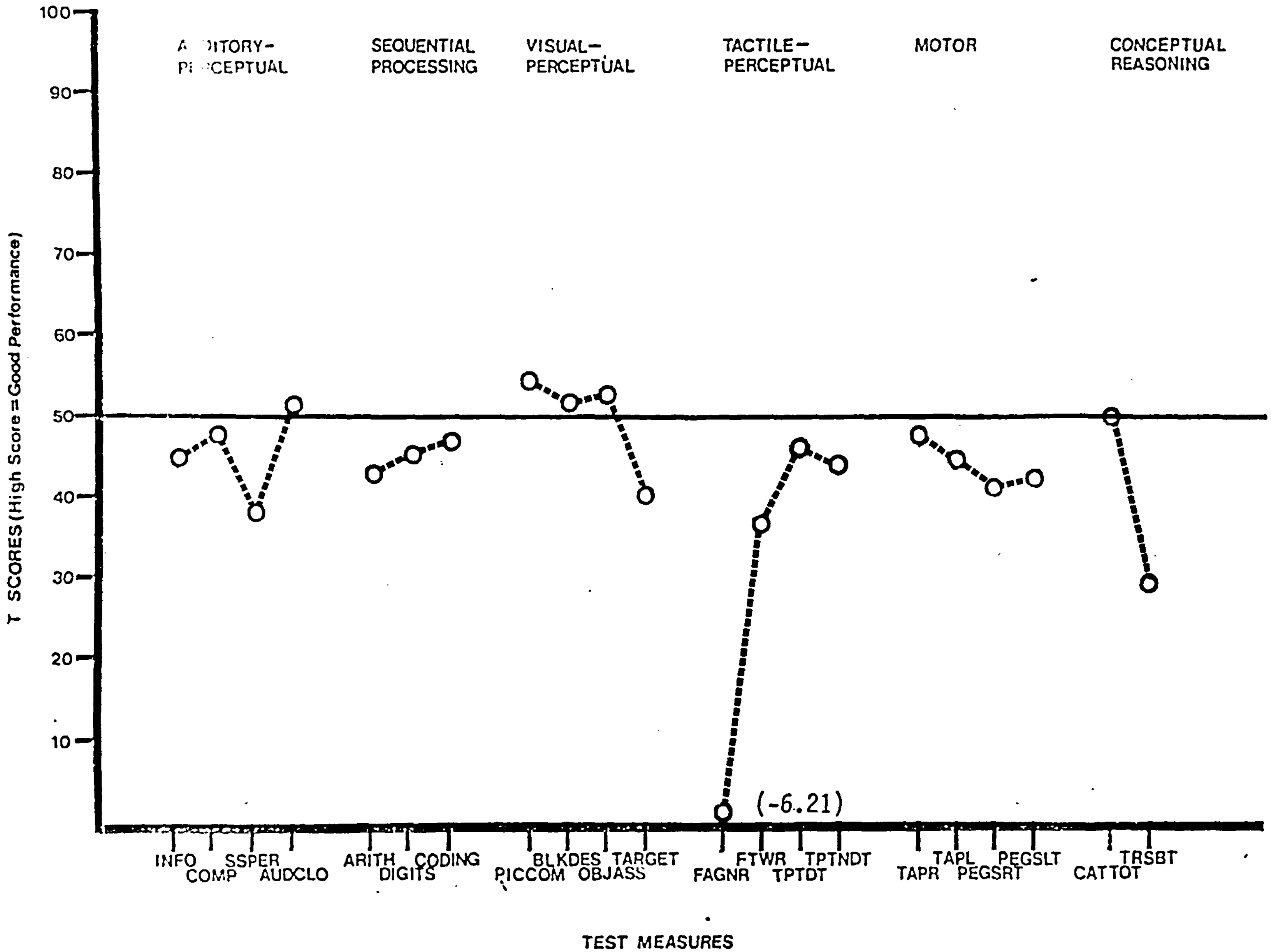

Figure 5. Plot of $\underline{T}$ score means for Cluster 1 of sinistral split sample 2.

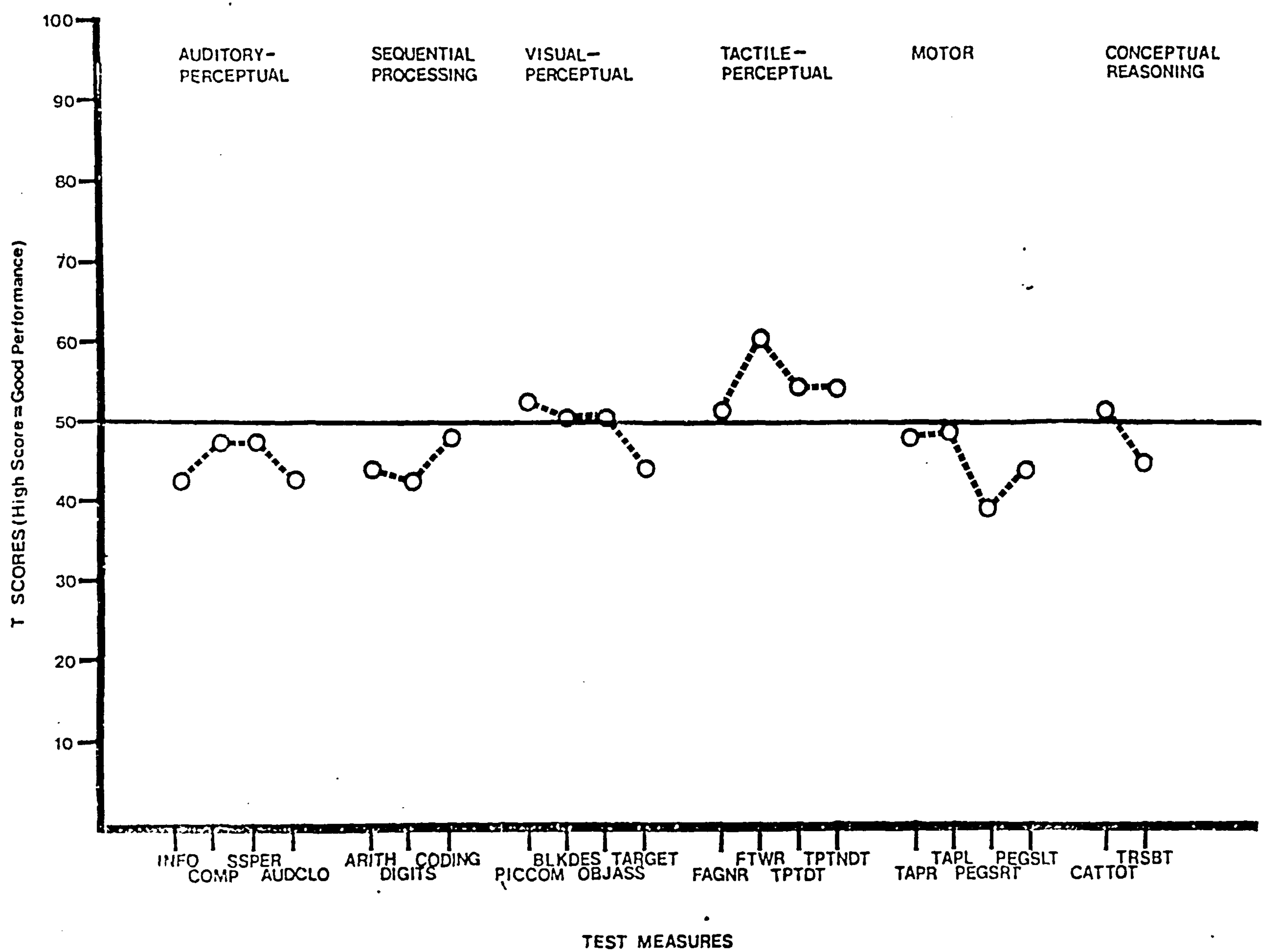

Figure 6 . Plot of T score means for Cluster 2 of sinistral split sample 2.

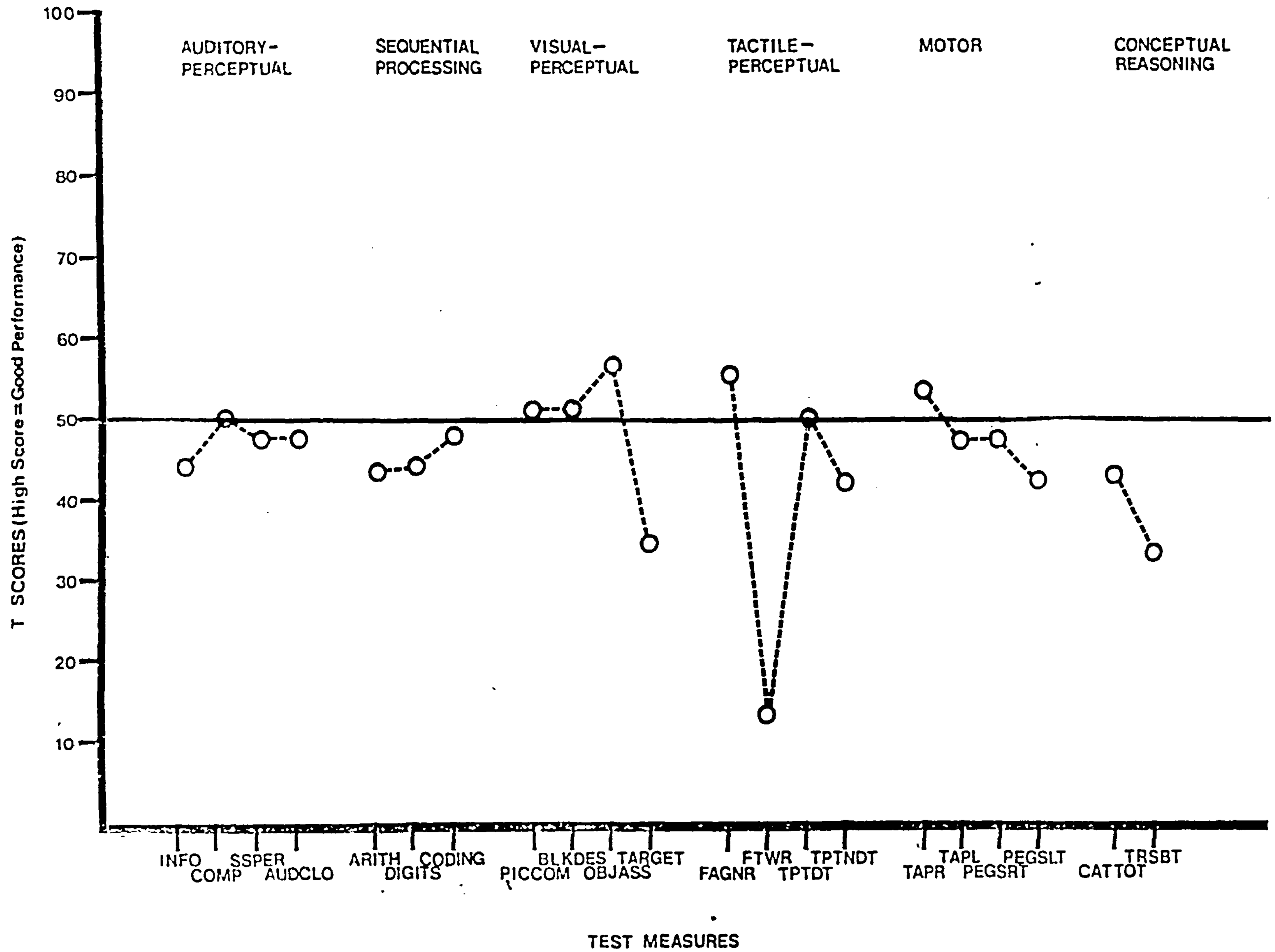

Figure 7. Plot of T score means for Cluster 3 of sinistral split sample 2.

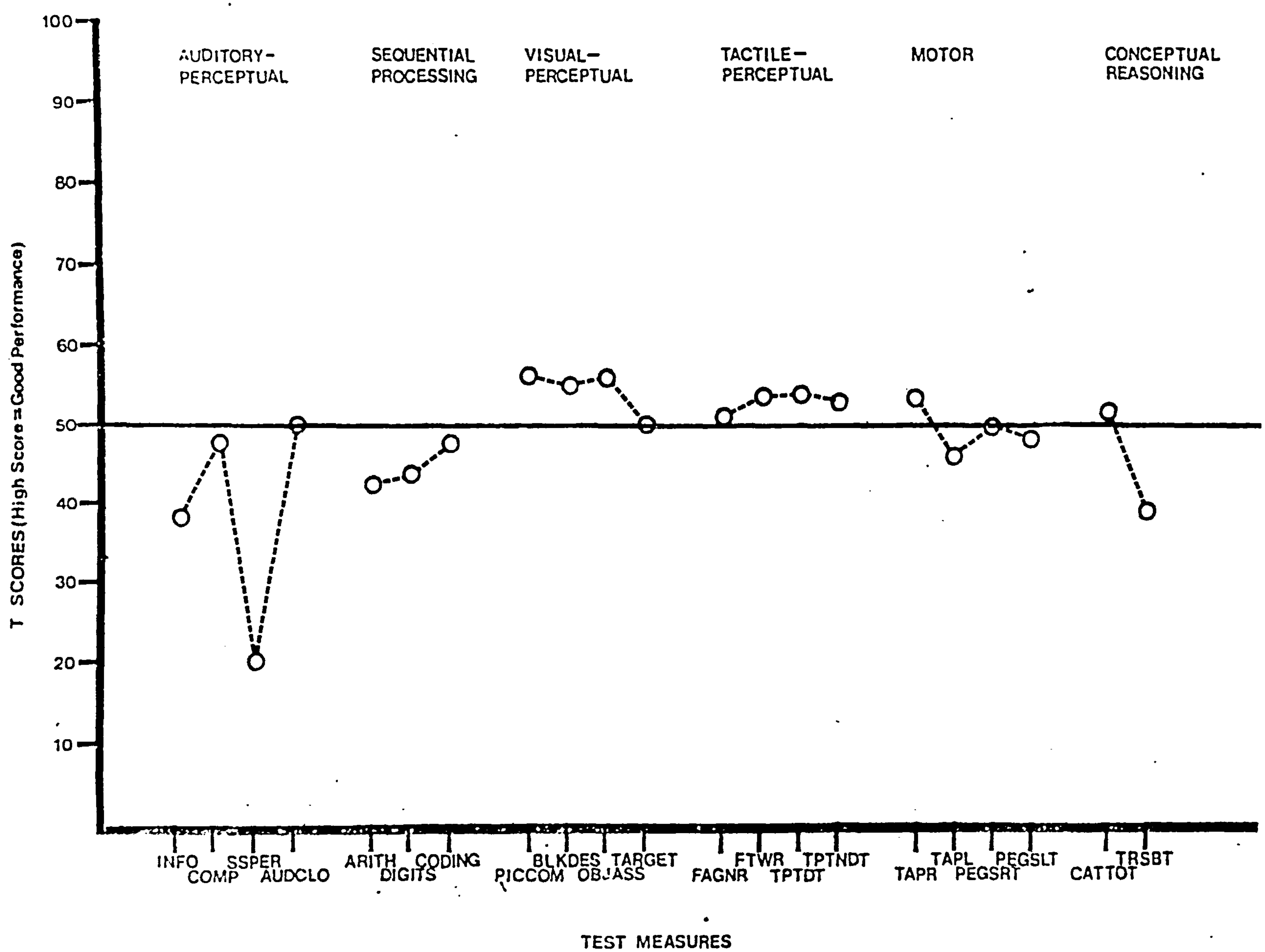

Figure 8. Plot of T score means for Cluster 4 of sinistral split sample 2.

APPENDIX G

Seven-Cluster Classification Arrays produced by Group Average, Centroid Sorting, Group Average Relocate, Centroid Sorting Relocate, Group Average Relocate (Random) and Centroid Sorting Relocate (Random)

Group Average

1	2	3	4	2	6	6	3	3	3	1	3	4	3	1	6	1	3	3	2
4	4	3	3	2	6	1	3	6	3	6	3	6	3	2	3	1	38	6	1
2	6	1	3	1	2	6	1	4	6	3	6	6	1	55	2	3	2	1	3
3	2	3	2	4	2	55	3	3	38	4	1	2	3	4	6	6	6	2	4
3	6	3	2	2	55	2	2	3	1	4	2	2	2	2	1	3	6	4	1
2	1	2	55	55	2	1	55	3	3	3	3	6	2	3	6	6	3	2	2
2	3	4	3	55	6	3	38	1	2	2	3	38	1	38	3	3	1	55	3
6	3	2	2	3	3	55	1	3	3	3	3	3	1	2	3	1	3	3	1
55																			

Group Average Relocate

7	2	2	6	2	2	5	3	8	3	7	3	6	3	1	5	1	3	3	1
1	1	3	1	8	8	6	3	5	3	5	3	5	3	2	8	7	7	5	6
2	8	1	3	7	2	8	7	1	5	5	5	8	1	8	2	3	2	1	8
3	2	5	2	1	2	8	6	3	7	1	6	8	3	1	8	5	5	2	1
3	5	3	5	2	8	2	2	3	5	6	2	2	2	2	1	8	5	6	1
2	1	2	8	7	2	1	8	3	3	3	3	5	2	3	5	5	3	2	5
2	3	6	1	8	5	3	7	6	8	2	3	3	1	8	3	3	1	8	3
2	3	2	8	3	3	7	1	3	3	3	3	3	6	2	3	1	8	6	1
8																			

Group Average Relocate (Random)

3	2	2	8	2	2	4	1	7	1	3	1	8	1	5	4	5	1	8	5
8	8	1	8	7	7	5	1	4	1	4	1	4	1	2	7	5	8	4	5
2	7	5	1	3	2	7	5	5	4	4	4	7	5	7	2	1	2	5	7
1	2	4	2	8	2	7	1	1	3	8	8	8	1	8	7	4	4	2	8
1	4	1	4	2	7	2	2	1	5	8	2	2	3	2	5	7	4	8	3
2	5	3	7	5	2	5	7	1	1	8	1	4	2	4	4	4	1	2	4
2	1	5	5	7	4	1	8	1	7	2	1	1	5	7	1	1	5	7	1

Centroid Sorting

1	1	3	3	1	3	7	3	3	3	1	3	13	3	3	16	3	3	3	3
3	3	3	3	1	3	3	3	7	3	3	3	13	3	1	3	3	38	7	3
1	3	3	3	1	1	3	13	3	7	3	7	13	3	55	1	3	1	3	3
3	1	3	1	16	1	13	3	3	38	3	3	1	3	3	3	7	7	1	16
3	7	3	1	1	13	1	1	3	3	3	1	1	1	1	3	3	7	3	3
1	3	1	13	3	1	3	13	3	3	3	3	7	1	3	7	7	3	1	1
1	3	3	3	3	7	3	38	3	1	1	3	3	3	3	3	3	3	13	3
3	3	1	1	3	3	3	3	3	3	3	3	3	3	1	3	3	3	3	3
3																			

Centroid Sorting Relocate

6	1	1	5	1	1	3	2	4	2	6	2	5	2	8	3	8	2	5	8
5	5	2	5	4	4	8	2	3	2	3	2	3	2	1	4	8	6	3	8
1	4	8	2	6	1	4	6	8	3	3	3	4	8	4	1	2	1	8	4
2	1	3	1	5	1	4	2	2	6	5	8	5	2	5	4	3	3	1	5
2	3	2	3	1	4	1	1	2	8	5	1	1	1	1	8	4	3	5	8
1	8	1	4	6	1	8	4	2	2	5	2	3	1	3	3	3	2	1	3
1	2	8	8	4	3	2	6	2	4	1	2	2	8	4	2	2	8	4	2
1	2	1	4	2	2	6	8	5	2	2	2	2	3	1	2	8	4	2	8
4																			

Centroid Sorting Relocate (Random)

3	2	2	8	2	2	4	1	7	1	3	1	8	1	5	4	5	1	8	5
8	8	1	8	7	7	5	1	4	1	4	1	4	1	2	7	5	8	4	5
2	7	5	1	3	2	7	5	5	4	4	4	7	5	7	2	1	2	5	7
1	2	4	2	8	2	7	1	1	3	8	8	8	1	8	7	4	4	2	8
1	4	1	4	2	7	2	2	1	5	8	2	2	3	2	5	7	4	8	3
2	5	3	7	5	2	5	7	1	1	8	1	4	2	4	4	4	1	2	4
2	1	5	5	7	4	1	8	1	7	2	1	1	5	7	1	1	5	7	1

N.B. See APPENDIX E for an explanation of the meaning of a classification array.

APPENDIX H

Dextral Split-Sample Validation Results

TABLE 3

T Score Means and Standard Deviations of Variables for Each Cluster Group for Dextral Split Sample 1

Clusters

Cluster 1

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILE	14	2087.62142857	847.20322798
INFO	14	44.28571429	7.44490607
COMP	14	44.04642857	4.74542469
SSPEL	14	31.72357143	15.94958529
AUDCLO	14	39.82285714	9.21561153
ARITH	14	41.19000000	5.93466738
DIGITS	14	41.10071429	6.07739122
CODING	14	45.95357143	8.18333166
PICCOM	14	54.04785714	11.10927553
BLKDES	14	56.19071429	9.32428959
OBJASS	14	56.90500000	10.39642125
TARGET	14	43.28214286	13.90829038
FAGNR	14	50.28571429	13.95043780
FTAR	14	45.23571429	24.25415800
TPTOT	14	51.43714286	7.62399091
TPTNOT	14	50.91642857	5.67163488
TAPR	14	52.16214286	9.69777705
TAPL	14	46.43357143	8.92663567
PEGSRT	14	34.90714286	7.08315165
PEGSLT	14	40.40428571	12.46563225
CATTOT	14	47.33428571	6.85727543
TRSBT	14	16.58214286	38.20482112

Cluster 2

VARIABLE	N	MEAN	STANDARD DEVIATION
[illegible]	14	1093.[illegible]71429	1016.06313160
[illegible]	14	[illegible]3.81000000	6.11057796
[illegible]	14	45.[illegible]14286	7.3662[illegible]67
[illegible]	14	42.67500000	16.52990644
AUDCLO	14	53.35000000	14.05294111
ARITH	14	43.81000000	6.25031445
DIGITS	14	44.99928571	6.88755898
CODING	14	43.09428571	10.49698785
PICCOM	14	53.09571429	9.46773314
BLKDES	14	56.42928571	10.41551318
OBJASS	14	54.04785714	10.55543580
TARGET	14	39.51428571	15.55320185
FAGNR	14	52.42857143	8.98472452
FTAR	14	38.88285714	16.22586702
TPTOT	14	51.82785714	6.21825004
TPTNOT	14	46.63571429	9.56348723
TAPR	14	53.63000000	12.52309067
TAPL	14	38.27000000	11.35176164
PEGSRT	14	38.46785714	15.08499671
PEGSLT	14	7.77857143	22.75529857
CATTOT	14	49.09500000	7.18753167
TRSBT	14	42.97000000	12.77745009

Clusters

Cluster 3

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILE	11	1877.65454545	762.10425975
INFO	11	41.81818182	6.21085794
COMP	11	44.24272727	8.03998892
SSPER	11	32.63545455	21.99468407
AUDCLO	11	38.19636364	15.22919779
ARITH	11	42.73000000	8.66959169
DIGITS	11	46.66545455	12.11022647
CODING	11	53.94181818	12.00238211
PICCOM	11	50.00000000	5.57813230
BLKDES	11	46.06090909	5.33819905
OBJASS	11	52.12181818	8.59993002
TARGET	11	37.91636364	13.00781940
FASNR	11	41.27272727	16.73971869
FTAR	11	-11.36545455	38.55654091
TPTOT	11	46.65454545	9.98511629
TPTNOT	11	47.61727273	12.33307431
TAPR	11	50.04909091	10.22595063
TAPL	11	38.09181818	11.80031249
PEGSRT	11	57.56818182	9.28637369
PEGSLT	11	43.07727273	9.51415902
CATTOT	11	47.84363636	7.30849680
TRSBT	11	45.33272727	10.55267084

Cluster 4

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILE	6	1055.10000000	613.07442917
INFO	6	49.44333333	5.34221552
COMP	6	50.00000000	5.57511230
SSPER	6	35.15333333	18.25569546
AUDCLO	6	73.18666667	10.27942930
ARITH	6	47.78000000	9.34840093
DIGITS	6	53.33333333	5.16596043
CODING	6	49.11333333	8.27642228
PICCOM	6	47.77666667	11.08777810
BLKDES	6	46.38333333	12.23139057
OBJASS	6	47.22166667	12.54712[illegible]
TARGET	6	43.91333333	10.7375533[illegible]
FASNR	6	43.00000000	19.33907961
FTAR	6	49.74500000	7.77315573
TPTOT	6	53.83500000	9.32739383
TPTNOT	6	54.34000000	7.29617708
TAPR	6	44.26500000	8.06224224
TAPL	6	37.37833333	7.60910880
PEGSRT	6	53.37500000	6.23538058
PEGSLT	6	35.05500000	10.51696552
CATTOT	6	51.02666667	9.08606772
TRSBT	6	34.12000000	8.27271902

Clusters

Cluster 5

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILE	18	2081.43888889	1956.82201756
INFO	18	44.81500000	5.62694071
COMP	18	48.70277778	10.48727509
SSPER	18	30.05777778	17.97158036
AUDCLU	18	44.57222222	10.55514402
ARITH	18	45.00000000	7.43143007
DIGITS	18	44.81555556	8.26287460
CODING	18	49.44444444	9.58341473
PICCOM	18	55.92555556	7.63130104
BLKDES	18	53.33277778	9.28840758
OBJASS	18	55.74000000	12.66859898
TARGET	18	45.78222222	11.04913015
FAGNF	18	5.37555556	30.76801131
FTAR	18	41.50055556	16.04245304
TPTOT	18	55.24111111	6.13515606
TPTNOT	18	50.32444444	6.88640111
TAPR	18	56.21611111	11.38494059
TAPL	18	43.38277778	8.38510641
PEGSRT	18	52.163[illegible]	10.92977161
PEGSLT	18	38.90333333	14.08397421
CATTOT	18	[illegible].297777[illegible]	[illegible].31472295
TRSBT	18	46.7[illegible]333[illegible]	10.30612910

Cluster 6

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILE	16	2254.92500000	2105.45842562
INFO	16	42.91750000	5.94686410
COMP	16	46.65625000	6.99269512
SSPER	16	50.65937500	11.27359052
AUDCLU	16	39.93000000	9.11697316
ARITH	16	44.37625000	8.56657093
DIGITS	16	48.12562500	7.79139523
CODING	16	5[illegible].95875000	9.60160391
PICCOM	16	[illegible]	12.2324404[illegible]
BLKDES	16	51.041[illegible]	8.06[illegible]15722
OBJASS	16	50.83312500	9.22[illegible]0123
TARGET	16	47.94375000	10.86595532
FAGNR	16	56.00000000	5.46504041
FTAR	16	57.20187500	8.76283456
TPTOT	16	54.24000000	6.88036046
TPTNOT	16	53.93875000	6.35130193
TAPR	16	56.93500000	10.90249513
TAPL	16	42.26875000	9.40464841
PEGSRT	16	63.42000000	8.16385040
PEGSLT	16	47.61062500	10.72061905
CATTOT	16	52.28625000	8.79715626
TRSBT	16	50.85687500	5.06025654

TABLE 3 (cont'd)

Clusters

Cluster 7

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILE	2	459.65000000	122.25876247
INFO	2	55.00000000	2.36173665
COMP	2	50.00000000	4.70933116
SSPER	2	52.65000000	0.98994949
AUDCLO	2	48.94000000	10.69145453
ARITH	2	61.67000000	7.07106781
DIGITS	2	60.00000000	4.70933116
CODING	2	46.66500000	4.71640223
PICCOM	2	35.00000000	2.36173665
BLKDES	2	38.33500000	11.78747004
OBJASS	2	40.00000000	0.00000000
TARGET	2	50.18500000	0.61518290
FAGNR	2	62.00000000	11.31370850
FTAR	2	46.91500000	10.73721751
TPTOT	2	46.45000000	13.54316593
TPTNDT	2	44.61000000	14.01485640
TAPR	2	63.35500000	4.16485594
TAPL	2	43.25000000	0.57982756
PEGSRT	2	42.25000000	12.84105915
PEGSLT	2	47.08500000	13.55523700
CATTOT	2	55.52500000	4.03000613
TRSBT	2	59.14000000	0.00000000

N.B. The seven cluster solution listed on this table represents the results of both the Group Average and Centroid Sorting Methods, since identical solutions were generated from each.

TABLE 4

T Score Means and Standard Deviations
of Variables for Each Group Average Cluster Group
for Dextral Split Sample 2

Clusters

Cluster 1

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILE	16	1614.79375000	309.55076882
INFO	16	44.70000000	4.70959786
COMP	16	48.75062500	7.78125136
SSPER	16	19.46625000	28.20133635
AUDCLU	16	39.45125000	14.75743784
ARITH	16	45.62500000	6.74517704
DIGITS	16	43.75000000	7.08467360
CODING	16	47.70937500	10.73003353
PICCOM	16	51.45875000	12.16933324
BLKDES	16	52.71562500	9.01614645
OBJASS	16	53.33375000	10.11028115
TARGET	16	44.05125000	9.07487672
FAGNR	16	0.25000000	30.93972635
FTWR	16	40.67062500	15.20969317
TPTOT	16	47.83375000	13.49305986
TPTNDT	16	50.06187500	11.60505279
TAPR	16	51.77875000	8.53917004
TAPL	16	41.72062500	8.58316315
PEGSRT	16	53.17562500	10.45358629
PEGSLT	16	40.70125000	13.29530989
CATTOT	16	52.13812500	9.17775660
TRSBT	16	32.27125000	14.28412493

Cluster 2

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILE	26	2101.36923077	891.91613835
INFO	26	43.38384615	4.35335096
COMP	26	51.02576923	8.47290749
SSPER	26	[illegible]	18.43625376
AUDCLU	26	[illegible]	11.13558413
ARITH	26	44.32076923	5.22188772
DIGITS	26	43.07692308	8.05194723
CODING	26	48.46076923	10.16468865
PICCOM	26	53.97461538	11.58561772
BLKDES	26	53.71769231	6.62145743
OBJASS	26	52.94884615	9.01115590
TARGET	26	41.16538462	12.46360533
FAGNR	26	57.84615385	10.19683209
FTWR	26	48.53230769	12.05884363
TPTOT	26	54.37384615	6.29943050
TPTNDT	26	51.72923077	6.88258319
TAPR	26	60.56807692	10.86552862
TAPL	26	47.34346154	9.46323733
PEGSRT	26	55.43615385	7.87808305
PEGSLT	26	43.94500000	11.90678000
CATTOT	26	50.92615385	7.67176802
TRSBT	26	36.77807692	18.12849492

Clusters

Cluster 3

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILL	4	2539.57500000	1120.49684032
INFO	4	46.67000000	8.16496581
CLAP	4	45.00000000	6.93673236
SSPER	4	48.36500000	16.79431154
AUDCLO	4	54.00000000	17.06360650
ARITH	4	49.16500000	6.87425845
DIGITS	4	45.00000000	6.38168734
CODING	4	42.50000000	6.31283349
PICCOM	4	45.32250000	3.19343553
BLKDES	4	48.32250000	4.30288566
OBJASS	4	50.83250000	5.69480538
TARGET	4	20.53000000	23.07039517
FAGNR	4	38.53000000	20.15771151
FTMR	4	34.09750000	25.28038419
TPIDT	4	49.17000000	8.57115706
TPTNDT	4	8.51750000	[illegible]4.38400752
TAPR	4	61.42750000	4.83790599
TAPL	4	48.14750000	12.22714841
PEGSRT	4	21.53750000	25.20223436
PEGSLT	4	-37.01750000	90.03319328
CATTOT	4	51.12750000	10.40708853
TRSBT	4	38.59750000	16.09906286

Cluster 4

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILL	11	1862.38181818	866.19614040
INFO	11	44.24181819	5.39435002
CLAP	11	45.45545455	5.85347656
SSPER	11	49.00090909	10.754[illegible]7702
AUDCLO	11	4[illegible].36727273	11.13556922
ARITH	11	[illegible]	6.04[illegible]2543
DIGITS	11	[illegible]	7.952[illegible]7930
CODING	11	50.60545455	6.96532444
PICCOM	11	47.57454545	7.90063335
BLKDES	11	48.78818182	6.54422466
OBJASS	11	47.87909091	9.45907760
TARGET	11	48.47090909	9.14314547
FAGNR	11	62.36363636	5.84613993
FTMR	11	58.17727273	3.27905807
TPIDT	11	54.33909091	6.79312955
TPTNDT	11	51.48363636	6.26062980
TAPR	11	58.55090909	8.27672333
TAPL	11	43.96363636	7.40960495
PEGSRT	11	42.86909091	9.53762492
PEGSLT	11	35.85909091	9.08209938
CATTOT	11	52.34909091	6.11680546
TRSBT	11	52.17181818	8.68587798

TABLE 4 (cont'd)

Clusters

Cluster 5

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILE	6	1448.26666667	927.12683419
INFO	6	46.11166667	8.27951549
COMP	6	51.66666667	11.30403009
SSPER	6	61.48333333	7.09842706
AUDCLO	6	52.07000000	4.70145084
ARITH	6	49.44333333	3.27775940
DIGITS	6	46.66666667	8.43458515
CODING	6	56.11000000	3.27911573
PICCOM	6	43.83000000	5.83717397
BLKDES	6	52.22333333	3.44437319
OBJASS	6	56.11166667	3.29039885
TARGET	6	41.06500000	7.20159913
FAGNR	6	47.00000000	10.95445115
FTAR	6	51.81833333	14.70741366
TPTOT	6	47.62500000	11.64080710
TPTNOT	6	57.81666667	5.72043935
TAPR	6	56.30666667	6.57203889
TAPL	6	43.31833333	11.04481854
PEGSRT	6	73.02500000	4.96729593
PEGSLT	6	52.04166667	6.40101372
CATTOT	6	50.87833333	7.11792222
TRSBT	6	51.67333333	9.92008804

Cluster 6

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILE	4	2733.33000000	442.20337643
INFO	4	41.66750000	4.30288566
COMP	4	40.00250000	4.71404550
SSPER	4	52.55000000	10.36600202
AUDCLO	4	63.50000000	11.11205555
ARITH	4	40.83250000	8.70535748
DIGITS	4	44.15500000	6.36941773
CODING	4	61.66750000	4.30283566
PICCOM	4	45.16500000	4.19479439
BLKDES	4	54.16750000	11.01505750
OBJASS	4	63.33250000	11.86373290
TARGET	4	43.62000000	7.67810306
FAGNR	4	54.00000000	13.95229969
FTAR	4	43.07250000	7.29675898
TPTOT	4	45.50750000	7.36106140
TPTNOT	4	49.66750000	7.64941556
TAPR	4	52.22250000	5.62770750
TAPL	4	43.23000000	3.12353432
PEGSRT	4	53.91500000	5.41168181
PEGSLT	4	41.30500000	8.76487117
CATTOT	4	47.06250000	5.05483514
TRSBT	4	50.21750000	2.98985308

TABLE 4 (cont'd)

Clusters

Cluster 7

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILC	13	2078.04615385	2323.29617010
INFO	13	42.82076923	5.90720106
COMP	12	45.66692302	4.50559100
SSPER	13	44.07538462	11.59805703
AUDCLO	12	43.19166667	8.04894779
ARITH	13	46.15384615	7.79959138
DIGITS	13	46.66692308	6.80305003
CODING	13	47.43538462	7.47220920
PICCOM	13	52.58923077	6.80694913
BLKDES	13	53.33307692	6.52786129
OBJASS	13	57.95000000	6.87474484
TARGET	13	36.83000000	15.23848775
FAGNF	13	50.30769231	10.35736906
FTWR	13	19.74153846	24.93675729
TPTOT	13	55.21076923	5.84370240
TOTNOT	13	51.10615385	4.46670099
TAPF	13	54.43307692	11.45773784
TAPL	13	36.57076923	6.72711115
PEGSPT	12	51.14500000	8.76996476
PEGSLT	12	34.59750000	13.87993131
CATTOT	13	54.11307692	5.16590487
TRSBT	13	48.09307692	6.64765546

N.B. The seven cluster solution listed on this table represents the results of both the Group Average and Centroid Sorting Methods, since identical solutions were generated from each.

TABLE 5

T Score Means and Standard Deviaitons
of Variables for Each Centroid Sorting Cluster Group
for Dextral Split Sample 2

Clusters

Cluster 1

VARIABLE	N	MEAN	STANCARD DEVIATION
NFILE	24	2070.22500000	916.60509312
INFO	24	40.27708333	4.49488064
COMP	24	49.72250000	7.91908605
SSPER	24	29.95041667	17.87931024
AUDCLU	24	44.93500000	11.08971674
ARITH	24	43.05541667	5.19211524
DIGITS	24	42.91666667	8.06504409
CODING	24	49.72166667	8.78725147
PICCOM	24	52.22208333	11.10583003
BLKDES	24	53.33375000	7.48576784
OBJASS	24	52.50041667	9.89176974
TARGET	24	42.96625000	11.57664433
FAGNR	24	60.66666667	8.93778820
FTWR	24	48.53833333	12.68647882
TPTDT	24	55.42791667	5.02111366
TPTNDT	24	52.13375000	6.87091147
TAPR	24	63.25958333	10.22412853
TAPL	24	49.64125000	7.77141379
PEGSRT	24	54.75416667	7.68603924
PEGSLT	24	41.54166667	11.60573871
CATTOT	24	50.60333333	7.96940436
TRSBT	24	40.71000000	14.93682523

Cluster 2

VARIABLE	N	MEAN	STANCARD DEVIATION
NFILE	4	2733.35000000	442.20837848
INFO	4	41.66750000	4.30288566
COMP	4	40.00250000	4.71404550
SSPER	4	52.55000000	10.86600202
AUDCLO	4	63.50000000	11.11305539
ARITH	4	40.83250000	8.76535748
DIGITS	4	44.16500000	6.86941773
CODING	4	61.66750000	4.30288566
PICCOM	4	49.16500000	4.19479439
BLKDES	4	54.16750000	11.01505750
OBJASS	4	63.33250000	11.86373290
TARGET	4	48.62000000	7.67810306
FAGNR	4	54.00000000	13.95229969
FTWR	4	45.07250000	7.29675898
TPTDT	4	49.50750000	7.36106140
TPTNDT	4	49.66750000	7.64941556
TAPR	4	52.22250000	5.62770750
TAPL	4	43.23000000	3.12353432
PEGSRT	4	55.91500000	5.41168181
PEGSLT	4	41.30500000	8.76487117
CATTOT	4	47.06250000	5.05483514
[illegible]	4	50.21750000	2.98985368

TABLE 5 (cont'd)

Clusters

Cluster 3

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILE	8	1639.87500000	1261.90343954
INFO	8	45.83375000	6.36265205
COMP	8	53.75000000	10.60615320
SSPER	8	53.35875000	9.28891111
AUDCLO	8	53.44250000	8.64098829
ARITH	8	48.33250000	7.34544514
DIGITS	8	45.41750000	8.71893629
CODING	8	42.91500000	8.98534998
PICCOM	8	57.50125000	8.30934661
BLKDES	8	52.08250000	5.89262432
OBJASS	8	56.66625000	9.42724916
TARGET	8	23.65000000	11.96157777
FAGNR	8	55.75000000	5.99404466
FTWR	8	51.63125000	11.32582566
TPTDT	8	46.91875000	11.22106366
TPTNDT	8	51.09125000	4.75533216
TAPR	8	53.40250000	7.07202285
TAPL	8	42.53000000	9.68592794
PEGSRT	8	52.09000000	6.61659602
PEGSLT	8	41.90125000	6.77961322
CATTOT	8	53.65375000	5.40056330
TRSBT	8	40.55750000	17.27894817

Cluster 4

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILE	11	2513.73636364	2390.85588327
INFO	11	42.42545455	7.16364344
COMP	11	43.94000000	4.67067019
SSPER	11	41.84727273	13.40044260
AUDCLO	10	46.21400000	10.68371159
ARITH	11	45.45454545	7.92741113
DIGITS	11	46.96909091	5.46701830
CODING	11	46.36272727	6.57491459
PICCOM	11	48.78727273	4.54019183
BLKDES	11	50.60545455	7.12219540
OBJASS	11	54.24272727	6.84537814
TARGET	11	35.02090909	18.43377794
FAGNR	11	42.36363636	13.79327900
FTWR	11	11.24909091	21.99536381
TPTDT	11	52.39000000	7.53150450
TPTNDT	11	33.70000000	43.38825141
TAPR	11	56.15818182	12.32005424
TAPL	11	39.00636364	9.90159005
PEGSRT	10	38.38800000	22.07312584
PEGSLT	10	0.85200000	62.12102181
CATTOT	11	52.55727273	6.63066979
TRSBT	11	41.49454545	8.99070783

TABLE 5 (cont'd)

Clusters

Cluster 5

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILE	17	1647.51764706	795.37172303
INFO	17	44.70411765	4.57416257
COMP	17	48.62823529	7.55107379
SSPER	17	18.16882353	27.82489036
AUDCLO	17	39.71882353	14.33135456
ARITH	17	45.49000000	6.55466628
DIGITS	17	44.11764706	7.02519442
CODING	17	48.04000000	10.47836283
PICCOM	17	51.37294118	11.78823607
BLKDES	17	52.94000000	8.73042668
OBJASS	17	52.94176471	9.92175718
TARGET	17	43.53235294	9.60887060
FAGNR	17	2.00000000	30.81395788
FTWR	17	40.49705882	14.74409957
TPTDT	17	48.44882353	13.30846013
TPTNDT	17	50.15294118	11.24282147
TAPR	17	52.28647059	8.52891255
TAPL	17	41.74117647	8.31106332
PEGSRT	17	53.028[illegible]529	10.13986824
PEGSLT	17	40.97352[illegible]1	12.92198705
CATTOT	17	52.1758[illegible]	8.88646795
TRSBT	17	29.90705882	16.92051298

Cluster 6

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILE	8	1607.11250000	1013.45656111
INFO	8	44.16625000	7.07292006
CCMP	8	51.25000000	7.54657538
SSPER	8	54.34375000	12.19875396
AUDCLO	8	44.91[illegible]000	9.86784641
[illegible]ITH.	8	48.3[illegible]5000	5.04062904
DIGITS	8	46.2[illegible]000	7.85634957
CODING	8	5[illegible]	9.75948906
PICCOM	8	[illegible]	9.87878969
BLKDES	8	52.[illegible]0	3.53570335
OBJASS	8	55.835[illegible]0	7.50766846
TARGET	8	46.10625000	8.48727440
FAGNR	8	46.50000000	10.35098339
FTWR	8	50.07125000	12.73649474
TPTDT	8	53.12375000	6.38334650
TPTNDT	8	58.20125000	4.72087291
TAPR	8	54.44625000	8.00860954
TAPL	8	37.92000000	9.67730925
PEGSRT	8	70.27875000	7.44778287
PEGSLT	8	54.24000000	6.84985297
CATTOT	8	50.83750000	7.23261808
TRSBT	8	54.52250000	6.33541012

TABLE 5 (cont'd)

Clusters

Cluster 7

VARIABLE	N	MEAN	STANDARD DEVIATION
NFILE	8	1939.22500000	744.08955634
INFO	8	45.00000000	4.36435890
COMP	8	45.00000000	9.08496089
SSPER	8	49.41625000	10.83663619
AUDCLO	8	44.15750000	12.26190588
ARITH	8	46.66625000	5.91071167
DIGITS	8	55.00125000	7.55897468
CODING	8	51.66625000	7.55960494
PICCOM	8	47.49875000	9.04113210
BLKDES	8	51.25000000	5.61672757
OBJASS	8	49.16625000	9.38451146
TARGET	8	50.21625000	8.18450965
FAGNR	8	61.50000000	9.18072515
FTWR	8	58.21625000	3.26200612
TPTOT	8	55.80375000	6.31869774
TPTNOT	8	51.09625000	7.42124159
TAPR	8	56.73000000	6.00761184
TAPL	8	41.81500000	7.53398965
PEGSRT	8	40.44250000	10.03052448
PEGSLT	8	35.71625000	10.57816746
CATTOT	8	54.08125000	6.04350286
TRSBT	8	54.19500000	7.57335178

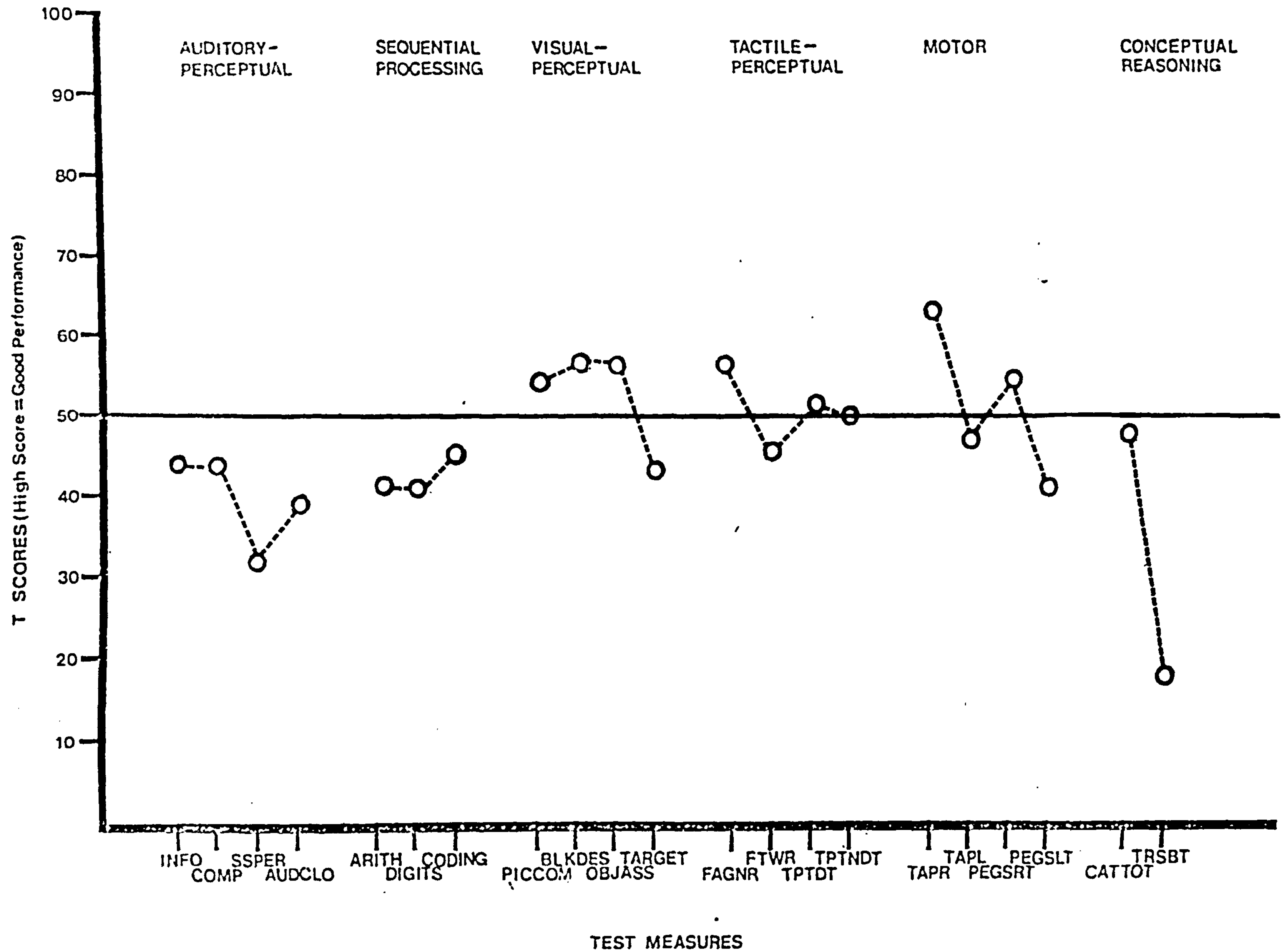

Figure 9. Plot of _T_ score means for Cluster 1 of dextral split sample 1.

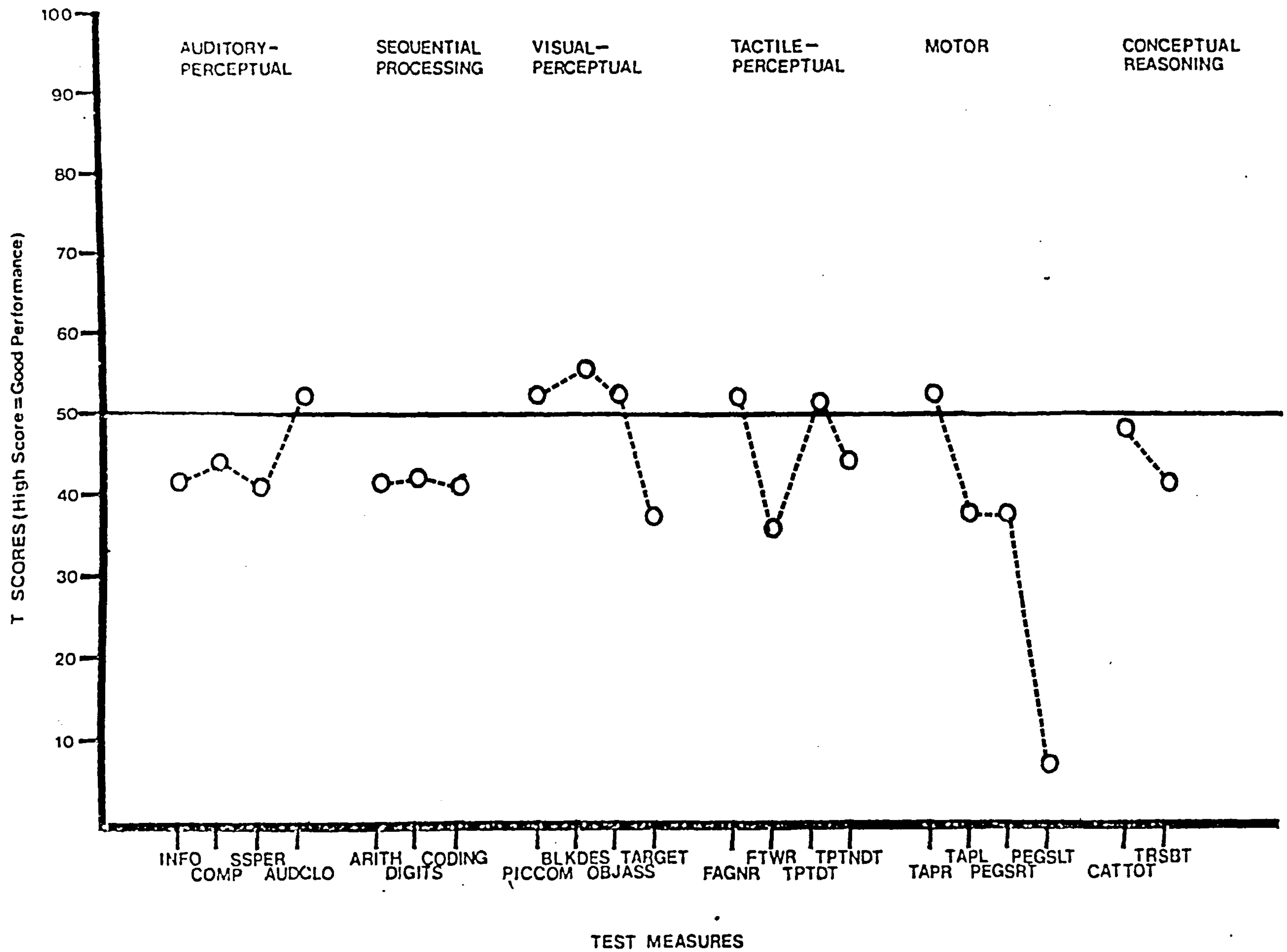

Figure 10. Plot of T score means for Cluster 2 of dextral split sample 1.

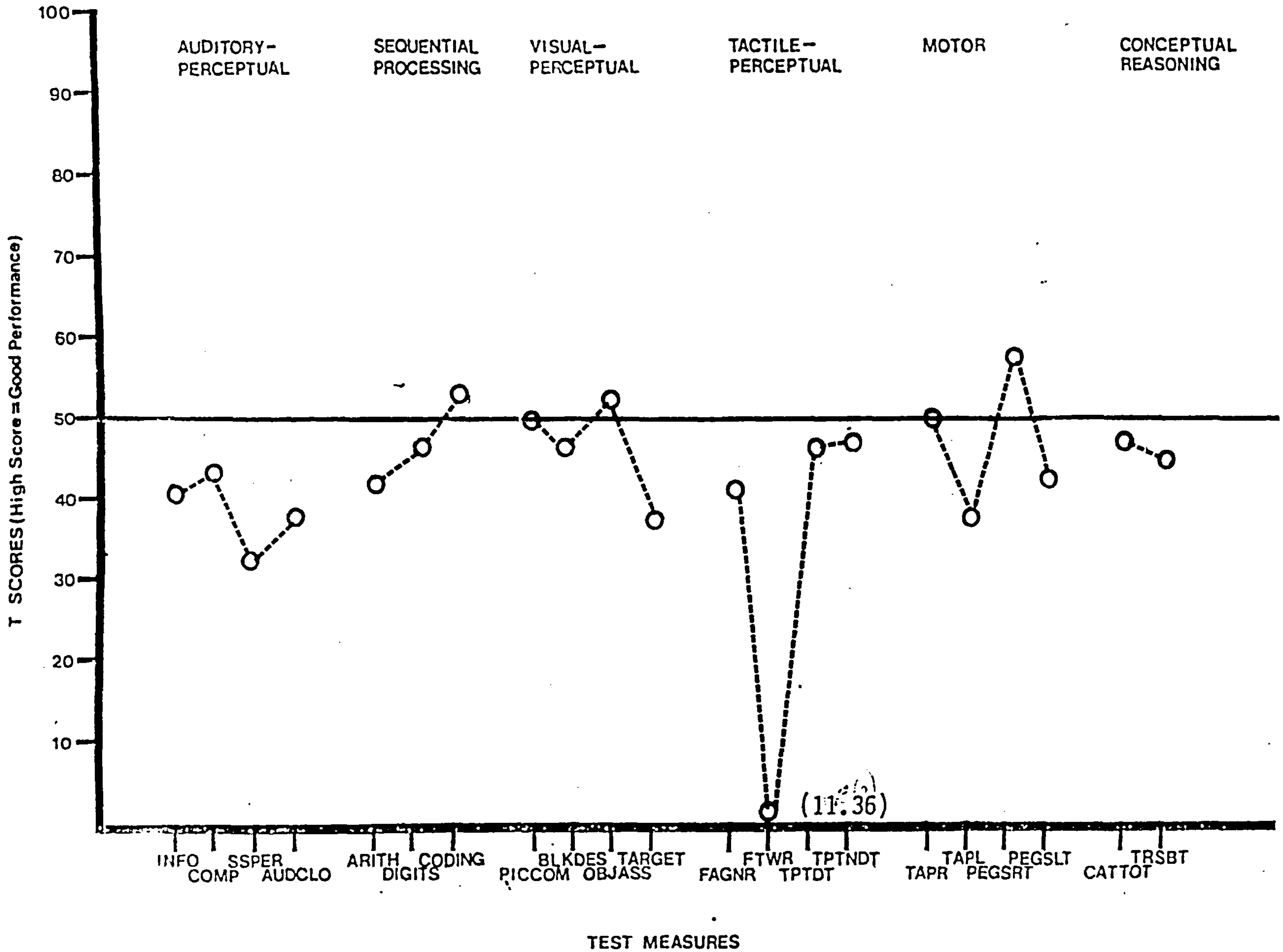

Figure 11. Plot of T score means for Cluster 3 of dextral split sample 1.

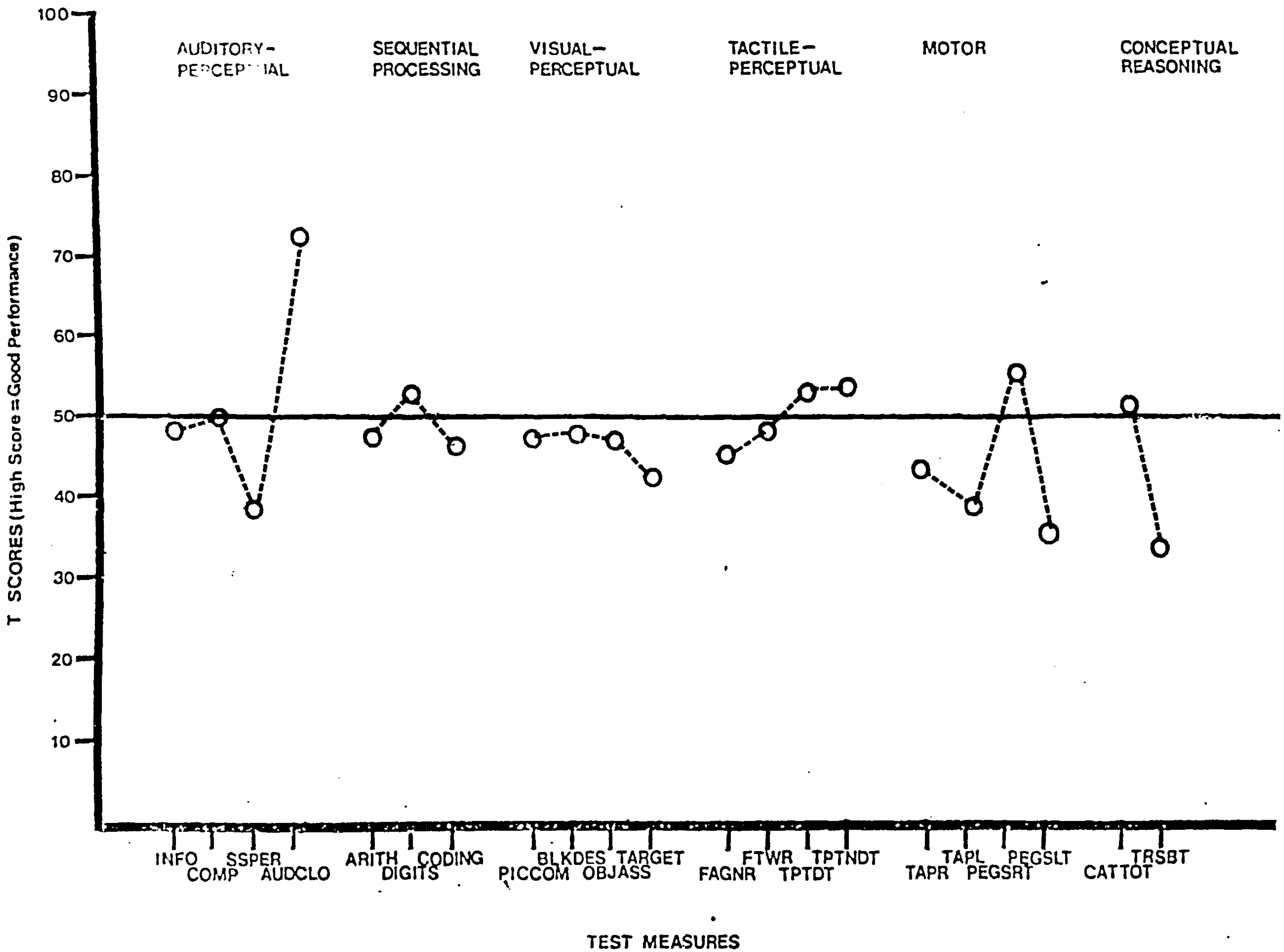

Figure 12. Plot of T score means for Cluster 4 of dextral split sample 1.

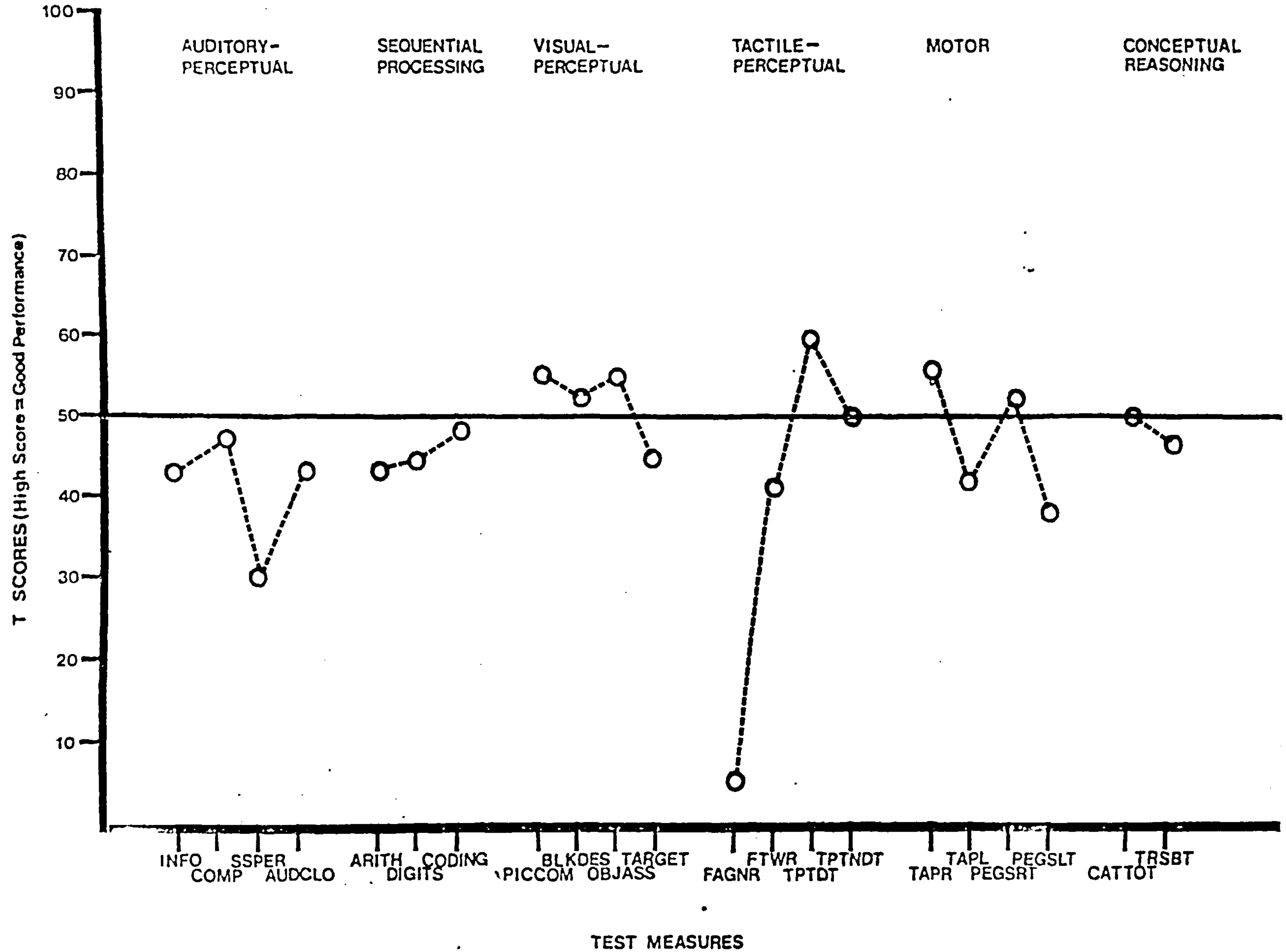

Figure 13. Plot of T score means for Cluster 5 of dextral split sample 1.

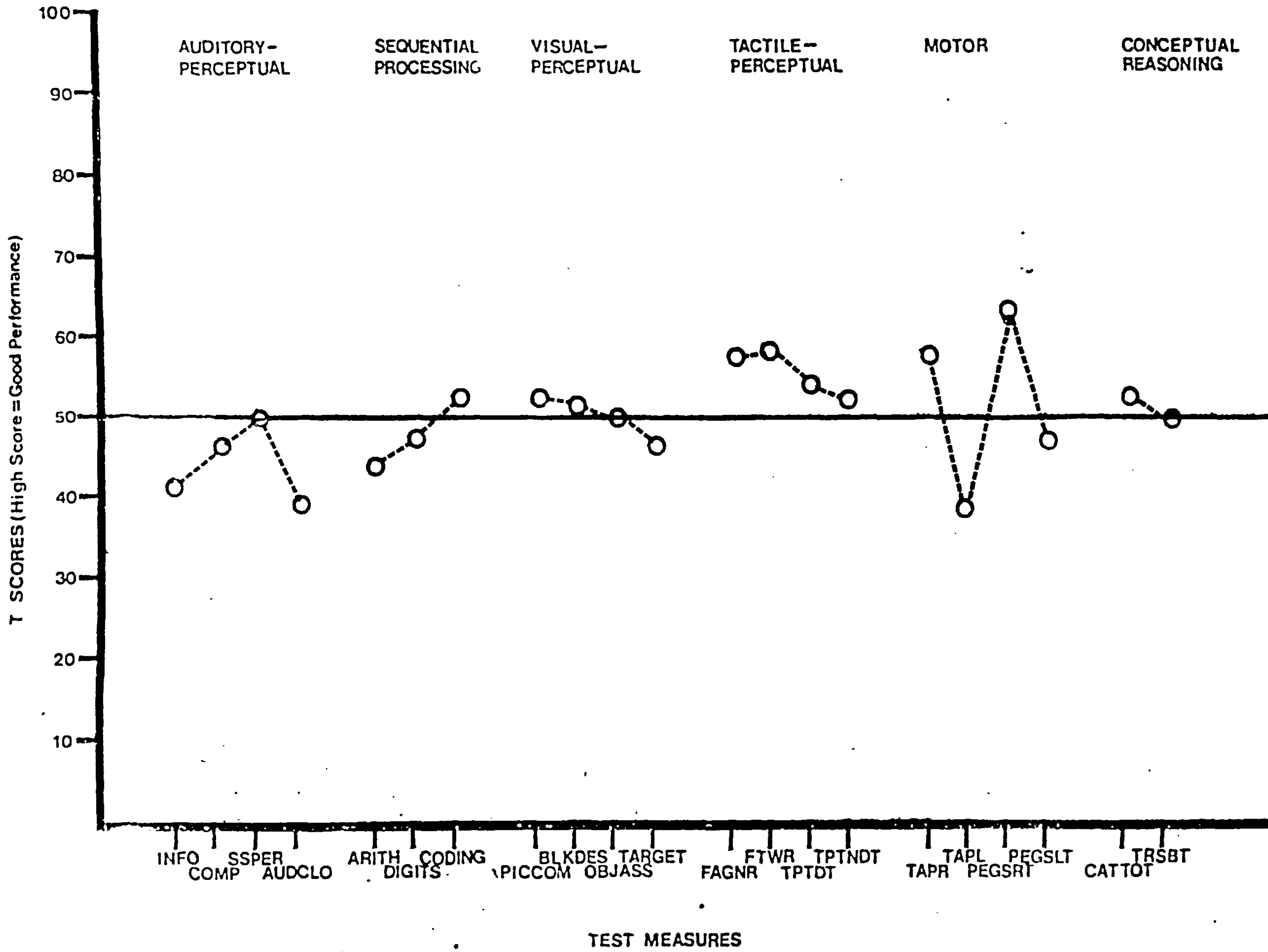

Figure 14. Plot of T score means for Cluster 6 of dextral split sample 1.

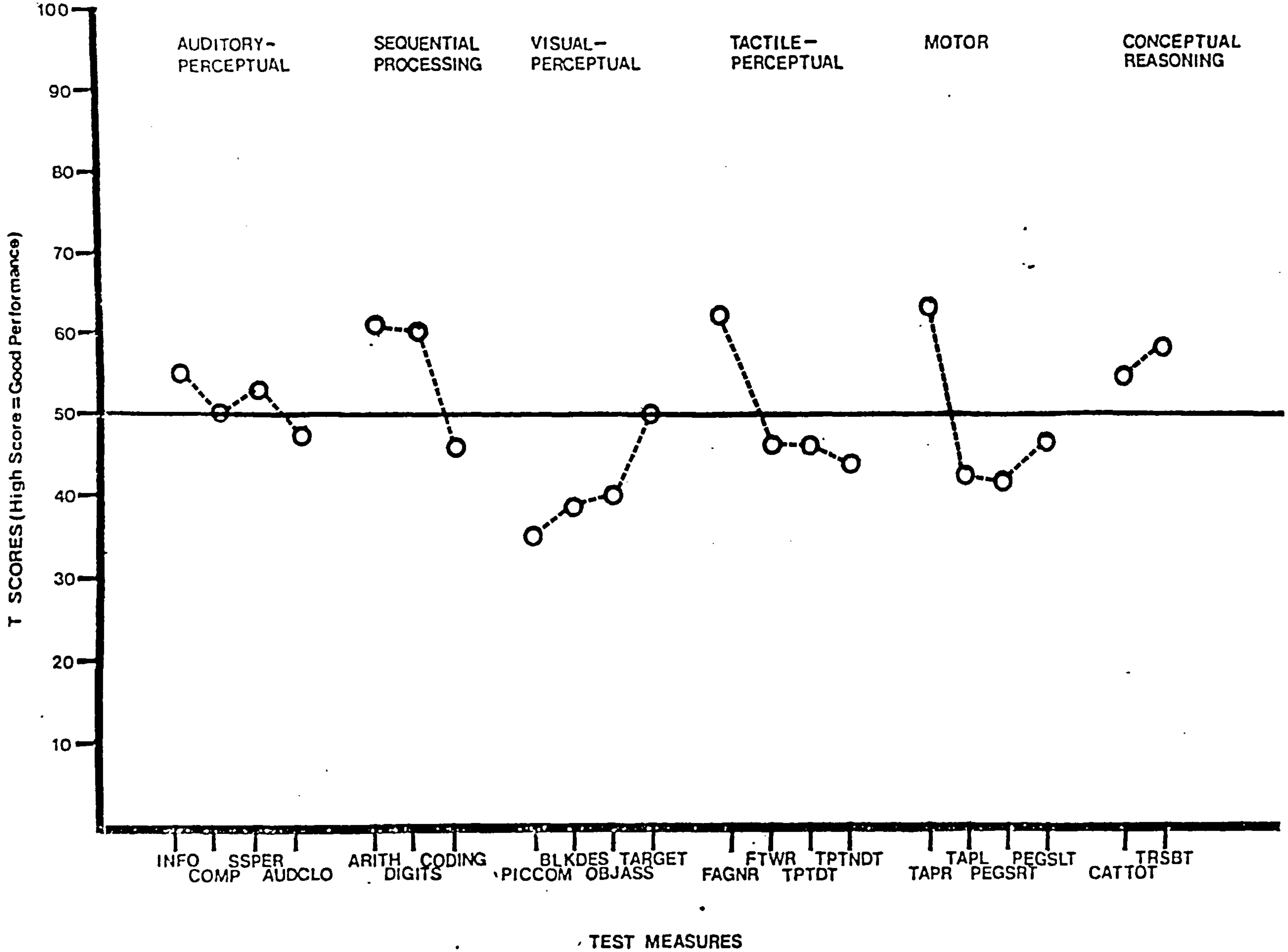

Figure 15. Plot of T score means for Cluster 7 of dextral split sample 1.

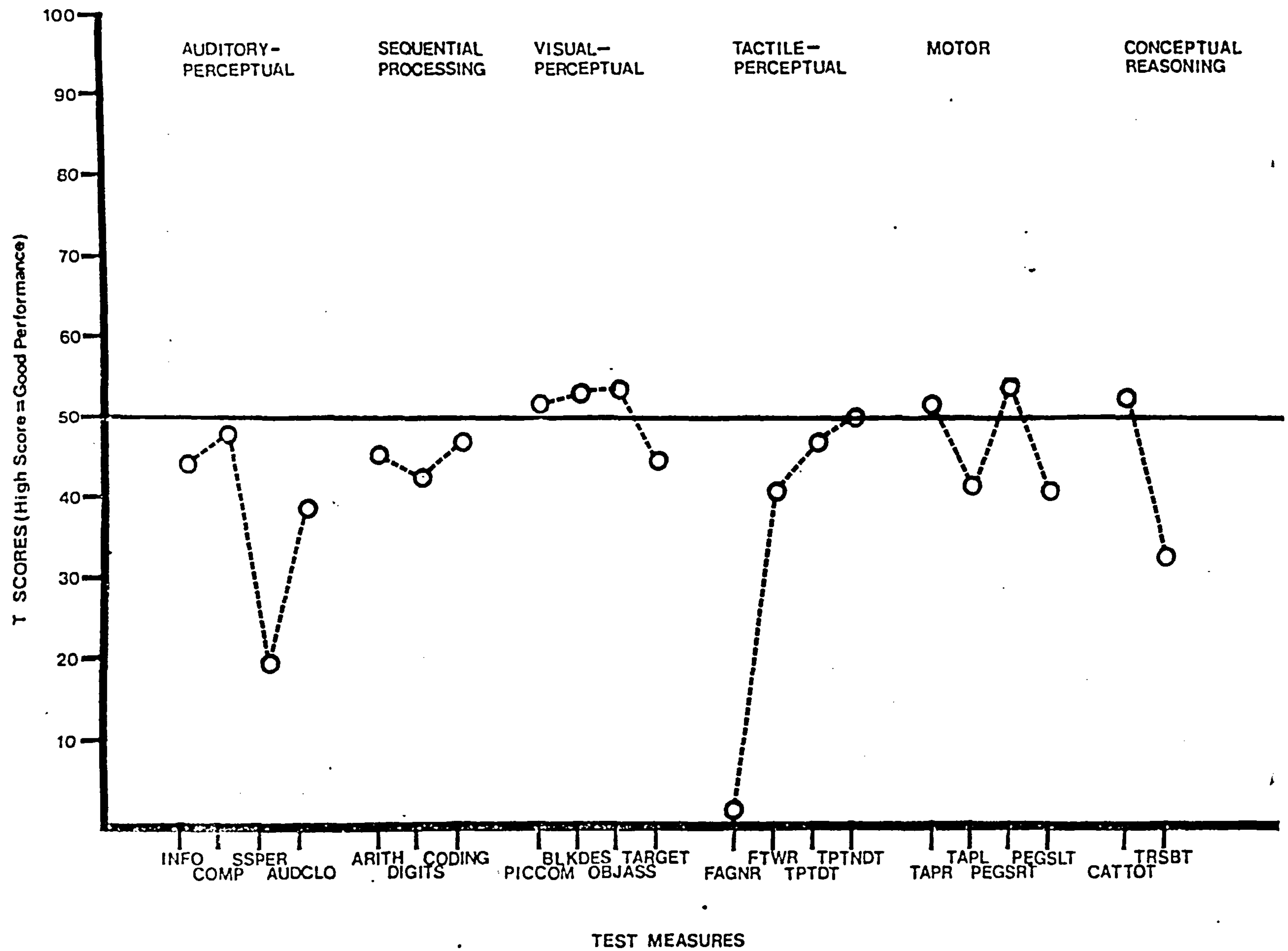

Figure 16. Plot of T score means for Cluster 1 of group average solution for dextral split sample 2.

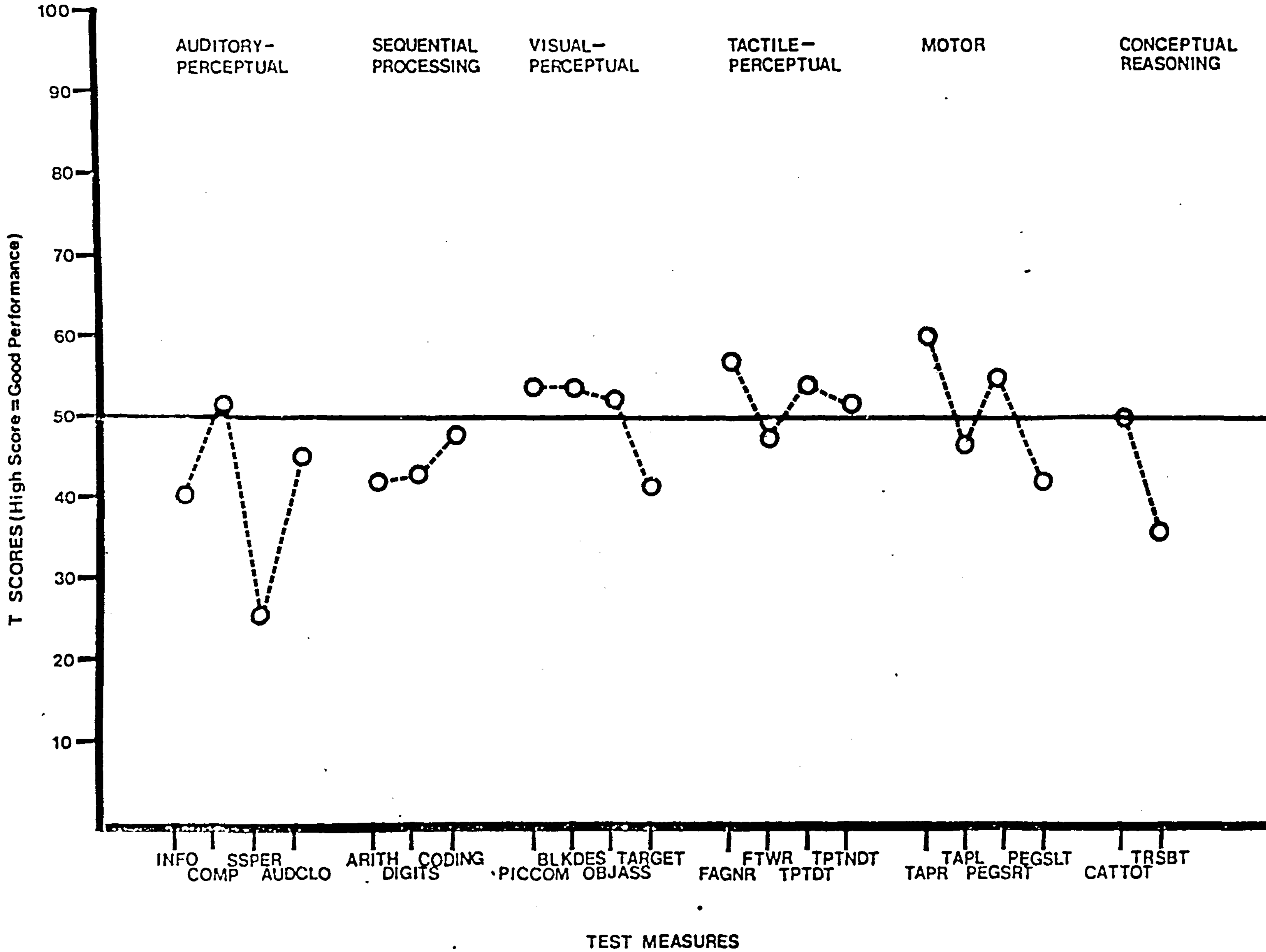

Figure 17. Plot of $\underline{T}$ score means for Cluster 2 of group average solution for dextral split sample 2.

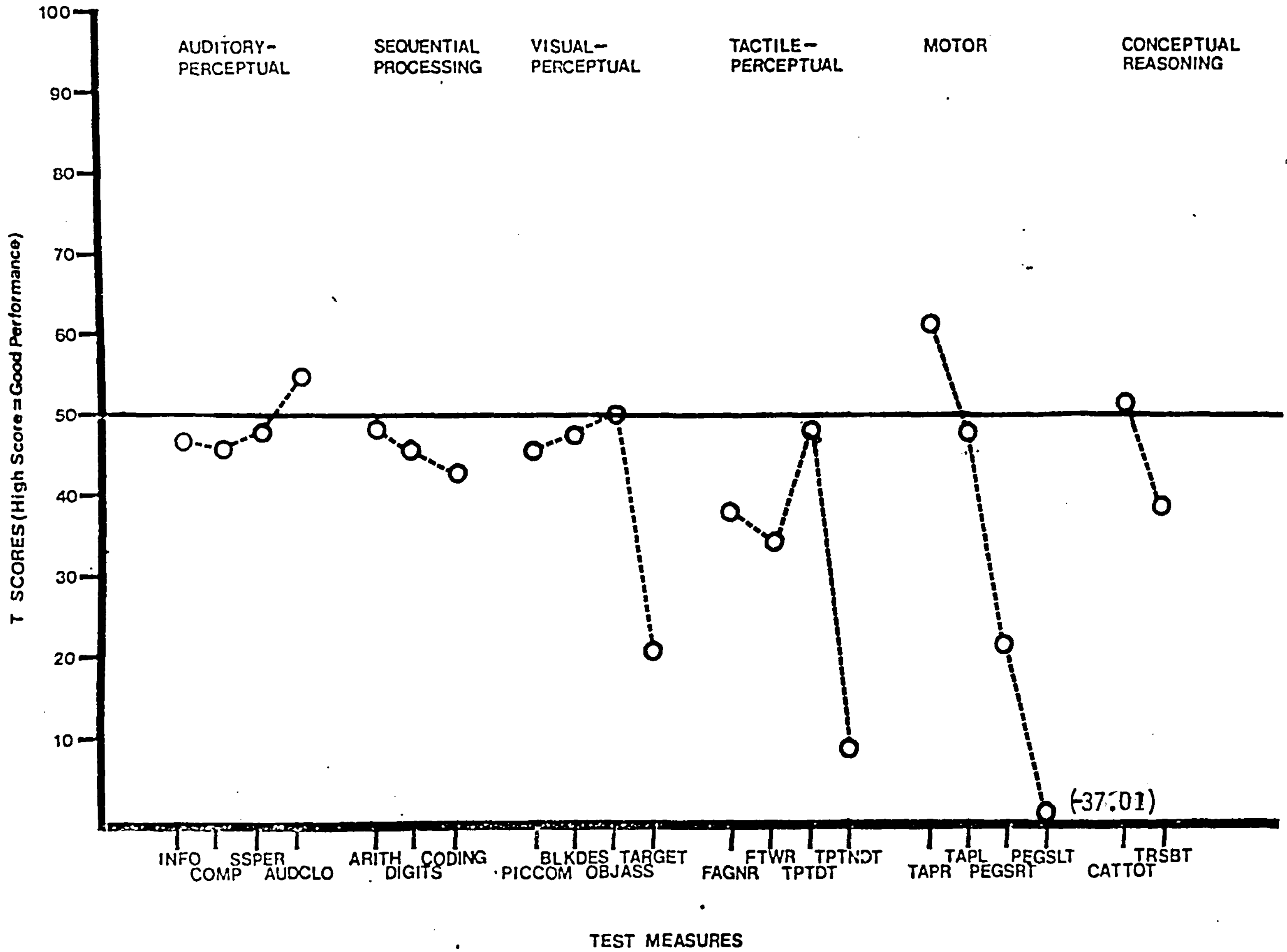

Figure 18. Plot of T score means for Cluster 3 of group average solution for dextral split sample 2.

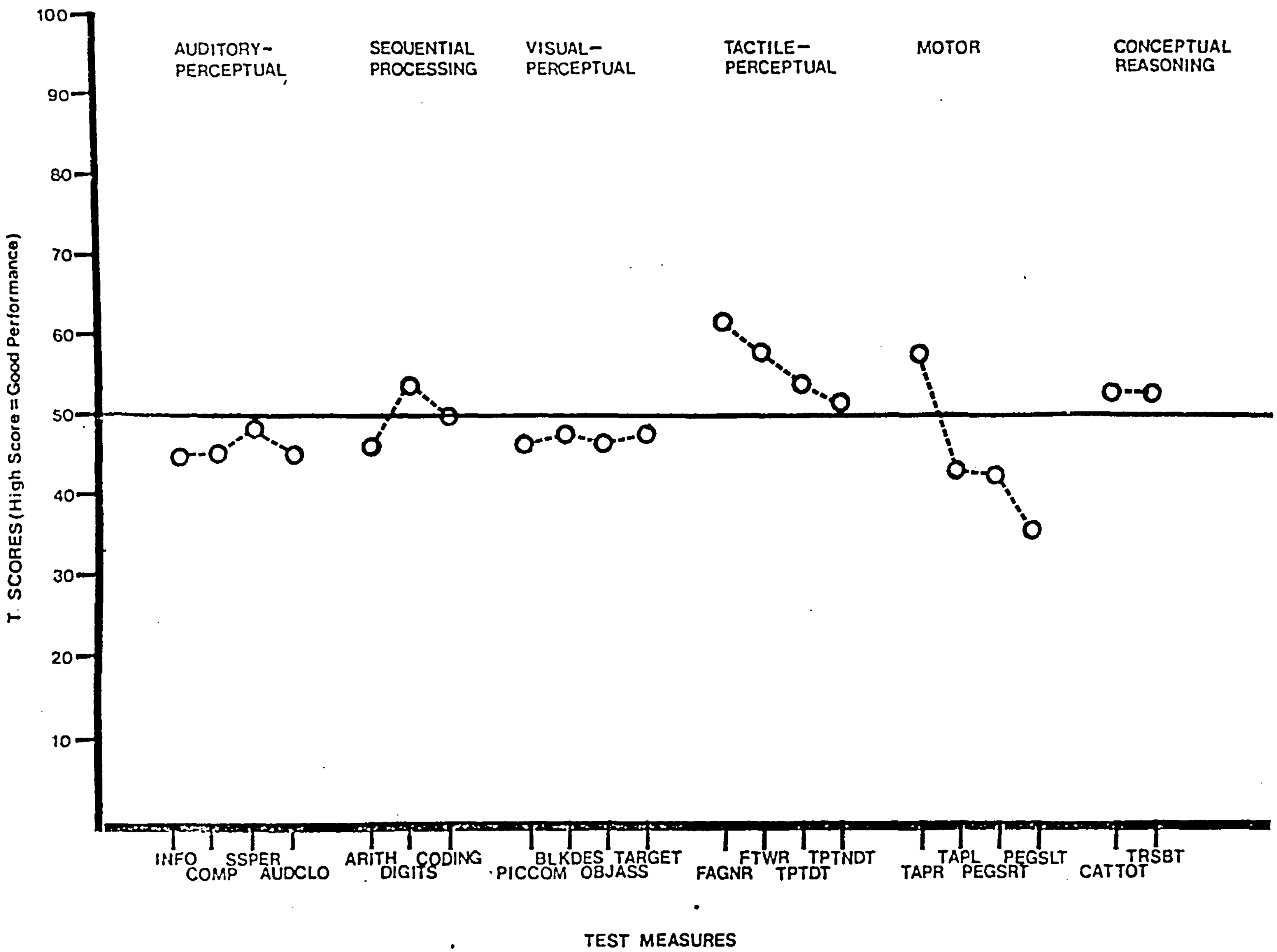

Figure 19. Plot of T score means for Cluster 4 of group average solution for dextral split sample 2.

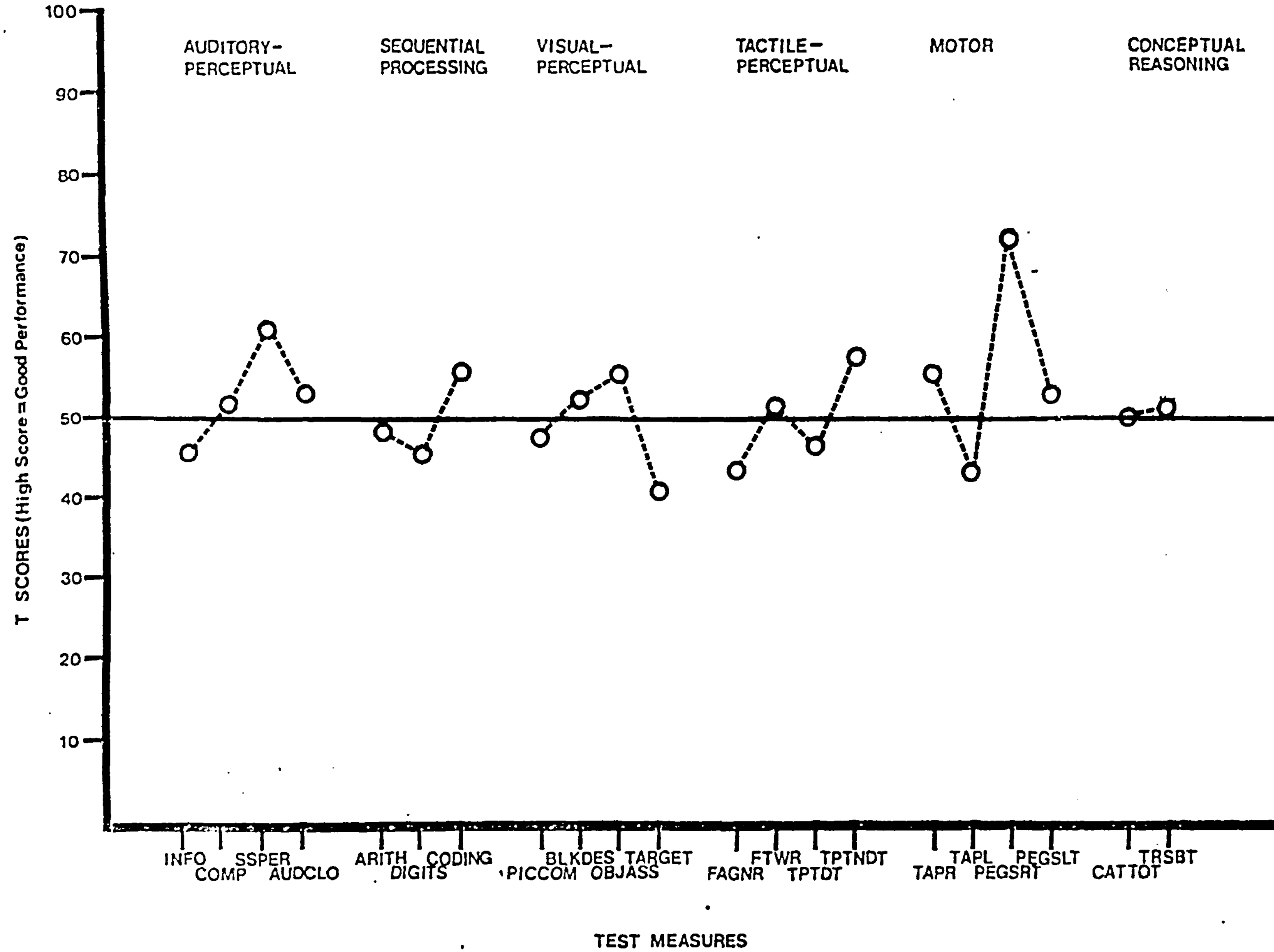

Figure 20. Plot of _T_ score means for Cluster 5 of group average solution for dextral split sample 2.

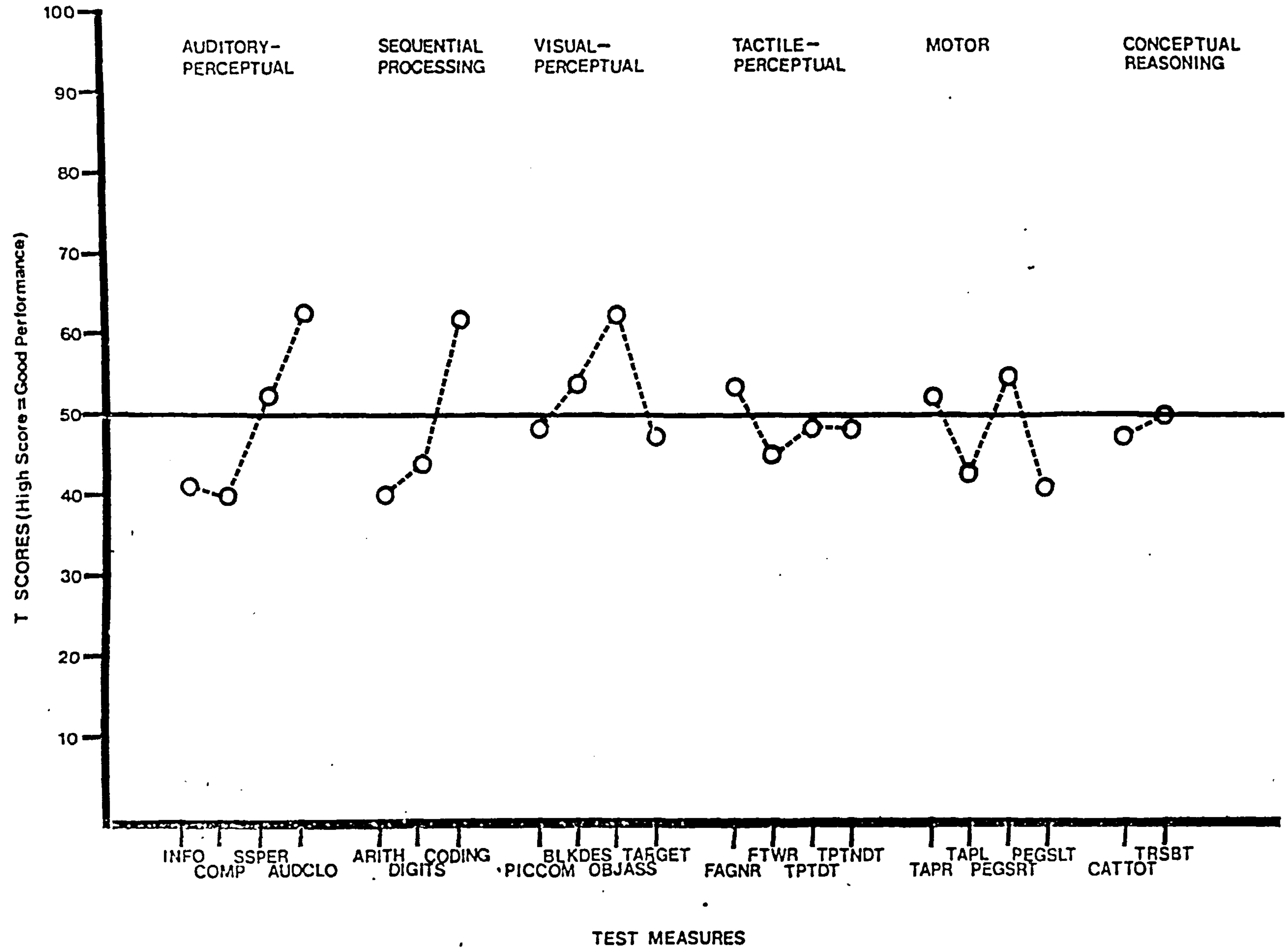

Figure 21. Plot of T score means for Cluster 6 of group average solution for dextral split sample 2.

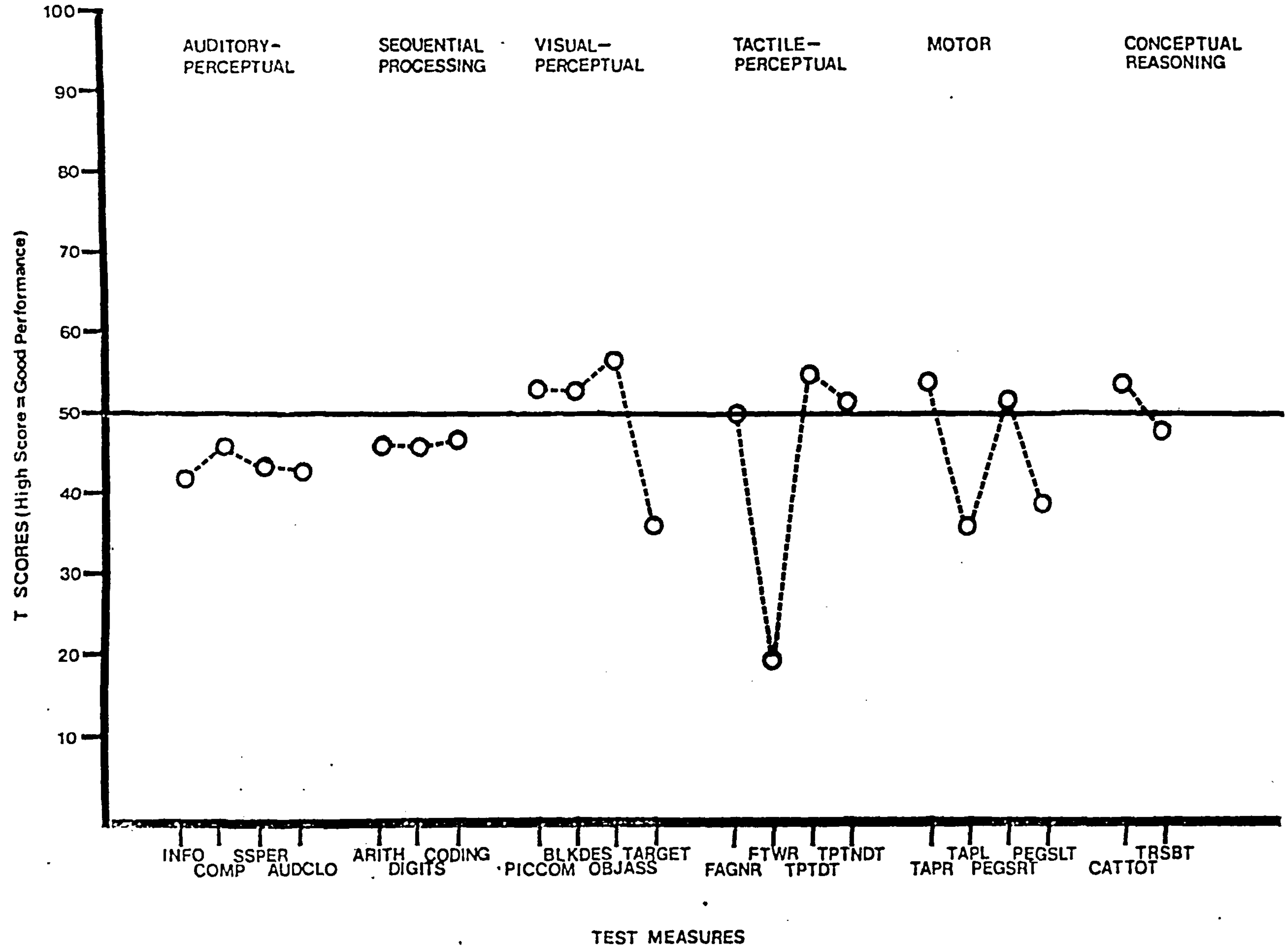

Figure 22. Plot of T score means for Cluster 7 of group average solution for dextral split sample 2.

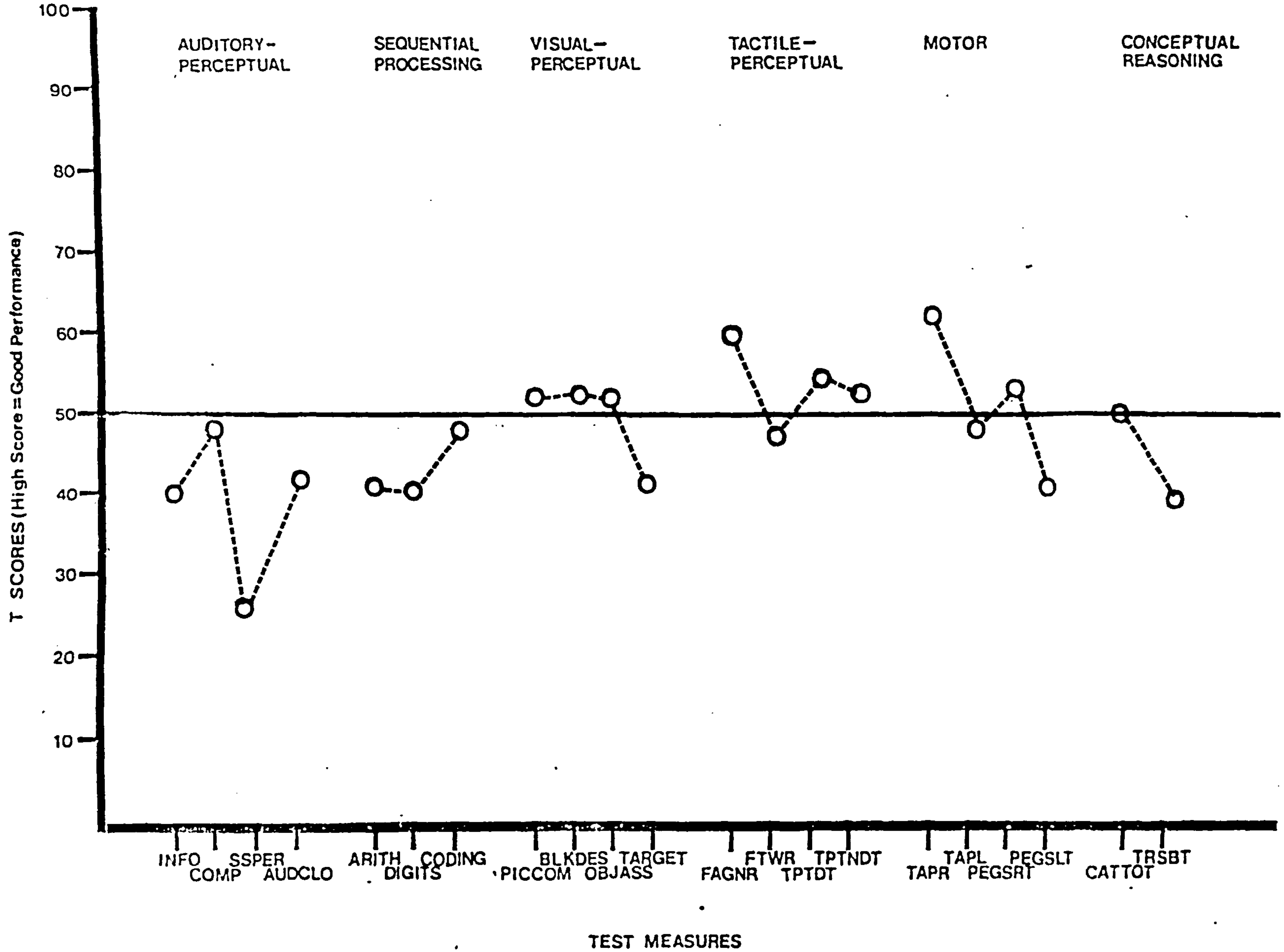

Figure 23. Plot of _T_ score means for Cluster 1 of centroid sorting solution for dextral split sample 2.

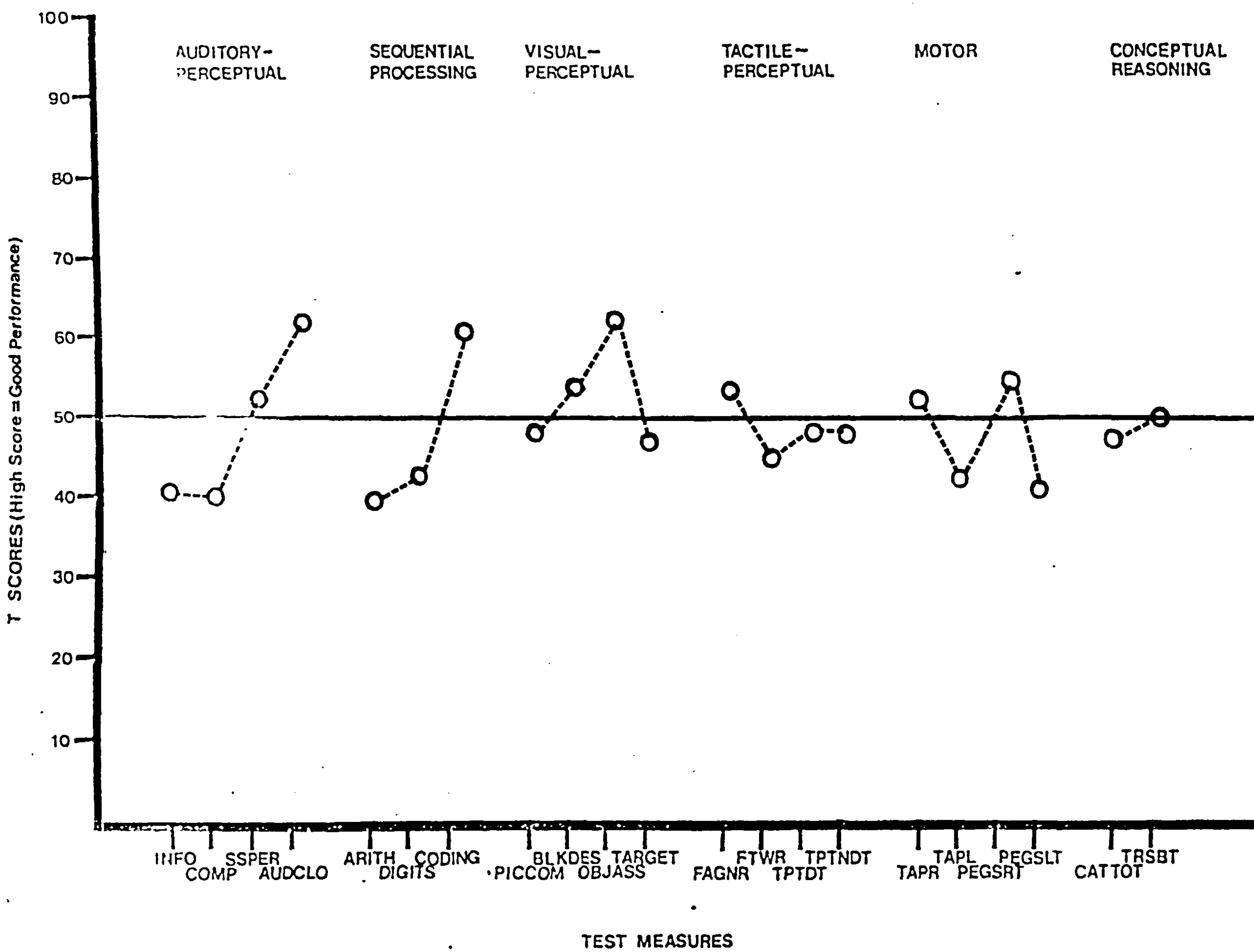

Figure 24. Plot of T score means for Cluster 2 of centroid sorting solution for dextral split sample 2.

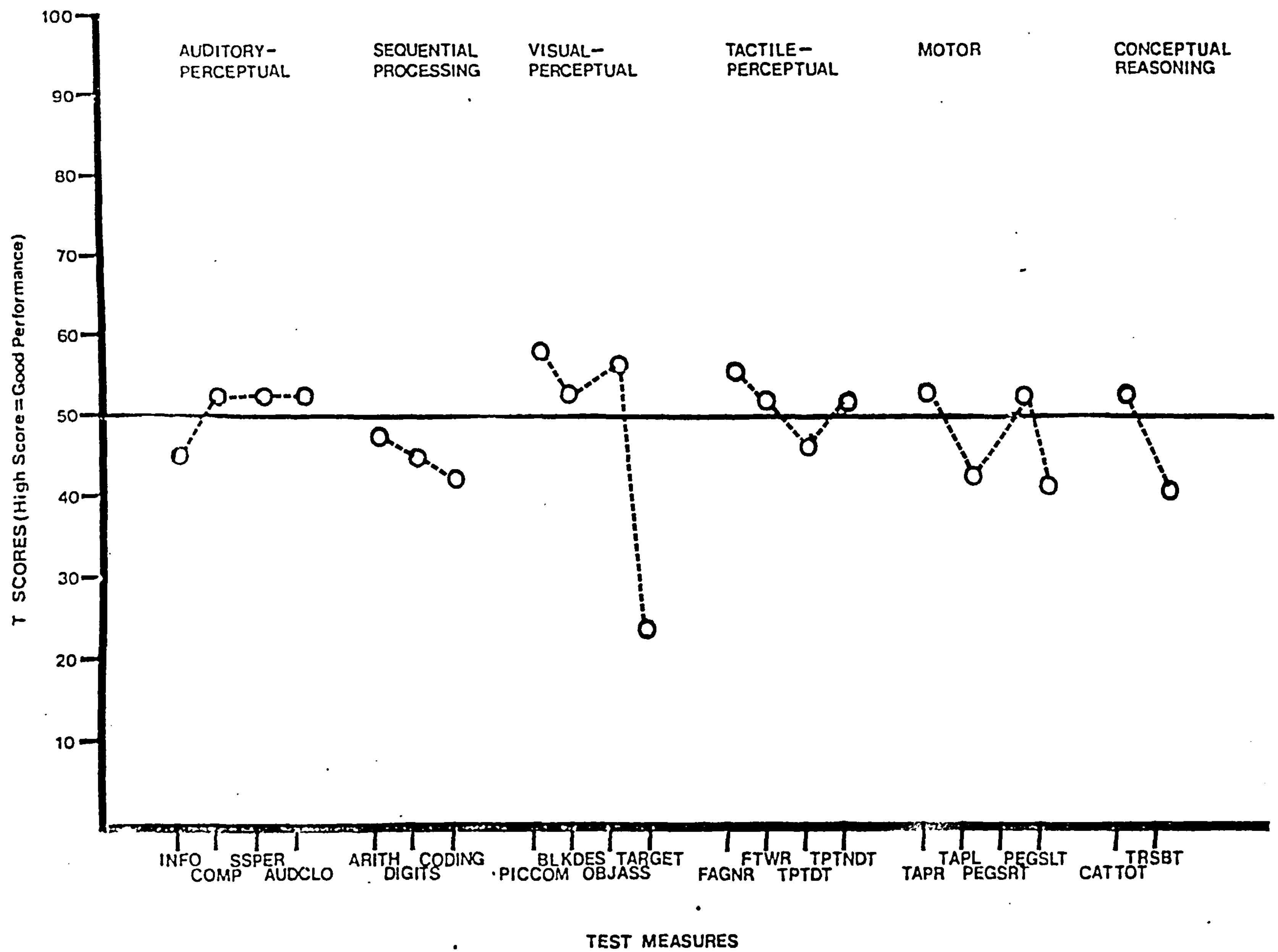

Figure 25. Plot of T score means for Cluster 3 of centroid sorting solution for dextral split sample 2.

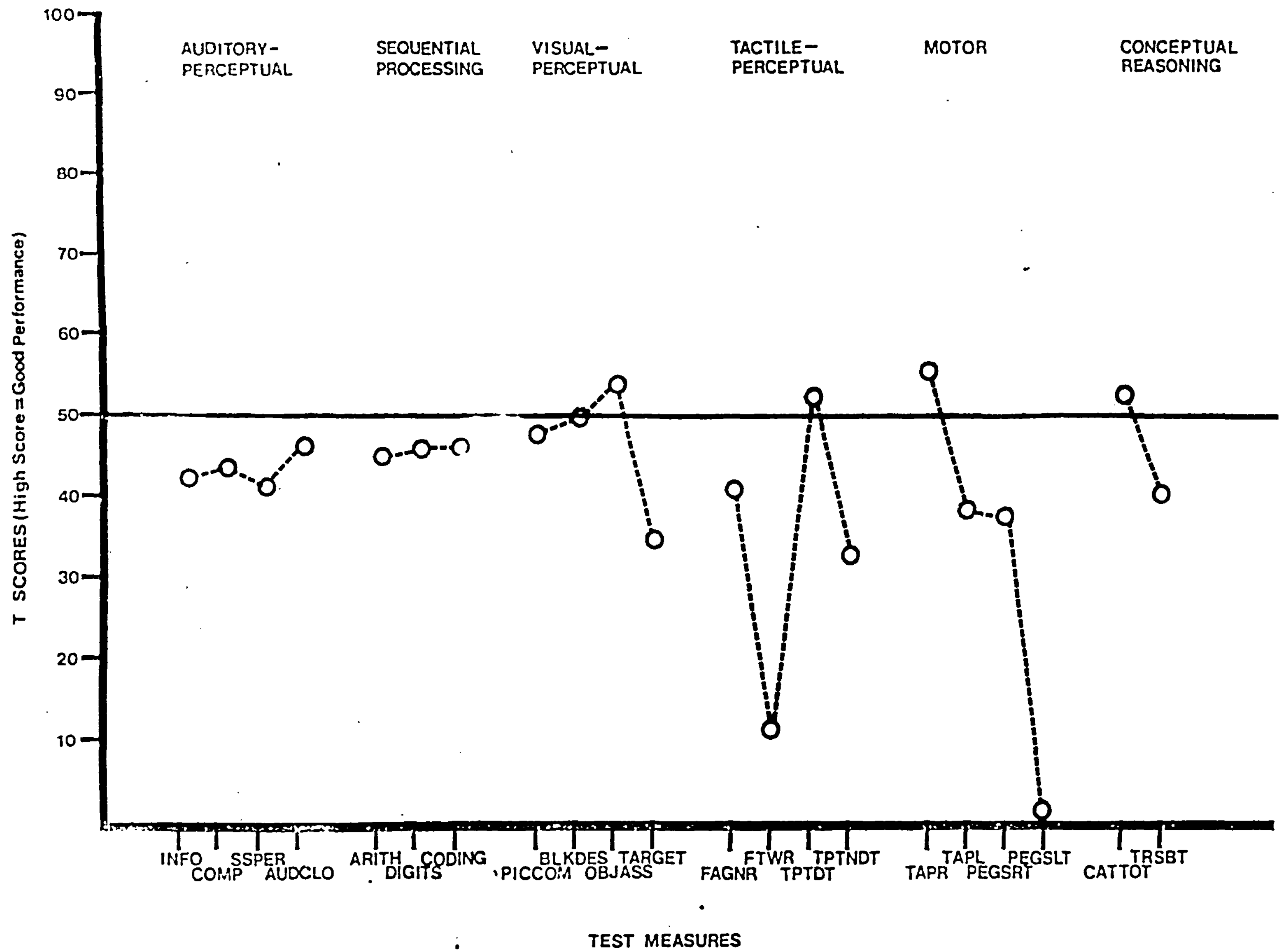

Figure 26. Plot of T score means for Cluster 4 of centroid sorting solution for dextral split sample 2.

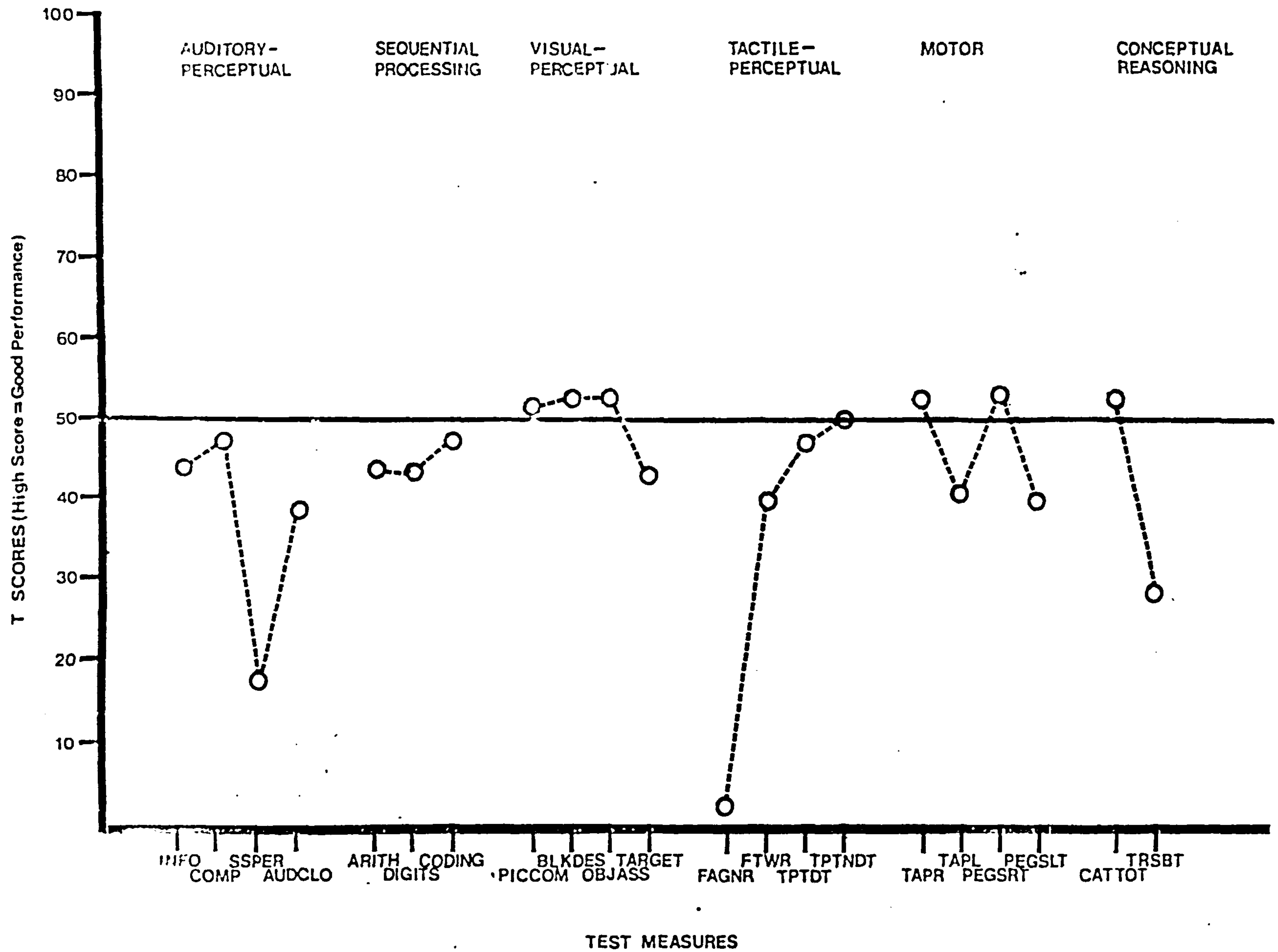

Figure 27. Plot of T score means for Cluster 5 of centroid sorting solution for dextral split sample 2.

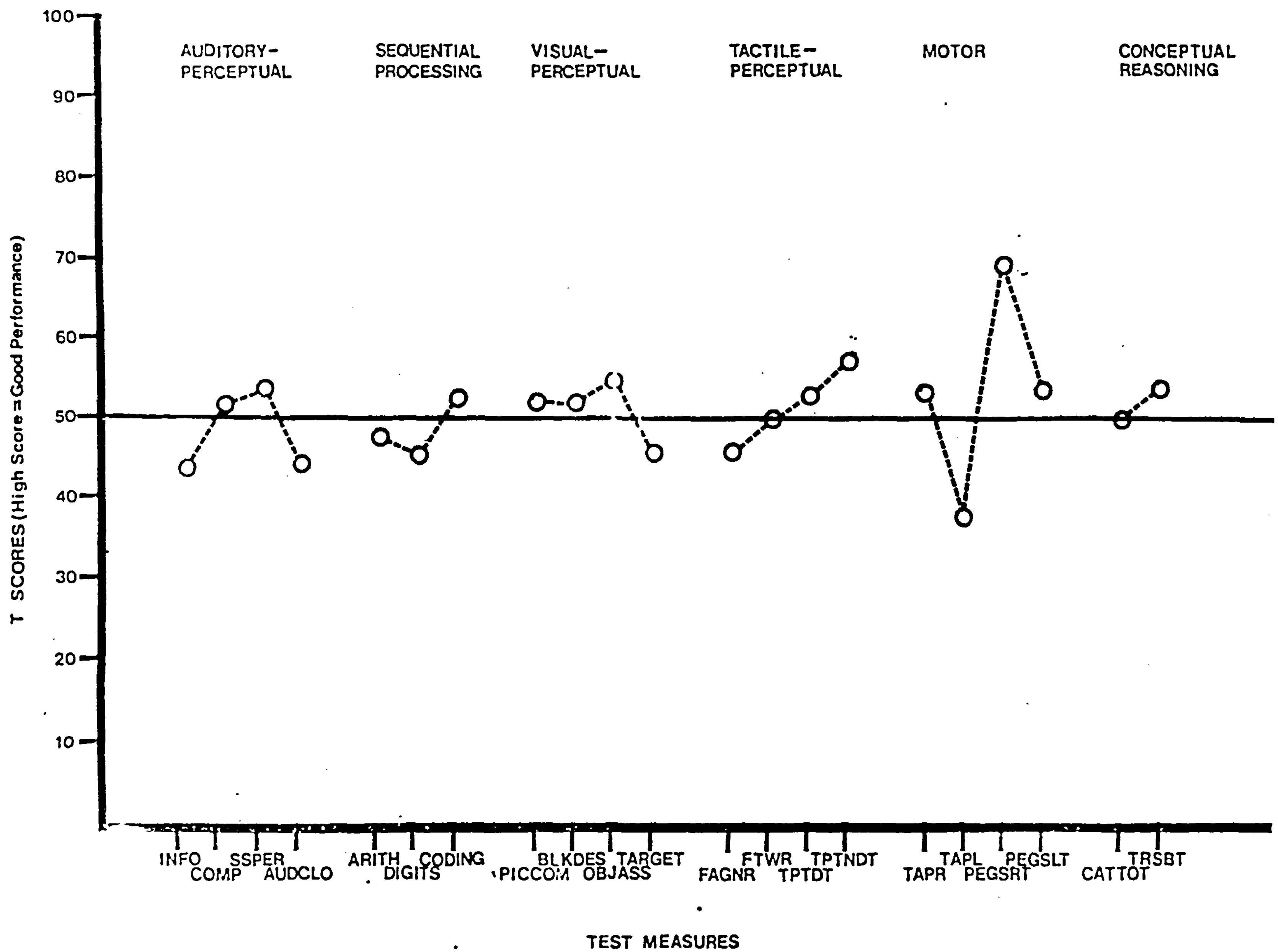

Figure 28. Plot of T score means for Cluster 6 of centroid sorting solution for dextral split sample 2.

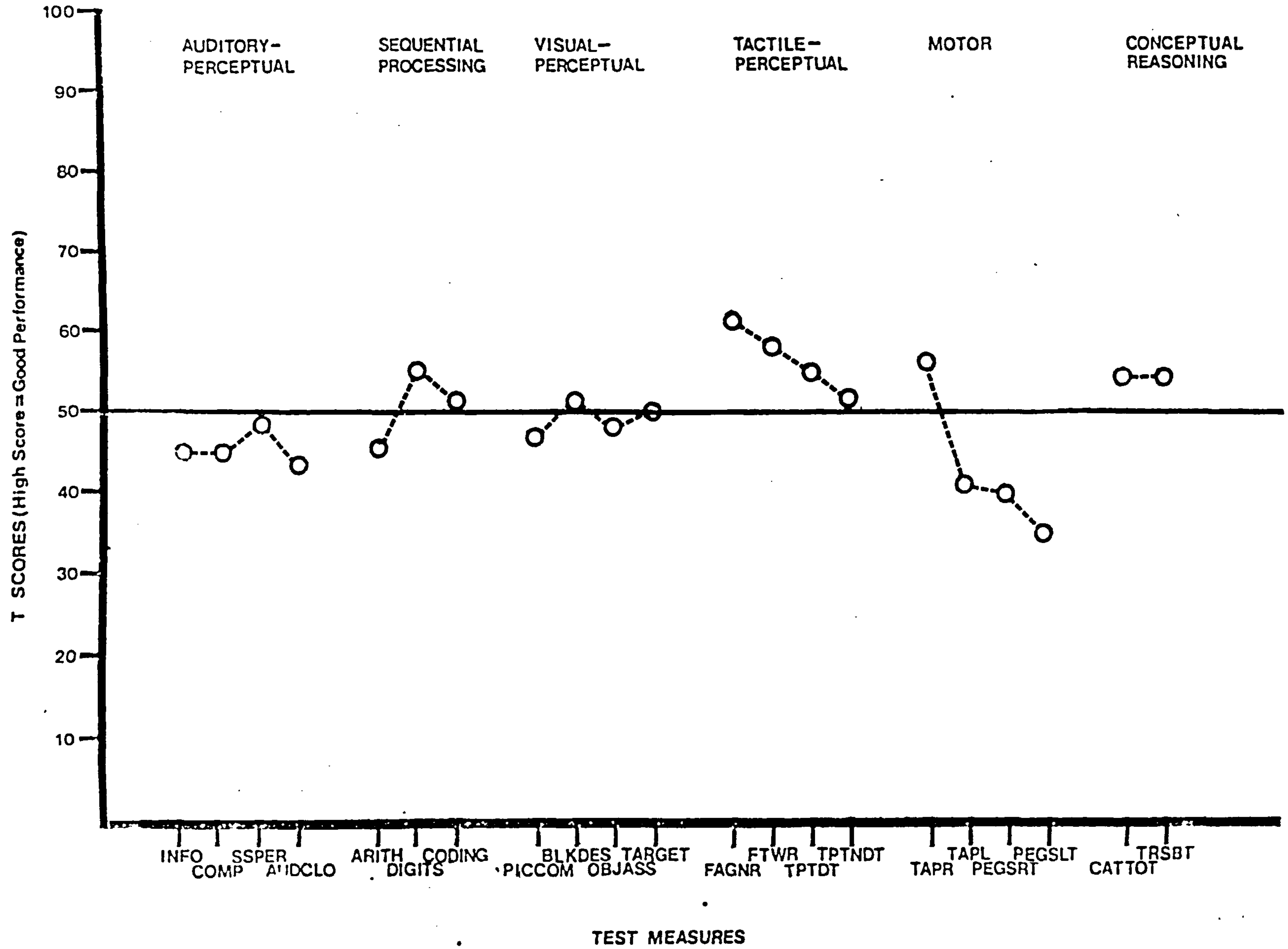

Figure 29. Plot of T score means for Cluster 7 of centroid sorting solution for dextral split sample 2.

VITA AUCTORIS

Jerel Eugene Del Dotto

1950 -	Born in Minneapolis, Minnesota, U.S.A.
1968 -	Graduated from Edina High School, Edina, Minnesota.
1975 -	Granted degree of Bachelor of Arts (Magna Cum Laude) with Honours in Psychology from Augsburg College, Minneapolis, Minnesota.
1978 -	Granted degree of Master of Arts in Psychology from the University of Windsor, Windsor, Ontario.
1978 - 1982	Registered as a Graduate student in the Department of Psychology at the University of Windsor, Windsor, Ontario.