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Personality Characteristics of Adults with Nonverbal Learning Disability Subtypes

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Abstract

The present study examined whether individuals with poor math ability possess more atypical personality characteristics than individuals with average or good math abilities. Individuals with nonverbal learning disability syndrome (NLD) have been found to have difficulties with mechanical arithmetic and psychosocial functioning, and it was hypothesized that the individuals in the poor math group in this study would be analogous to individuals with NLD with respect to psychosocial functioning. The Minnesota Multiphasic Personality Inventory - 2 (MMPI-2) was used to assess the personality characteristics of 48 undergraduate university students (31 females and 17 males), assessed as having poor, average and good math ability based on their performance on the Wide Range Achievement Test - 3 (WRAT-3). The hypothesis that the individuals with poor math abilities would resemble individuals with NLD in their social-emotional deficits was not upheld, as the individuals in the poor math group did not display any more significant elevations on the Clinical nor Content Scales of the MMPI-2 than did the individuals in the other math ability groups. These findings suggest that the deficits of NLD do not run along a continuum of mathematical ability, and that the poor math group in this study was not simply displaying attenuated forms of the deficits seen in NLD individuals.

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Historical Background

The concept of learning disability can be traced to several different lines of inquiry and historical epochs. Although its history is replete with inconsistencies, there has tended to have been one constant; evidence of two broad concepts, language and perceptual-motor disorders. This has been apparent in each stage of the evolution of learning disability.

Medical/neurological stage.

The earliest stage of learning disabilities research involved the investigation of brain/behaviour relationships in the context of linguistic disorders. Physicians, such as Pierre Paul Broca (1879) and Karl Wernicke (1908) studied adult patients who had lost expressive or receptive language as the result of brain lesions caused by accidents or disease. By combining precise behavioural observations with the knowledge of where the damage to the brain was localized, these doctors were able to begin "mapping" the linguistic functions of various brain regions. Theorists during this foundation phase were also often concerned with difficulties in the acquisition of written language, and terms such as "congenital word blindness" and "dyslexia" were coined by James Hinshelwood in 1917 and R. Berlin in 1887 respectively, to describe reading difficulties (Westman, 1990).

Samuel Orton (1937) was also interested in reading disabilities, and did so by postulating the neurological underlying mechanisms them. He believed that reading disabilities arose from confused cerebral dominance, which led to a breakdown in perceptual-motor abilities. Perceptual motor difficulties in brain injured soldiers were also studied at this time by a neurologist, Kurt Goldstein (Kavale & Forness, 1992). Goldstein found these men to have a common set of behavioural symptoms, including figure-ground confusion, perceptual difficulties, distractibility, perseveration, rigidity, concrete thinking, and a multitude of emotional problems.

Alfred Strauss (Strauss & Lehtinen, 1947), a neuropsychiatrist and perceptual-motor theorist, was also interested in brain disorders. He studied children within the general category of mental retardation and distinguished children with brain injury (experienced either pre-, peri- or post-natally) or “exogenous” retardation, from children whose mental incapacity was familial and unrelated to injury to the central nervous system (“endogenous” retardation). The “brain-injured” children experienced difficulties similar to the men studied by Kurt Goldstein, such as disturbances in perception, thinking, and emotional behaviour. These observations persuaded Strauss that they could be differentiated from children with endogenous retardation. Not only did Strauss identify this group of children as having a unique set of learning deficits, he also devised strategies for teaching them. Strauss and his colleague, Werner (Werner & Strauss, 1941), reinforced the perceptual-motor perspective and influenced many figures, such as Cruickshank, Kephart, Lehtinen and Kirk, in the field of learning disabilities - all of whom emphasized perceptual-motor problems and training methods to remediate them (Bender, 1992).

Educational stage.

Around the late 1930's there was a shift away from the study of brain function and dysfunction to the clinical study of children who were not learning in ordinary school environments. Research moved therefore, from hospitals and institutions to the classroom. A dominant theme of this research was related to perceptual-motor deficits in cases of academic problems (Kavale & Forness, 1992). For example, Newall Kephart (1967), a perceptual-motor theorist who started his work with Strauss and Werner, felt that all behaviour is motor based, and that motor development precedes, and is essential for, perceptual development, and that the ultimate goal of mature cognition was attaining a perceptual-motor match (Bender, 1992). William Cruickshank, also a perceptual-motor theorist who had worked with Strauss, focussed on distractibility and hyperactivity and was responsible for applying Strauss' findings to nonretarded children (Cruickshank, Bentzen, Ratzburg, & Tannhauser, 1961).

Language-based theorists were also busy in organizing classroom-based educational interventions. Samuel Kirk started a long term study of language usage in nonretarded children, that was designed to identify visual- and auditory-based ability deficits that affected academic achievement (Kirk & Kirk, 1971). Helmer Myklebust began working with deaf children on disorders of spoken language and quickly expanded to include written language and reading in his research (Myklebust, 1968). Myklebust was an advocate of modality training - using the most well developed sensory modalities of students with the hope of maximizing learning (Myklebust, 1975).

During this period of learning disabilities research, there were many changes in terminology - mild exogenous mental retardation (mild mental retardation caused by brain injury), minimal brain dysfunction (behaviour associated with brain injury, although brain damage could not be verified), perceptual impairment (persistent difficulty in interpreting sensory stimulation), hyperactivity (excessive and socially inappropriate behaviour accompanied by problems in learning), and slow learning (a child whose achievement is not far enough below average to indicate mental retardation) (Hallahan, Kauffman & Lloyd, 1996). Most of the terms offered could be placed in one of two groups: those that referred to presumptive biological causes; and, those that implicated behavioural or cognitive disorders (Lerner, 1993). It was not until 1963 that the term "learning disabilities" was introduced; Samuel Kirk suggested it at a meeting of concerned parents advocating for special educational services for their children who were having difficulty in school but were not considered disabled because of mental retardation or emotional disturbance. The term was immediately embraced and has gained widespread acceptance from educators, parents and the general public (Mazurek & Winter, 1994), probably in large part because it includes a variety of learning deficits without negative connotations.

Modern stage.

The birth of the term "learning disabilities" marked the beginning of the modern stage in the history of learning disabilities. Upon deciding that their cause should be called "learning disabilities," the concerned parent group that Kirk addressed in 1963 organized themselves into the Association for Children with Learning Disabilities (ACLD) (Kavale & Forness, 1992). Soon after, other professional organizations were formed, and in 1967 the first journal of many dedicated to learning disabilities - the *Journal of Learning Disabilities* was created. The field grew quickly as learning disabilities programs were implemented in response to parental lobbying for governmental laws requiring services for children with learning disabilities. During this time, learning disabilities became an established discipline within the field of special education.

The Issue of Definition

Although parents, educators, researchers and practitioners were able to agree on a name for the learning difficulties experienced by many children, the actual concept of learning disabilities remained and still remains one of the most controversial and ambiguous in the realm of special education (Haight, 1980). At the root of many of the difficulties is the fact there is no "one" accepted definition for learning disabilities. Different definitions are used by various professionals and populations, with each serving different purposes, such as, identification, assessment, instruction and research. Thus, defining learning disabilities in a manner acceptable to all interested parties continues to be a controversial issue and the absence of an agreed upon definition has seriously impeded progress in the field (Gallagher, 1984). Nevertheless, despite the controversy over formulating an acceptable definition, learning disabilities has become a "defensible construct" (Lerner, 1993, p.11), and draws the interest of professionals in various disciplines.

Although there is an array of definitions of learning disabilities, there are some elements common to the majority. First, most focus on neurological processes as explanations of learning disabilities. Thus, the majority of learning disabilities definitions reflect the belief that learning disabilities arise from some sort of **neurological dysfunction** . That is, since all learning originates within the brain, a disorder in learning is plausibly caused by a dysfunction of the central nervous system (Bender, 1992; Lerner, 1993). A second common thread among the definitions is that the learning disabled have behavioural manifestations of **strengths and weakness in learning abilities, in academic skills and, not uncommonly, language**

functioning (Bender, 1992; Lerner, 1993). The functions affected in the definitions are wide-ranging, from purely academic, such as reading, writing or mathematics difficulties, to more general problems in listening, reasoning and social skills. Nevertheless, some definitions are vague in identifying where the strengths and weaknesses lie, stating simply there may be a disability in perception, language or cognition which is preventing the individual from learning at a normal rate. A third common aspect found in many definitions is the identification of a **gap between what the student is potentially capable of learning** (as measured by an intelligence tests, tests of cognitive abilities, and/or clinical impressions), **and what the student has, in fact, learned or achieved** (Bender, 1992; Lerner, 1993). As there are many reasons for an individual to be underachieving (e.g., poor teaching, lack of interest, emotional factors), a criterion of underachievement alone is insufficient for determining the presence of a learning disability. Although this is a commonly used perspective in diagnosing a learning disability, it is not without controversy, as it is difficult to be certain that intelligence and achievement tests measure purely what they claim to measure. There is also the added difficulty in determining at what point the discrepancy between achievement and potential is severe enough to warrant a diagnosis of "learning disabled". Finally, many of the definitions state that learning disabilities are **not primarily the result of other causes**, such as being due to mental retardation, emotional disturbance, sensory impairment or cultural, social or economic disadvantage (Bender, 1992; Lerner, 1993). The inclusion of this "exclusion" clause into the definition of learning disabilities arose from the need to establish learning disabilities as a separate and discrete category of disorder, in order to secure appropriate legislation and funding for students with learning disabilities.

Although many of the definitions for learning disabilities share common elements, there is still no widely accepted single definition. This is perhaps, partially explained by the hope that learning disabilities can be defined as a homogeneous entity despite the fact that many different types of deficits fall under the umbrella of learning disabilities. Fortunately, within the last thirty years, it has become recognized, that learning disabilities are a very heterogeneous collection of developmental disorders rather than a single condition (Newby & Lyon, 1991). This has prompted some researchers in the field to suggest that there are subtypes of learning disabilities, with each one calling for a different definition (McKinney, 1984).

Learning Disability Subtypes

Subtyping of learning disabilities, with recognition of the learning disabled population as a heterogeneous entity, seems to be one of the most promising advances in the study of learning disabilities (Little, 1993). According to Torgensen (1993), two of the most extensively developed causal subtyping theories of learning disabilities are: the theory of reading disabilities centering on phonological processing [based mainly on the work of Isabelle Liberman and her colleagues (Bradey & Shankweiler, 1991; Shankweiler & Liberman, 1989) at Haskins Laboratories]; and, the nonverbal learning disabilities syndrome based on the work of Byron Rourke (1987, 1988a, 1989). Following the classification of theories used above, Liberman's work would be considered that of a language theorist and a portion of Rourke's work that of a perceptual-motor theorist.

Theory of phonological reading disabilities.

Children with phonological reading disabilities (PRD) experience problems academically with reading, as they are unable to develop fluent word identification strategies. Phonics are especially difficult for these children and they have a hard time learning how to employ the "alphabetic principle" - using grapheme-phoneme correspondences in sounding out unfamiliar words (Beitchman & Young, 1997). There seems to be a core deficit in the language skill that entails the detection and manipulation of individual speech sounds (Lovett, 1992). Extended practice helps these children in gaining a sight vocabulary for words they frequently encounter, but their speed in reading these words is still impeded (Denckla & Rudel, 1976; Wolf & Obregon, 1992). Although these children are impaired in their reading abilities, their intelligence is usually average or above, and their other academic abilities, including mathematics are intact (Torgensen, 1993). Despite this, children with PRD still have other subtle deficits, such as: difficulties in speech perception, speech production, and naming, as well as problems in short term memory tasks involving verbal material (Torgensen, 1993).

Given that PRD are considered to be a product of language processing difficulties, it is not surprising that studies carried out at neuroanatomical levels have found evidence supporting a left hemisphere deficit in reading disabled individuals when compared to non-reading disabled individuals (Beitchman & Young, 1997). Researchers studying PRD feel the information-processing skills deficient in PRD individuals are usually associated with functional abnormalities in the grey matter of the left temporal region of the brain (Damasio & Geschwind, 1984). Galaburda (1988) has postulated that the neurological aberrations in this part of the brain linked to PRD usually arise very early in development, and therefore are the cause, rather than the result of PRD. Flowers (1993) conducted cerebral blood flow studies and examined differences in the left hemispheric functioning of reading disabled individuals compared to non-learning disabled individuals. The study revealed that there is a left temporal component associated with both phonological and orthographic skills requiring fine auditory discrimination as well as an inferior left parietal component associated with word meaning (Flowers, 1993). There is a consensus in the literature that these brain anomalies are thought to be genetically transmitted, suggesting phonological processing ability is heritable (Olsen, Wise, Conners, Rack & Fulker, 1989; Shepherd & Uhry, 1993; Snowling, 1991), with various studies linking reading disabilities to chromosomes 6 and 15 (Cardon et al., 1994; Grigorenko et al., 1997; Smith, Kimberling, Pennington, & Lubs, 1983).

According to Beitchman and Young (1997), one of the most common comorbid conditions in childhood is that of reading disabilities and attention-deficit/hyperactivity disorder (ADHD). It has been reported that 20% to 25% of reading-disabled children have ADHD (Silver, 1981), and 10% to 50% of children with ADHD have concurrent reading disabilities (Hinshaw, 1992). The exact reason for the comorbidity between reading disabilities and ADHD is not known, but recent studies suggest that heredity may play a role (Light, Pennington, Gilger, & DeFries, 1995; Stevenson, Pennington, Gilger, DeFries, & Gillis, 1993). Due to the frequent co-occurrence of ADHD and reading disabilities, stimulant medication has been used in the treatment of reading disabilities (Beitchman & Young, 1997). Although improvements in attention and concentration can help the child to better function in the learning environment, and therefore lead to an increase in productivity (Elia, Welsh, Gullotta, & Rapoport, 1993), there is *direct* evidence of the effect of medication on reading ability (Richardson, Kupietz, Winsberg, Maitinsky, & Mendell, 1988). Richardson et al. (1988) found the medication directly affected verbal retrieval mechanisms, which result in improved reading vocabulary; they also found more general effects on reading achievement as an indirect result of improved behavioural control.

Theory of nonverbal learning disabilities.

Most neurological research in the realm of learning disabilities has focussed on left hemispheric functioning, as the side of the brain associated with language processing. This is not surprising, as most of the general research in the field of learning disabilities has focussed on language disorders. However, there are some researchers who are interested in learning disabilities that do not involve language - **nonverbal learning disabilities** (NLD) which account for no more than 10% of all learning disabilities (Denckla, 1991). This learning disability subtype is associated with deficits in neuropsychological and adaptive functioning usually associated with the right hemisphere, including difficulties in spatial abilities, visuoperceptual/simultaneous information processing, and social-emotional functioning (Beitchman & Young, 1997).

The idea of a "nonverbal" learning disability was initially proposed by Myklebust in 1968 (1968, 1975). Since Myklebust, there have been many different research teams investigating learning disabilities that have repeatedly identified a subgroup of learning disabled children whose deficits are typified by a core of nonverbal factors such as, inferior visual-motor skills compared to verbal skills, poorer mathematical achievement compared to sight-word reading ability, and relatively limited success at solving abstract, nonverbal problems (Bender & Golden, 1990; Ozols & Rourke, 1988; Rourke, 1989; Rourke, Young, & Leenaars, 1989; Share, Moffitt, & Silva, 1988). Some of the terms used to identify individuals with these types of deficits are: nonverbal perceptual-organization-output disorders (Rourke & Finlayson, 1978), left hemisyndrome (Denckla, 1978), and social-emotional learning disabilities (Voeller, 1991). Although this research does not involve direct measures of the brain through autopsies, MRIs, CAT- or PET-scans, it strongly suggests that this subgroup of learning disabled individuals have processing strengths and deficits similar to adults with documented damage to the right hemisphere of the brain (Hallahan, Kauffman, & Lloyd, 1996).

Academically, individuals with NLD have average or above average abilities in reading and spelling, and difficulties in arithmetic performance. A specific arithmetic problem area for NLD individuals concerns mechanical calculations, due to difficulties such as: (1) reading the operation signs; (2) forming numbers; (3) correctly aligning the columns of numbers; (4) using all of the numbers in question (sometimes, numbers are visually neglected); (5) adding, subtracting, and multiplying in the proper direction; (6) carrying out standard procedures in a systematic and orderly manner; (7) generally organizing their work; (8) using an adequate procedure for checking answers; and, (9) completely understanding the underlying concept of a particular arithmetic operation (Rourke & Strang, 1983).

Some of the neuropsychological symptoms that delineate the NLD syndrome include: primary deficits in tactile perception, visual perception, complex psychomotor functioning, and the processing of novel material in combination with primary assets in auditory perception, simple motor skills, and mastery of rote material. Secondary and tertiary assets and deficits in skills such as attention, memory, concept formation and problem-solving, all of which are dependent upon the primary abilities also exist (Rourke 1987, 1988a, 1989). These primary neuropsychological assets and deficits are thought to lead to the secondary neuropsychological assets and deficits, and ultimately the academic (e.g., arithmetic difficulties) and socioemotional/adaptive characteristics of the NLD syndrome (Rourke, 1993). The social realm is one area where individuals with nonverbal learning disabilities experience significant difficulties. They are usually socially inept, displaying deficits in their ability to interpret the social behaviour of others and to understand the impact of their own immature behaviour on others (Hallahan, Kauffman & Lloyd, 1996), with these deficits especially evident in novel situations. As one researcher put it: "Terms such as *spacy* or *in a fog* or *disorganized in a disoriented way* abound in the literature on [nonverbal learning disabilities]"(Denckla, 1993, p.118). The NLD individual's ineptitude in social judgement and interaction would be caused by his/her primary and secondary neuropsychological deficits in reasoning, concept-formation, and intermodal integration (Casey, Rourke, & Picard, 1991). Even though some may be academically competent, adults with nonverbal learning disabilities often have trouble holding a job because of their problems in social interaction (Rourke, 1995).

Individuals with NLD also suffer from language peculiarities, such as poor prosody and pragmatics while retaining good vocabulary. These language difficulties, coupled with the social difficulties of NLD, have lead some researchers in the field to postulate that a continuum exists between NLD and pervasive developmental disorders, Asperger's syndrome, and/or schizoid personality disorder (Semrud-Clikeman & Hynd, 1990). Rourke's model on NLD syndrome hypothesizes that as a result of their neuropsychological deficits, individuals with NLD syndrome are at a significantly greater risk for internalized forms of socioemotional dysfunction, such as social withdrawal, depression, and increased suicide risk in adolescence and adulthood (Casey et al., 1991; Denckla, 1991; Ozols & Rourke, 1991; Rourke, et al., 1989; Semrud-Clikeman & Hynd, 1990) than are individuals with other subtypes of learning disabilities, or individuals without learning disabilities (Rourke, 1987, 1988a, 1989; Rourke & Fuerst, 1991).

Study Rationale

This research deals with a group of individuals analogous to the well-defined NLD syndrome group: individuals suffering from poor mathematical proficiency. In the children's LD research, there is evidence of different personality characteristics in different subtypes of learning disabilities (Rourke, 1987, 1988b, 1989). This is not the case for adults; investigation of adults with NLD-like problems has been limited, especially with respect to personality development. For example, little empirical research has been published relating to the relationship between MMPI-2 scale elevations and cognitive abilities, although several researchers have examined this topic with the original MMPI, obtaining inconsistent results (Crossman, Casey & Reilly, 1994). The present study used the MMPI-2, and examined the personality characteristics of a population that is not often investigated with respect to the comorbidity of learning difficulties and personality/socioemotional functioning - adults.

Minnesota Multiphasic Personality Inventory - 2

The Minnesota Multiphasic Personality Inventory (MMPI; Hathaway & McKinley,

1942) has been one of the most extensively used and researched psychological tests in the world, and has been employed in a variety of contexts, such as psychiatry, medicine, academia and industry (Lubin, Larsen, Matarazzo & Seever, 1985). Over time, many of the people using the MMPI noted problems with it, such as out of date items and questionable norms (Butcher & Williams, 1992). There was a cry for an updated version, and in 1989, a new version of the MMPI - the MMPI-2, became available. It boasted more appropriate norms, as well as more contemporary items, while retaining the validity and standard scales of the original version so previous research findings remained applicable (Butcher & Williams, 1992).

As the MMPI-2 is a new assessment instrument, most clinical research chronicling its utilization and pertinence is with typical psychiatric patients, such as, inpatient alcohol abusers (Levenson, Aldwin, Butcher, de Labry, Workman-Daniels, & Bosse, 1990), child-abusive mothers (Egeland, Erickson, Butcher, & Ben-Porath, 1991), marital counselling patients (Hjemboe & Butcher, 1991), and, post-traumatic stress disordered veterans (Litz, Park, Walsh, Hyer, Blake, Marx, Keane, & Bitman 1991). Unfortunately, populations with developmental disabilities appear to have been overlooked in studies evaluating the MMPI-2 (Gregg et al., 1992a).

Several questions arise upon consideration of administration of the MMPI-2 to individuals with learning disabilities, such as whether their cognitive development and reading or language skills are sufficient to respond accurately to the MMPI-2 questions (Gregg et al., 1992a). Attention needs to be paid to the motivation and attentional capabilities of the learning disabled people responding to self-report measures such as the MMPI-2 (Gregg, Hoy, King, Moreland, & Jagota, 1992b). The MMPI-2 manual suggests an eighth grade reading comprehension level is required for independent administration of the test (Butcher, Dahlstrom, Graham, Tellegen, & Kaemmer, 1989), although, there is an audiocassette version available which is useful for individuals for whom reading comprehension ability may be in question (Butcher & Williams, 1992).

Previous Research on LDs and MMPI-2

Although the study of socioemotional difficulties in the learning disabled population is growing at a phenomenal rate (Rourke, 1991), the vast majority of the attention is still focussed on the study of children (Morris & Walter, 1991). Nevertheless, some studies have been carried out that illustrate the persistence of Rourke's nonverbal learning disabilities into adulthood. For example, in the adult population studied by McCue, Goldstein, Shelly, and Katz (1986), it was discovered that the adults had the same cognitive profiles as the children studied by Rourke, and they concluded that these subtypes do, indeed, persist into adulthood. Rourke, Young, Strang and Russell (1986) also illustrated the endurance of subtype characteristics into adulthood; they found adults displaying the same patterns of performance on neuropsychological variables as previously studied in children (Del Dotto, Fisk, McFadden, & Rourke, 1991).

The research team of Gregg, Hoy, King, Moreland, and Jagota have studied the learning disabled population using the MMPI-2 (1992a, 1992b). They examined the MMPI-2 profiles of learning disabled adults from different settings: university students and rehabilitation centre clients, and compared these profiles to a normative population of normally achieving college students. Gregg et al. found that the learning disabled adults in both settings - university students and rehabilitation centre clients, had personality profiles that differed significantly from that of the normative population of normally achieving college students. The rehabilitation group displayed feelings of social isolation, poor self-concept, self-doubt, and extreme restlessness (Gregg et al., 1992a, 1992b), whereas, the university group demonstrated feelings of fear, obsessive thoughts, lack of self-confidence, self-doubt, and extreme self-criticism (Gregg et al., 1992a). Gregg et al. (1992a) also found that both groups exhibited profiles of individuals experiencing extreme short- and long-term stress leading to anxiety. Although Gregg et al. (1992a) were comparing two different populations of learning disabled individuals, subtypes based on neuropsychological assets and deficits were not considered.

Del Dotto, Fisk, McFadden, and Rourke (1991) have also looked at the learning disabled adult population using the MMPI (Hathaway & McKinley, 1967). Del Dotto et al. were interested in developmental changes that may have occurred in adults, originally identified as suffering from NLD syndrome when they were children, with one area of investigation being socioemotional and personality functioning. Only five individuals were examined and the authors exercised caution in generalizing from such a limited sample. However, Del Dotto et al. found that, four of the five NLD adults they evaluated showed indications of emotional disturbance, although there were no distinct patterns to this socioemotional disturbance, and no indications of depression were reported.

Learning disabled college students were studied by Ackerman, McGrew and Dykman (1987) using the MMPI and the Wide Range Achievement Test (WRAT). Their results indicated that for both sexes, specific arithmetic disability was associated with elevated MMPI profiles, whereas dyslexic students, conversely, had fewer problem areas as indicated by their responses on the MMPI.

Present Study

As university students were to be used as subjects for this study, this study was primarily concerned with the personality characteristics of individuals with NLD syndrome. At the university level, it would be very difficult to find a sufficient number of subjects with reading or spelling difficulties severe enough to be considered clinically significant, as at least average reading and spelling ability is a necessity for success in most university courses. This is not the case with mathematical ability, as it is not found as frequently in the courses offered in arts programs, from which the subjects were drawn. This is supported by the study by Morris and Walters (1991) which attempted to validate the Rourke's subtypes in a population of college students. They used WRAT scores as an *a priori* method of classifying their subjects, and they were only able to find subjects with poor math abilities relative to reading and spelling abilities - they did not find any subjects with poor reading or spelling abilities relative to math ability in their college student population.

Academically, one of the most prominent ways in which NLD syndrome manifests itself is in difficulties with mathematical operations (Rourke, 1987, 1988a, 1989). Studies examining NLD subtyping have employed performance on the WRAT as a means of placing subjects into appropriate ability groups. Rourke and Finlayson (1978) found that subjects who scored markedly better on the WRAT spelling and reading subtests as compared to their arithmetic subtest performance exhibited specific deficits on tasks assessing their visual-spatial and visual-perceptual abilities. NLD subjects in a series of studies by Rourke and his colleagues (Rourke & Finlayson, 1978; Rourke & Strang, 1978, 1983; Strang & Rourke, 1985) were all initially classified into three learning disabled subtypes based on their WRAT performance patterns.

McCue, Goldstein, Shelly & Katz (1986) utilized an "operational, rule-based definition of subtypes" (p. 15) in classifying learning disabled adults for their study. A criterion level of at least a 1.5 grade-level discrepancy between the reading and arithmetic subtests of the WRAT-R was used in placing the subjects into the appropriate learning disability subtype group. They found the adults in their study to have the same cognitive profiles as the children in the Rourke studies (Rourke & Finlayson, 1978; Rourke & Strang, 1978, 1983), suggesting that the Rourke subtypes of NLD persists into adulthood (McCue et al., 1986). McCue et al. justified their subtyping methodology by stating they were examining existing subtypes (Rourke's), as opposed to establishing new subtypes, which would call for more detailed subtyping procedures, such as cluster analysis. Since the McCue et al. method yields the same results as the Rourke method without being as intrusive on the subjects' time (the Rourke methodology requires extensive neuropsychological testing which can take many hours), an adaptation of the McCue et al. method of subtyping using WRAT-3 standard scores for subject placement in groups, was used for this study.

Although it would have been preferential to have used severely learning disabled individuals, it was impossible to find adequate numbers of university students with such problems; instead, mildly affected university students served as subjects for this study. One of the three groups of subjects, the Poor Math group, was assumed to be analogous to a NLD group.

It was hypothesized that the deficits that NLD individuals possess run along a continuum of severity from severely impaired (individuals diagnosed with NLD), to mildly impaired (Poor Math Group), to no mathematical impairment (Average Math Group), to enhanced mathematical ability (Good Math Group). Therefore, of the three groups used in this study (Poor Math, Average Math, and Good Math), the Poor Math Group, would be most similar to NLD syndrome individuals, in that they possess the same types of neuropsychological deficits, although to a less severe degree.

Based on previous research (Ackerman, McGrew & Dykman, 1987; Rourke, 1987, 1988a, 1989;), it was hypothesized that the Poor Math Group would exhibit more elevations on the MMPI-2 than both the Average and Good Math Groups. Due to the neuropsychologically based deficits of NLD individuals (e.g., visual perception, processing of novel material, problem solving, etc.), which detrimentally influence their social functioning due to faulty processing of information, it was hypothesized that the Poor Math Group would show elevations on the following Clinical Scales of the MMPI-2: Depression, Psychopathic Deviate, Psychasthenia, Schizophrenia, and Social Introversion; and elevations on the following Content Scales: Anxiety, Depression, and Social Discomfort.

Depression scale elevations on the MMPI-2 have been associated with some of the following descriptors, which NLD individuals also tend to exhibit: low self-confidence (Rourke et al., 1989; Rourke et al., 1986), ill-defined somatic complaints (Glosser & Koppell, 1987), and difficulty assessing novel situations (Rourke et al., 1989; Semrud-Clikeman & Hynd, 1990), thus creating difficulties in decision making. They also tend to be withdrawn and socially isolated from others (Rourke, 1989; Tranel, Hall, Olson, & Tranel, 1987), which would give the impression they are introverted, shy and aloof. It is well documented that individuals with NLD display signs of depression and withdrawal (Rourke et al., 1989; Rourke et al., 1986; Tranel, et al., 1987), and thus this should show up as an elevation on the MMPI-2 Clinical Scale of Depression for individuals in the Poor Math Group. Also, Ackerman, McGrew, and Dykman (1987) found in their study of learning disabled college students that there was a significant association between elevated Depression scale scores on the MMPI and poor arithmetic as compared to reading performance.

Psychopathic Deviate elevations have been associated with: stormy relationships, insensitivity to the needs of others, superficial relationships, absence of deep emotional response, being unable to profit from experience, as well as poor judgement and planning skills. NLD individuals have difficulties with: benefitting from positive and negative feedback (Casey et al., 1991; Rourke et al., 1989); social cause and effect relationships (Rourke et al., 1989; Rourke, 1987, 1988b); concept formation (Casey et al., 1991; Rourke et al., 1989); hypothesis testing (Casey et al., 1991; Rourke et al., 1989); social competence (Rourke et al., 1989; Semrud-Clikeman and Hynd, 1990; Weintraub and Mesulam, 1983); and, lack of insight into their own problems (Rourke et al., 1989; Glosser and Koppell, 1987). They could, therefore, exhibit many of the characteristics on the Psychopathic Deviate scale, and an elevated score was predicted for persons in the Poor Math Group.

Psychasthenia Clinical Scale elevations on the MMPI-2, have been associated with some of the following descriptors, which NLD individuals tend to exhibit as well: anxiety (Rourke et al., 1989; Strang and Rourke, 1985); feelings of insecurity, shyness and self-consciousness (Rourke et al., 1989; Tranel et al., 1987); performance of tasks in a persistent and stereotypic manner (Casey et al., 1991; Rourke, 1987, 1988b, 1989); lack of originality in thought and problem-solving (Casey et al., 1991; Rourke et al., 1989); and reports of physical complaints (Glosser & Koppell, 1987). Because NLD individuals exhibit many of the characteristics associated with Psychasthenia, and elevation on this Clinical Scale was hypothesized for the Poor Math Group subjects.

Schizophrenia scale elevations on the MMPI-2 have been associated with some of the following descriptors, which NLD individuals also tend to possess: excessive anxiety (Casey et al., 1991; Rourke et al., 1989); a sense of alienation which leads to social withdrawal and isolation (Casey et al., 1991; Rourke et al., 1989); self-doubts and insecurity (Casey et al., 1991; Tranel et al., 1987); and, difficulty with problem-solving (Casey et al., 1991; Rourke et al., 1989). Again, the NLD individuals' neuropsychological deficits would cause them to exhibit the above descriptors, leading to the expectation that individuals in the Poor Math Group would show an elevation on the Schizophrenia Clinical Scale.

In the previously mentioned Clinical Scales, one trait, social introversion, seems to recur. Because of their extreme difficulty in adapting to novel and complex situations, inability to benefit from positive and negative feedback, and deal with cause and effect relationships, and, difficulties in nonverbal problem-solving, concept formation, and hypothesis testing (Casey et al., 1991), NLD individuals tend to fare poorly at social interactions. This lack of success in social situations for NLD individuals leads them to become socially introverted, shy, and difficult to get to know, and would manifest itself as an elevation on the MMPI-2 Clinical Scale of Social Introversion for the Poor Math Group participants.

Because of these neuropsychological assets and deficits displayed by NLD individuals, one would think that they would show an elevation on the MMPI-2 Content Scale of Anxiety. Elevations on this scale are characteristic of individuals who: are anxious, have difficulties making decisions, suffer from indecision, and find life a strain. NLD individuals have been reported as anxious (Rourke et al., 1989; Strang and Rourke, 1985), and experience difficulty in generating solutions to problems (Rourke et al., 1989; Casey et al., 1991; Myklebust, 1975), and decision making. As a function of their indecisiveness, and anxiety, these individuals would find life arduous, and, thus it is hypothesized that the people in the Poor Math Group would have an elevated Anxiety Content Scale score.

Depression is another Content Scale score that would most likely be elevated in NLD individuals, and therefore, individuals included in the Poor Math Group. These individuals have the following characteristics that would be indicative of an elevation on the Depression Content Scale: feeling depressed, hopeless and empty (Tranel et al., 1987; Rourke et al.,1989; Brumback and Staton, 1982); possible thoughts of suicide (Rourke, 1993; Rourke et al., 1989); and feeling that others are not supportive and that they are alone in the world (Tranel et al., 1987; Rourke et al., 1986; Strang and Rourke, 1985).

The Social Discomfort Content Scale is the third and final Content Scale for which an elevation is hypothesized. NLD individuals tend to: be introverted and distanced from others, prefer to be alone rather than with others, and be shy and steer clear of social functions and gatherings (Tranel et al., 1987; Rourke et al., 1986; Strang and Rourke, 1985). All of these characteristics are indicative of an elevation on the Social Discomfort Content Scale of the MMPI-2, and thus an elevation on this scale is hypothesized for the Poor Math Group.

Method

Participants

Students from three psychology courses at varying levels (first, second and third year) were approached during class time and asked to participate in a study examining personality traits in individuals with varying strengths in arithmetic, reading and spelling abilities. They were told the study involved completing an intelligence test, an achievement test, and a personality test, and if they wished, they would be able to get feedback concerning their results. It was also mentioned that the testing would take approximately three hours to complete. Interested students were asked to write their names and phone numbers on a sign-up sheet that was passed around in order for the experimenter to contact them. Students were told that their participation in this study was voluntary, involved no risk to them, and that their results would be kept confidential. They were also encouraged to contact the researcher at any time if they had any questions or concerns related to the study.

Testing

Testing took place in a quiet research room at the university that was free from distractions. Each participant was tested individually by the researcher, and before testing began, the experimenter briefly explained to each participant what he/she would be doing, and the rationale behind the study. After the study had been explained to the participant, he/she was asked to read and sign the consent form (see Appendix). All tests were presented in the same order to all participants. Testing took approximately three hours for each participant to complete, and took place over a four month period. In total, 60 participants were tested. All scoring was conducted by the researcher.

Materials

Minnesota Multiphasic Personality Inventory - 2. The Minnesota Multiphasic Personality Inventory -2 (MMPI-2; Butcher, Dahlstrom, Graham, Tellegen & Kaemmer, 1989) is a widely used objective personality assessment inventory that aids in the diagnosis of patterns of emotional disorders and the assessment of personality traits. The MMPI-2 requires subjects to respond to nearly 600 statements with a true, false, or "cannot say" response. Many scales measuring different variables of personality comprise the MMPI-2, with the main scales being the ten Clinical Scales, the fifteen Content Scales, the validity scales, and supplementary scales. For the purposes of this study, the scales of most interest were the 10 empirically derived Clinical Scales, where what matters most is the way an item is endorsed, not its content and the answers are merely signs of problem types, without regard to specific response content. Also of interest were three of the Content Scales - Depression, Anxiety and Social Discomfort - with Content Scale items tapping an individual's feelings, personality style and past or current problems. Each scale yields a T-score, with the normal range of scores falling between 50 and 65 (i.e., between the 50th and 93rd percentiles). A score above 65 indicates the individual "belongs" to the criterion group; for example, a T-score on the Depression scale of 75 would indicate that the subject responded in a manner similar to the criterion group of depressed individuals used to formulate the Depression scale. The MMPI-2 takes approximately 60 to 90 minutes to complete. Although the paper and pencil version of the MMPI-2 was administered, the experimenter entered each participant's MMPI-2 responses into a computer to enable a computer program to score the participants' responses, as a reliability control.

Wechsler Adult Intelligence Scale - Revised. The Wechsler Adult Intelligence Scale - Revised (WAIS-R; Wechsler, 1981) is a widely used test measuring intellectual abilities. Individually administered, it is composed of 11 subtests, with some subtests requiring verbal responses, and others requiring the manipulation of test materials. The WAIS-R yields a Full Scale IQ score, Verbal IQ score, and Performance IQ score, with average intelligence reflected as a Full Scale IQ somewhere between 90 and 110 points. The full test takes approximately an hour to administer. For this study, due to time constraints, each participant was administered a four subtest short-form of the WAIS-R suggested as being both reliable and valid by Sattler (1988), consisting of the following subtests: arithmetic, block design, vocabulary and similarities.

Wide Range Achievement Test - 3. The Wide Range Achievement Test - 3 (WRAT-3; Jastak & Wilkinson, 1993) is a brief, individually administered test of academic skills.. It is composed of three subtests: Spelling, Reading and Arithmetic, and it is concerned mainly with the mastery of the mechanics involved in these three subject areas. The Spelling subtest is a measure of written single-word spelling. The Reading subtest provides a measure of oral single word reading. The Arithmetic subtest is time-limited written test covering a broad range from basic arithmetic operations to more advanced mathematical reasoning and problem solving. Questions for each subtest are arranged in ascending order of difficulty, and the test takes approximately 20 to 30 minutes to administer. Performance on the WRAT-3 subtests can be represented in either standard scores, percentiles, or grade equivalents. Only standard scores were used for this study.

Procedure

Classification of the subjects into the appropriate experimental group (Poor Math, Average Math or Good Math) was accomplished first by rank ordering all 60 participants' Arithmetic WRAT-3 subtest standard scores, and dividing them into thirds. The range of Arithmetic standard scores was from 72 to 126; the Poor Math group had standard scores between 72 and 94; the Average Math group had standard scores between 96 and 108; and, the Good Math group had standard scores between 110 and 126.

The second criterion for participant inclusion in one of the experimental groups was that the average of their Reading and Spelling WRAT-3 subtest scores fell within one standard deviation of the mean of all 60 participants' average Reading and Spelling subtest scores. Twelve subjects fell outside of this range and were not included into one of the experimental groups. A third criterion for inclusion in one of the experimental groups was at least an average level of psychometric intelligence, as defined by obtaining a Full Scale IQ score of 90 or more points (all participants met this criterion). Finally, in order to be included in one of the groups, the participants had to have valid MMPI-2 profiles.

Although the McCue et al. (1986) subtyping procedure was not formally utilized in the creation of the experimental groups, the results of the participants in the Poor Math Group did comply with the requirements of the McCue et al. (1986) subtyping method, requiring a grade level discrepancy of 1.5 years between a subject's WRAT-3 reading and arithmetic subtest scores. All of the subjects in the Poor Math Group had reading scores in the last year of high school or post-high school grade level, and the highest arithmetic score was at the first year high school grade level. Therefore, the subjects in this study met the same criteria as the learning disabled subjects in the McCue et al. study.

Results

Data were gathered on a total of 60 participants, and of these 60 individuals, 12 were excluded as they did not meet the inclusionary criteria for placement into a math ability group. There were 16 participants in each math ability group. The Poor Math group consisted of 10 females and six males, and the mean age of the group was 26.0 years. The Average Math group consisted of 12 females and four males, and had a mean age of 25.6 years. Finally, the Good Math group had nine females and seven males, and the mean group age was 26.1 years (see Table 1).

Before any statistical analyses were carried out, the data were checked for anomalies and outliers. There were two participants with three Clinical Scale score elevations - one was a male in the Average Math group, and the other was a female in the Good Math group. Upon examination of the data, there was one Content Scale score outlier and four Clinical Scale score outliers that were more than three standard deviations from the mean - three of which belonged to one individual. This was of particular concern because this individual was one of only four males in the Average Math group. When follow-up univariate analyses were conducted on significant MANOVA's to see where exactly the differences lay, the participants were broken down into math ability groups based on gender, therefore forming six groups (e.g., Poor Math males, Average Math males, Good Math females, etc.). Due to the small size of the Average Math male group, an individual with extreme scores within that group may unduly influence the results. In order to see if this was the case, the analyses were carried out in two different ways. The first way was to analyse the data as it was, not worrying about the outliers (this will be

Table 1

Characteristics of Student Sample

	Math Ability Groups									
	Poor Math (n = 16)			Average Math (n = 16)			Good Math (n = 16)			
	M	SD	SE	M	SD	SE	M	SD	SE	Signif.
Age	26.0	7.2	1.8	25.6	7.4	1.9	26.1	6.0	1.6	NS
Gender										
Male	6			4			7			
Female	10			12			9			

Note: Sample N = 48

referred to as the original data set). The second set of analyses were conducted by replacing the outliers with the Clinical Scale score mean for the group to which the individual belonged (this will be referred to as the altered data set).

Statistical analyses were conducted using SPSS for Windows software. An alpha level of .05 was used for all statistical tests. In preliminary analyses, a one-way ANOVA and a chi-square were used to examine possible differences between the math ability groups with respect to age and gender, and no statistical differences were revealed between the groups for age $F(2, 43) = .02$, $p > .05$ nor gender $\chi^2(2, N = 48) = 1.27$, $p > .05$ (see Table 1). Differences between the math ability groups with respect to Full Scale I.Q. scores calculated from the short form of the WAIS-R were also examined using an one way ANOVA, revealing no statistical differences between the groups with respect to IQ $F(2, 43) = 2.96$, $p > .05$. Univariate ANOVAs were carried out on the four subtests of the short form of the WAIS-R that were administered and the math ability groups. Results indicated that the math ability groups only differed significantly with respect to their scores on the Arithmetic subtest ($F(2, 45) = 11.33$, $p < .05$) with the Good Math group having significantly higher scores than the other groups. There were no differences between the groups for the Block Design ($F(2, 45) = 2.39$, $p > .05$), Vocabulary ($F(2, 45) = 1.39$, $p > .05$), nor Similarities ($F(2, 45) = 0.04$, $p > .05$) subtests (see Table 2). Pearson product-moment correlations were also calculated between the math ability groups and each of the WAIS-R subtests administered. The results indicated significant, moderate correlations for both the Arithmetic subtest ($r = .57$, $p < .05$) as well as for the Block Design subtest ($r = .31$, $p < .05$), indicating that the higher the math ability, the higher their mean Arithmetic and Block Design scores were. No significant correlations were found between the other two WAIS-R subtests and the math ability groups. As would be expected, the math ability groups did statistically differ in their mean WRAT-3 Arithmetic subtest scores $F(2, 43) = 12.11$, $p < .05$, as these scores were the basis on which the participants were grouped, but the groups did not differ with respect to mean of their WRAT-3 Reading and Spelling scores $F(2, 43) = .56$, $p > .05$. Table 2 presents the mean short form I.Q. scores and WRAT-3 scores of the math ability groups.

In order to investigate whether there was a difference in verbal/nonverbal functioning between the two groups, "lateralization indices" were calculated using the subtests of the WAIS-R that were administered. The first index was calculated by dividing each participant's Vocabulary (a verbal subtest) score by their Block Design (a nonverbal subtest) score. A Pearson product-moment correlation was calculated between this index and the math ability groups, revealing a moderate negative correlation ($r = -.32$, $p < .05$). A second lateralization index was calculated by dividing the mean of two of the verbal subtests: Vocabulary and Similarities by the nonverbal subtest of Block Design. A Pearson product-moment correlation was again calculated between this index and the math ability groups revealing a moderate negative correlation ($r = -.31$, $p < .05$). These findings imply that as math ability groups increase in mathematical ability, their nonverbal abilities (as measured by the Block Design subtest) are better developed than their verbal abilities (as measured by the Vocabulary and Similarities subtests). Table 2 contains the mean lateralization indices for each math ability group. Pearson product-moment correlations were also carried out between each of the lateralization indices and each of the Clinical Scales of the MMPI-2, although no significant

Table 2

Means, Standard Deviations, and Standard Error of Test Measures

	Math Ability Groups									
	Poor Math (n = 16)			Average Math (n = 16)			Good Math (n = 16)			
	M	SD	SE	M	SD	SE	M	SD	SE	Signif.
I.Q.	108.9	8.3	2.1	111.7	7.6	2.0	115.5	6.5	1.7	NS
WAIS-R Subtests										
Arithmetic	9.2	1.8	0.5	10.5	1.2	0.3	12.7	2.6	0.7	<.001
Block Design	11.6	2.2	0.5	12.4	2.9	0.7	13.4	2.0	0.5	NS
Similarities	12.2	1.9	0.5	12.1	1.7	0.4	12.5	1.6	0.4	NS
Vocabulary	12.6	2.1	0.5	12.3	2.0	0.5	11.5	1.5	0.4	NS
WRAT-3										
Arithmetic	87.9	6.5	1.6	101.7	4.2	1.1	114.9	4.9	1.3	<.001
Ave. Reading & Spelling	106.4	2.9	0.7	106.0	2.3	0.6	107.0	2.6	0.7	NS
Lateralization Index										
Vocabulary / Block Design	1.15	.42	.10	1.06	.31	.08	.88	.19	.05	
(Vocabulary + Similarities) / Block Design	2.25	.72	.18	2.09	.50	.12	1.82	.35	.09	

Note: Sample N = 48; WAIS-R subtest scores are scaled scores with a mean of 10 and a standard deviation of 3; WRAT-3 subtest scores are standard scores with a mean of 100 and a standard deviation of 15.

Table 3

Pearson Correlations Between Lateralization Indices and Clinical Scales of MMPI-2

Clinical Scales	Lateralization Indices			
	Vocabulary / Block Design	p	Vocabulary + Similarities / Block Design	p
Hs (1)	-.10	.48	-.13	.39
D (2)	-.09	.54	-.12	.40
Hy (3)	.12	.43	.09	.53
Pd (4)	-.07	.64	-.08	.59
Mf (5)	-.02	.87	.06	.67
Pa (6)	.21	.15	.25	.09
Pt (7)	.04	.80	.03	.83
Sc (8)	-.04	.81	-.02	.88
Ma (9)	-.10	.51	-.15	.31
Si (0)	.06	.70	.05	.76

Note: p = probability

results were obtained (see Table 3).

Before any MANOVA analyses were carried out, the data were reviewed to ensure the integrity of the assumptions of analysis of variance. Stevens (1984) suggested using skewness and kurtosis coefficients to ensure normality of variable distributions when group size is less than 20. Both the Clinical and Content Scale scores for each math ability group were examined for skewness and kurtosis, for both the original and adjusted data sets. A table listing the critical values for skewness and kurtosis for small sample sizes in D'Agostino and Tietjen (1971, 1973) was consulted for critical cutoff points. Stevens (1984) suggested using an alpha level of .01 when looking at critical values for skewness and kurtosis, so as to minimize the overall type I error rate. Examination of the original data set for skewness and kurtosis revealed a few difficulties: for the Average Math group, the Clinical Scale of Schizophrenia (Sc8) was both positively skewed and leptokurtotic and the Clinical Scale of Psychopathic Deviate (Pd4) was platykurtotic; and, for the Good Math group, the Content Scales of Anxiety (ANX) and Depression (DEP) were also both positively skewed and leptokurtotic. For the adjusted data set, the Clinical Scale for Psychopathic Deviate (Pd4) was again platykurtotic for the Average Math group, and the Content Scale of Depression (DEP) was positively skewed and leptokurtotic for the Good Math group. According to Stevens (1984), when only one variable in one group exhibits platykurtosis, as is the case for the Psychopathic Deviate variable in the Average Math group, it is not cause for concern, as it will only have a small potential effect on power. For the other variables mentioned where there were skew and kurtosis problems, these variables were transformed using the arc sine transformation, as suggested by Stevens (1984), to induce normality, so MANOVAs could be carried out.

Homogeneity of covariance was also examined for both data sets, using Box's test. For both data sets, Box's test revealed that the homogeneity of covariance matrices assumption was tenable for both the Clinical ($F(110, 5481) = .94$, $p > .05$ for original data set; $F(110, 5481) = .94$, $p > .05$ for the adjusted data set) and Content ($F(12, 9813) = .70$, $p > .05$ for original data set; $F(12, 9813) = .87$, $p > .05$ for the adjusted data set) Scale analyses.

Given that the assumptions of analysis of variance were upheld, SPSS MANOVAs were carried out with the previously discussed applicable data transformations on each data set, looking at the 10 Clinical Scales of the MMPI-2 with the two factors of group and gender (see Table 4 for group means). For the original data set, the MANOVA yielded a significant group by gender interaction (Wilk's $\Lambda = .38$, $F(20, 66) = 2.06$, $p < .05$). Univariate F-tests revealed that the significant differences were found for the Hysteria scale (Hy3) ($F(2, 42) = 4.41$, $p < .05$) and the Social Introversion scale, Si(0) ($F(2, 42) = 10.11$, $p < .05$). Follow-up univariate analyses were conducted by placing the participants into six groups based on ability and gender (e.g., Poor Math males, Average Math females, Good Math males, etc.). For the Social Introversion scale, there was a significant difference between the six groups ($F(5, 42) = 4.46$, $p < .05$), with the Student-Newman-Keuls test revealing that Average Math males have higher Social Introversion scale scores than Good Math males, Average Math females, Poor Math females, and Poor Math males (see Figure 1). For the altered data set, the MANOVA of the Clinical Scales with the two factors of group and gender did not reveal any significant interactions (Wilk's $\Lambda = .46$, $F(20, 66) = 1.59$, $p > .05$), group (Wilk's $\Lambda = .83$, $F(10, 33) = 0.64$, $p > .05$), nor gender main effects

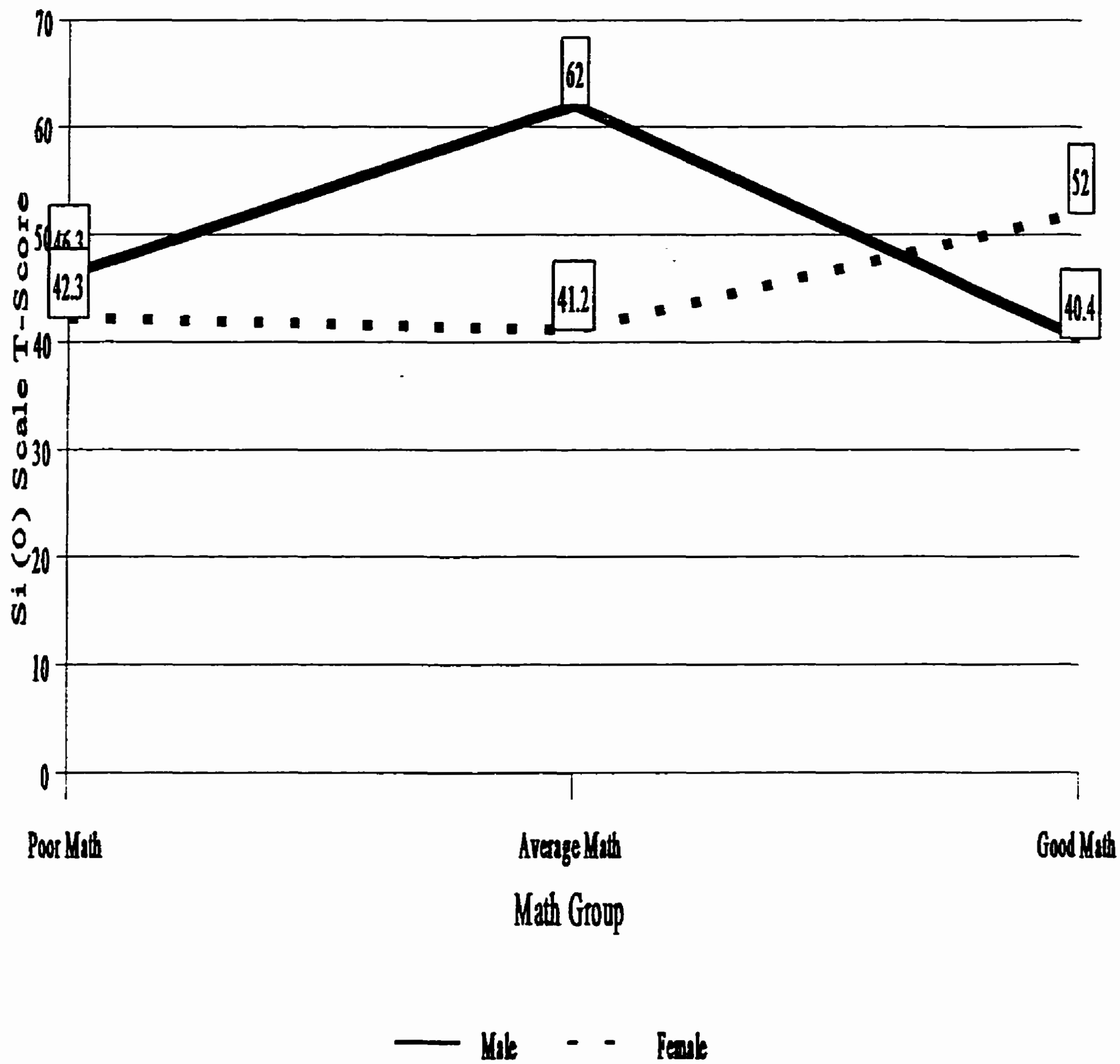
Table 4

Means, Standard Deviations, and Standard Error of MMPI-2 Clinical Scales T-Scores for the Original and Adjusted Data Sets

	Math Ability Groups									
	Poor Math (n = 16)			Average Math (n = 16)			Good Math (n = 16)			
Clinical Scales	M	SD	SE	M	SD	SE	M	SD	SE	Signif
Hs (1)	50.6	8.2	2.1	49.8	6.3	1.6	49.1	8.1	2.0	NS
D (2)	49.6	9.7	2.4	49.0	7.8	1.9	50.0	9.9	2.5	NS
Hy (3)	49.8	7.2	1.8	48.3	7.2	1.8	49.8 (48.3)	9.7 (7.2)	2.4 (1.8)	< .05 NS
Pd (4)	54.0	8.1	2.0	54.1	9.7	2.4	50.4	8.3	2.1	NS
Mf(5)	52.4	8.7	2.2	55.2	14.2	3.6	48.5	11.0	2.7	NS
Pa (6)	54.9	7.8	1.9	53.2	9.6	2.4	50.4	10.8	2.7	NS
Pt (7)	51.3	7.2	1.8	52.8 (51.4)	9.1 (6.4)	2.3 (1.6)	51.4	8.9	2.2	NS NS
Sc (8)	53.1	6.2	1.5	55.4 (53.3)	10.5 (5.5)	2.6 (1.4)	48.9	7.9	2.0	NS NS
Ma (9)	53.7	12.3	3.1	54.6	9.2	2.3	51.9	8.8	2.2	NS
Si (0)	43.8	8.1	2.0	46.4 (44.4)	12.9 (9.6)	3.2 (2.4)	46.9	11.8	2.9	< .001 NS

Note: N = 48; numbers in brackets are the values where the adjusted data set differs from the original data set; Clinical Scales scores are T scores with a mean of 50 and a standard deviation of 10, and scores >65 are clinically significant.

<u>Figure 1.</u> Mean MMPI-2 Social Introversion [Si (0)] scale scores as a function of gender and math ability group for the original data set.



(Wilk's Λ = .64, F(10, 33) = 0.82, p > .05). Table 4 presents the mean MMPI-2 Clinical Scale scores for each data set.

Since the Clinical Scales of Hysteria and Social Introversion had significant differences in the original data set, the corresponding Harris-Lingoes scales were examined. Before a MANOVA of these scales and the factors of group and gender was carried out on the original data set, the scales were examined for normality of distribution. The scales of Hy_3, Hy_4 and Si_3 had to be transformed using the arc sine transformation, in order to induce normality. The homogeneity of covariance matrices assumption was also investigated and was tenable. Table 5 presents the means of the Harris-Lingoes subscales that were examined. The MANOVA revealed a significant group by gender interaction (Wilk's Λ = 0.43, F(16, 70) = 2.27, p ,< .05). Univariate F-tests indicated that the significant differences were with the Hy_1- Denial of Social Anxiety (F(2, 42) = 9.2, p , .05) and Si_1 - Shyness (F(2, 42) = 8.55, p < .05) scales. Follow-up univariate analyses revealed that there was a significant difference between the six gender/ability groups (F(5, 42) = 4.95, p < .05) for the Hy_1 scale, with the Average Math males having lower Hy_1 scale scores than all other groups (see Figure 3). For the Si_1 scale, follow-up univariate analyses again revealed a significant difference between the six groups (F(5, 42) = 4.54, p < .05), with the Average Math males having higher Si_1 scores than Average Math females, Poor Math females, and Good Math males, as well as Good Math females having higher Si_1 scores than Average Math (see Figure 2).

Finally, MANOVAs were carried out on both data sets for the Content Scales hypothesized to differentiate the groups: Anxiety (ANX), Depression (DEP), and Social

Table 5

<u>Means, Standard Deviations, and Standard Error of Selected MMPI-2 Harris-Lingoes and Content Scales T-Scores for the Original Data Set</u>

	Math Ability Groups									
	Poor Math (n = 16)			Average Math (n = 16)			Good Math (n = 16)			
	M	SD	SE	M	SD	SE	M	SD	SE	Signif
Harris-Lingoes Scales										
Hy_1	53.2	7.7	1.9	52.6	10.6	2.7	49.9	9.4	2.4	< .001
Hy_2	51.4	8.6	2.1	47.9	7.7	1.9	50.1	8.4	2.1	NS
Hy_3	48.2	9.7	2.4	48.1	7.8	2.0	50.7	8.8	2.2	NS
Hy_4	49.6	9.5	2.4	47.6	7.3	1.8	48.4	7.0	1.7	NS
Hy_5	43.6	9.5	2.4	48.7	11.3	2.8	47.2	8.8	2.2	NS
Si_1	46.7	8.1	2.0	47.8	11.3	2.8	50.8	10.9	2.7	< .05
Si_2	46.7	9.7	2.4	47.7	11.2	2.8	47.4	10.5	2.6	NS
Si_3	46.9	10.2	2.5	47.9	6.7	1.7	48.9	8.0	2.0	NS
Content Scales*										
ANX	48.8	7.9	2.0	48.6	7.7	1.9	51.3	9.1	2.3	NS
							(49.6)	(5.4)	(1.3)	NS
DEP	50.1	8.5	2.1	48.3	8.0	2.0	48.0	7.6	1.9	NS
SOD	46.4	8.3	2.1	47.5	12.4	3.1	50.6	11.0	2.7	< .05

Note: Sample N = 48; Harris-Lingoes and Content Scales scores are T-scores, which have a mean of 50 and a standard deviation of 10, clinically significant scores are >65.
*Content Scales were also examined for the adjusted data set and the values in parentheses are where the adjusted data set differed from the original data set.

Figure 2. Mean MMPI-2 Harris-Lingoes Si_1 (Shyness) scale scores as a function of gender, and math ability group for the original data set.

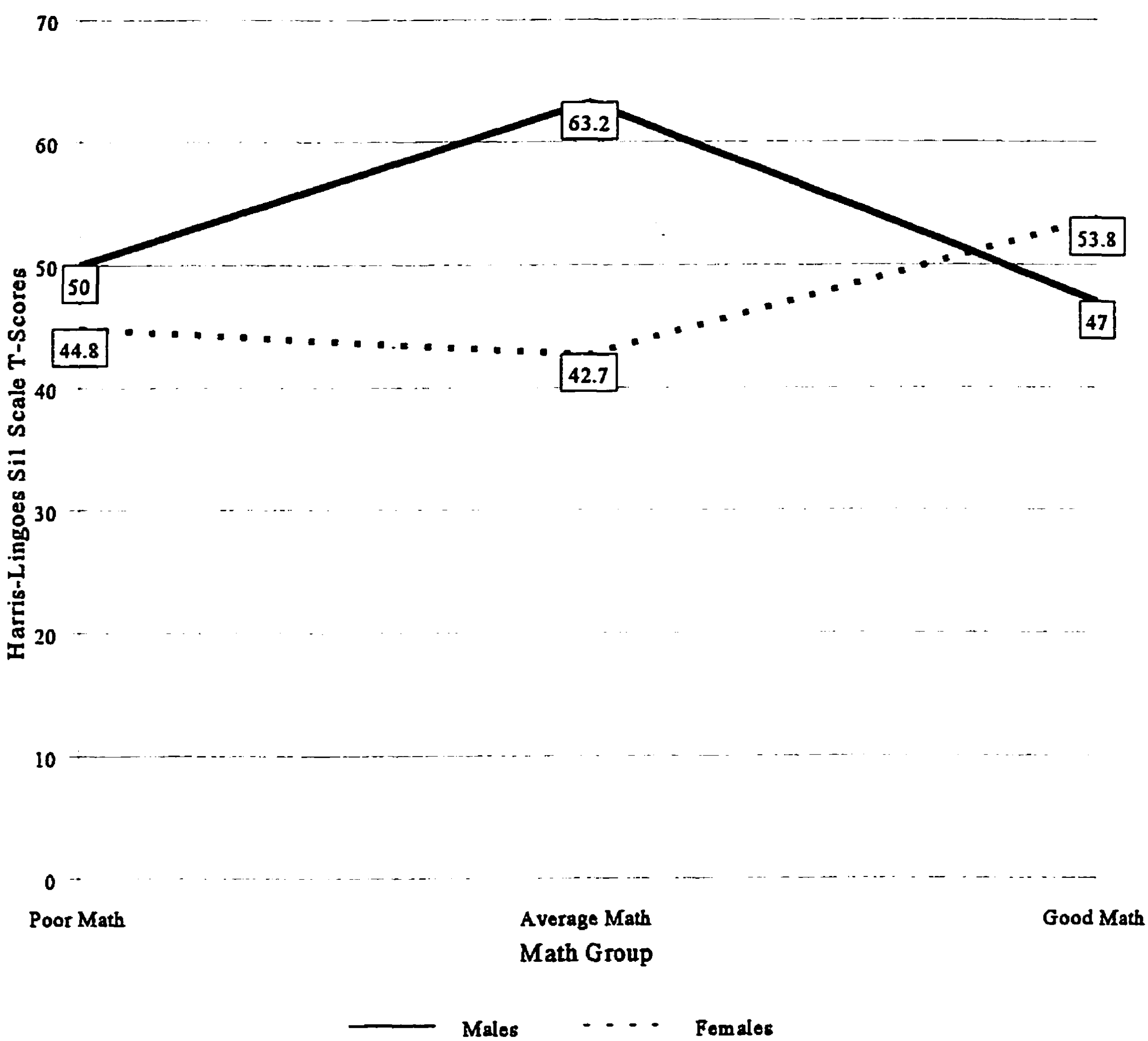
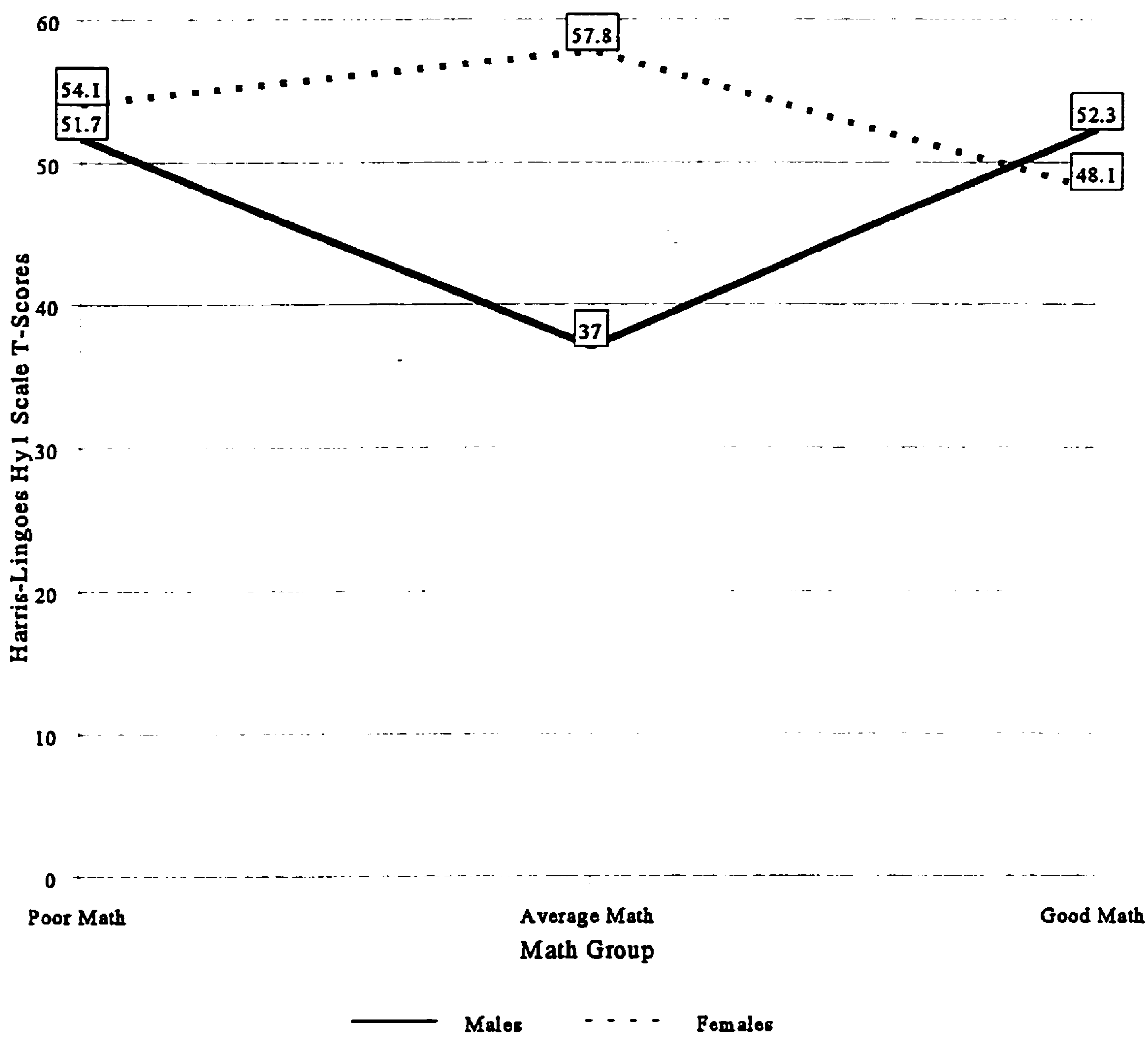
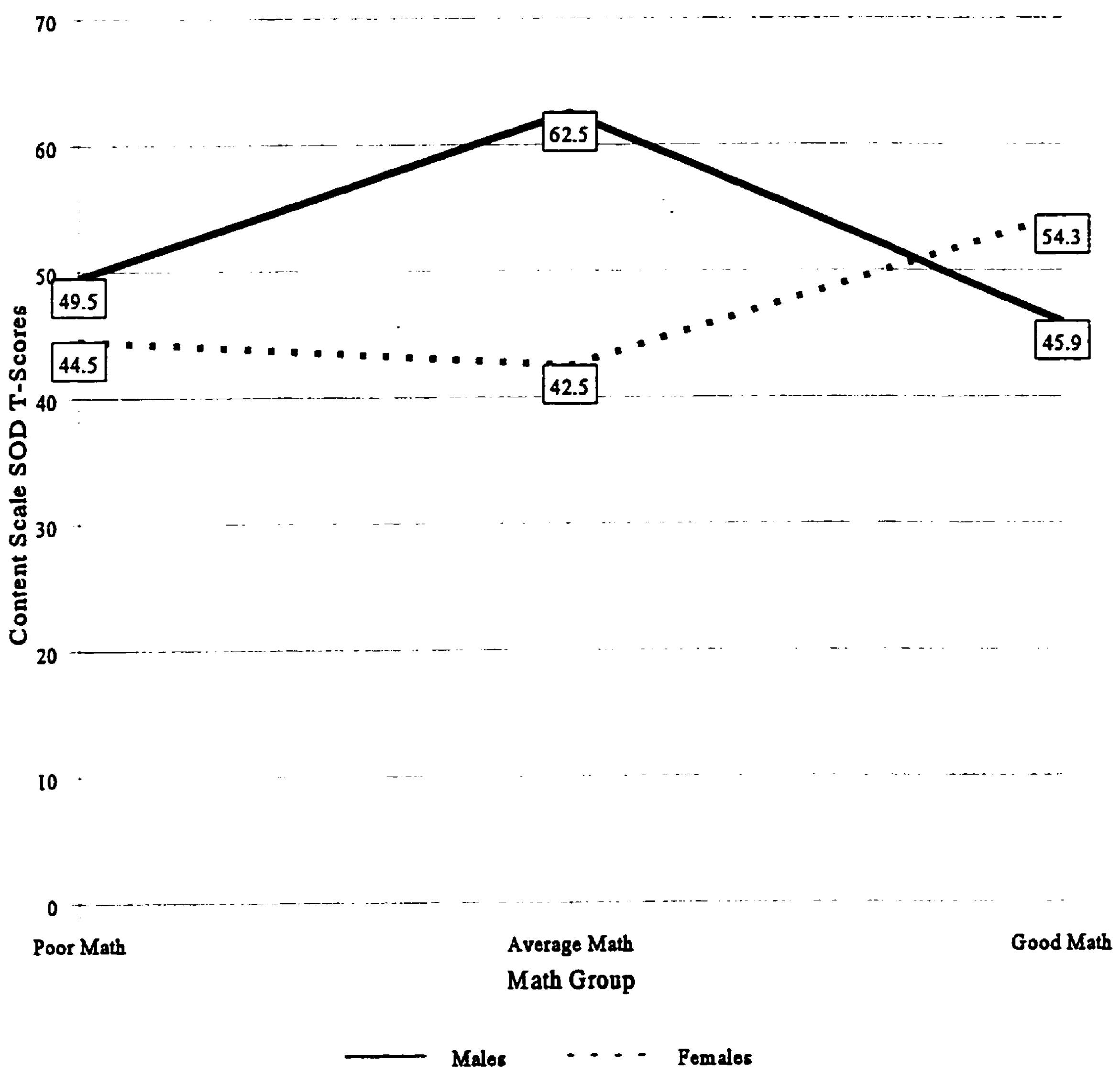


Figure 3. Mean MMPI-2 Harris-Lingoes Hy_1 (Denial of Social Anxiety) scale scores as a function of gender and math ability group for the original data set.



Discomfort (SOD), and the two factors of group and gender (see Table 4 for group means). For the original data set, as already mentioned, both the Anxiety and Depression scale scores had to be arc sine transformed to obtain normality, and for the adjusted data set, only the Depression scale scores had to be transformed. The MANOVAs for both the original and adjusted data sets displayed the exact same results for the MANOVA, univariate F-tests and follow-up univariate analyses. There was a significant group by gender interaction (Wilk's $\Lambda = 0.70$, $F(6, 80) = 2.65$, p ,< .05). Univariate F-tests revealed that the difference lay with the Social Discomfort (SOD) scale ($F(2, 42) = 8.08$, $p < .05$). Follow-up univariate analyses revealed a significant difference between the six group/gender groups ($F(5, 42) = 4.04$, $p < .05$). Post hoc tests using the Student-Newman-Keuls statistic reveal that the Average Math males had higher Social Discomfort scale scores than did the Average Math females, the Poor Math females and the Good Math males, as well as the Good Math females having higher scores than the Average Math females (see Figure 4).

Figure 4. Mean MMPI-2 Content Scale SOD (Social Discomfort) scores as a function of gender, and math ability group for both the original and altered data sets.



Discussion

The primary purpose of this study was to investigate the relationships among selected MMPI-2 scale scores and mathematical ability as measured by the WRAT-3. As stated in the Results section, the data were examined in two data sets, as outlier scores were discovered for some of the Clinical and Content Scales. Of particular concern was one individual with three Clinical Scale score outliers that were three standard deviations from the mean of the math ability group to which he belonged (Average Math). The original data set consisted of the data as it was - with outliers included. The only manipulations done to this data set were arc sine transformations for MMPI-2 scales that were not normally distributed. The second data set addressed the issue of outliers by replacing the outlier values with the group mean for the scale on which it occurred. Again, any necessary arc sine transformations were carried out to ensure normality of the MMPI-2 scales scores. Data analyses on this second data set were carried out in order to see if any results obtained in the original data set were unduly affected by the outlier scores. In the end, there were three MMPI-2 scales for which there were significant differences between the math ability groups for the original data set, and only one scale for the adjusted data set.

Analyses of the original data set revealed some significant results although they were not the ones hypothesized to be significant based upon the learning disabilities research. The group of individuals that stood out were males in the Average Math group - the group that contained the individual with three extreme Clinical Scale scores. It should be noted that although the males in the Average Math group had significantly higher mean scores than the males and females in the other math ability groups for three of the MMPI-2 scales, the values of these elevations were not high enough to be considered as a problem of clinical significance as they did not register in the clinical range, which is defined as a T score ≥ 65.

One of the scales in the original data set on which the mean score of the males in the Average Math group stood out was the Clinical Scale of Si (0) - Social Introversion. This Clinical Scale is unique as it is one of only two Clinical Scales which measures personality in a bipolar manner, where both low and high scores can be clinically interpreted - high scores assess social introversion and low scores reflect social extroversion. As a group, the males in the Average Math group had the highest Si(0) score - significantly higher than all of the groups except the females in the Good Math group; but this score did not register in the clinical range for social introversion. The males in the Good Math group as well as the females in the Poor and Average Math groups all scored in the clinical range for social extroversion, as their T-scores were less than 45.

Since the interpretation of a Clinical Scale can sometimes be complicated by the scale's heterogeneous content, the Harris-Lingoes subscales for the Clinical Scale of Si were examined. Harris-Lingoes subscales are valuable for selecting the most relevant standard scale descriptors from the large pool of potential descriptors. Only one of the Harris-Lingoes subscales for the Si scale revealed a statistical difference between the groups - the Si_1 scale (Shyness) with the males in the Average Math group presenting the highest mean score - significantly higher than the males in the Good Math group and the females in the Poor and Average Math groups. Again, although the males in the Average Math group had the highest mean score for the Si_1 scale, this score was not elevated enough to be in the clinical range. High scorers for this scale usually deny being sociable, with elevations indicating: shyness in interpersonal situations, discomfort around others, and reluctance to begin relationships.

It was hypothesized the individuals in the Poor Math group would have the highest Si scale scores, as there is an abundance of literature stating that NLD individuals display signs of social withdrawal (Rourke et al., 1989; Rourke et al., 1986; Tranel et al., 1987). They also tend to fare poorly at social interactions due to: their difficulty in adapting to novel situations; their inability to benefit from positive and negative feedback; their lack of understanding of cause and effect relationships; as well as their difficulties with nonverbal problem solving and hypothesis testing (Casey et al., 1991). In trying to explain this unexpected result of the Average Math males having the highest Si(0) and Si_1 scale scores, a review of the pertinent literature revealed that High Achieving males scored higher on the Si(0) scale of the MMPI compared with lower achieving men in a study by Kodman (1984). This information coupled with the learning disabilities research would be able to explain if the males in the Poor and Good Math groups had high Si(0) scores, but it does not explain why the males in the Average Math group have a high Si(0) score.

When looking at the original data set, another scale on which the males in the Average Math group had a significantly different score than the other groups was the Harris-Lingoes Hy_1 - Denial of Social Anxiety scale. The Average Math males had the lowest score of the six math ability/gender groups. High scorers for this scale endorse items indicating they are socially extroverted and comfortable in social settings. The Average Math males did not endorse these sentiments and did not deny being anxious in social settings nor deny being introverted. The fact that the males in the Average Math group obtained a low score for the Hy_1 scale is consistent with the elevation they also obtained for the Si_1 - Shyness scale.

The final scale for which the Average Math group differed significantly on with respect to the other math/ability groups was the Content Scale of Social Discomfort (SOD), which assesses uneasiness in social situations. Unlike the previous two elevations, the significant difference on this scale was seen in both the original and adjusted data sets. The males in the Average Math group had the highest group score of the six ability/gender groups and high scorers for this scale tend to be very uneasy around others, and like to be by themselves. In social situations, they are loners, preferring to sit alone rather than join in the group; they view themselves as shy and dislike parties and other group events. For the original data set, the elevation on this scale corroborates the sentiments presented by the elevation on the Si_1 scale - Shyness, and the low score on the Hy_1 scale - Denial of Social Anxiety.

The impression created by the three elevated scores in the original data set analyses is that the male Average Math group is shy. However, the adjusted data set analyses indicates that this "shyness" is seen only in the SOD Content Scale. This may lead one to conclude that in the original data set, the individual with the three extreme scores is unduly influencing the mean score of the Average Math group. This is most probably the case, rather than there being something unique about the males in the Average Math group that makes them more likely to be reticent and withdrawn. Also, the fact that this group is the smallest of the six math ability by gender groups, with only four individuals, leaves little room for variance among the individuals, so any one individual with extreme scores will have a great influence - greater than if that individual were in a group of a larger size.

In trying to explain the results of this study, this experimenter was able to generate some reasons why the hypotheses proposed at the beginning of this study were not supported. First, the sample size was very small considering the number of MMPI-2 scales evaluated. Perhaps with a greater sample number, clearer results would have been obtained. Greater numbers of participants would have allowed for greater variability among the participants, and “outlier” individuals would not have had as much of an influence in skewing the results.

Second, instead of the obvious preference for a clinical population, a normal population was used. Due to availability limitations, it was not practical to use a clinical population, as an even smaller sample size would have resulted using this approach. The logic in using individuals from a normal population was that there is a continuum of mathematical ability, with the Poor Math group displaying attenuated forms of the deficits seen in NLD individuals. Perhaps these deficits do not run along a continuum and it is more of an “all of none” situation. If this is the case, then, it would make sense that the Poor Math group did not show any significant elevations on the MMPI-2, as they do not have any right hemispheric abnormalities. When Pearson product-moment correlations were carried out on the math ability groups and the lateralization indices, there were, however, some moderate negative correlations. This indicates that individuals in the Good Math group had smaller lateralization indices than those in the Average Math group, and those in the Average Math group had smaller indices that those individuals in the Poor Math group, thereby, supporting the continuum hypothesis and the grouping method.

What this implies is that there was a continuum of verbal/nonverbal abilities across the math ability groups, with individuals in the Good Math group having better developed nonverbal skills compared to verbal skills and the individuals in the Poor Math group having better verbal skills compared to nonverbal skills.

Another explanation for the lack of MMPI-2 elevations for individuals in the Poor Math group is that there is some controversy in the literature with respect to MMPI profiles and hemispheric functioning. The hypotheses generated for this study were based on learning disabilities literature and, in part, drew on research relating lateral hemispheric brain functions to social-emotional behavioural characteristics. Heilman, Bowers, and Valenstein (1985) summarized the evidence pertaining to right hemispheric dysfunction and concluded that this lead to: difficulties in reading facial expressions and in detecting speech prosody; avoiding eye contact; displaying flattened affect and unexpressive speech; and, not displaying concerns about their deficits (unlike individuals with left hemisphere damage). Several studies have shown left-sided, but, not right-sided, trauma leads to elevated scores on the Depression Clinical Scale of the MMPI (Gasparrini, Satz, Heilman, & Coolidge, 1978; Black, 1975; Dikmen & Reitan, 1974). However, other studies have found that right hemisphere damage leads to more disturbed MMPI scores than left hemisphere damage on virtually every scale, and especially on the Schizophrenia and Depression Clinical Scales (Lishman, 1968; Woodward, Bisbee, & Bennett, 1984). In light of this conflicting evidence with respect to personality and lateralization of hemispheric damage, it is perhaps, not surprising that the present study does not produce a clear resolution of the question whether putative right hemisphere dysfunction is associated with social and emtional anomalies.

Yet another reason for the ambiguous results of this study could be due to the way the subjects were placed in the math ability groups. Even though they met the criteria for McCue et al.'s (1987) study, perhaps the method used for this study did not allow for enough of a difference between the groups with respect to mathematical ability. Possibly grouping solely on WRAT-3 scores is not an efficient enough method for differentiating the differences seen in individuals with NLD. The WRAT-3 Arithmetic scores for the Poor Math group ranged from 72 to 94, and the mean score on the Arithmetic subtest of the WAIS-R for the Poor Math group was 9.2. This places some of the scores for this group within the "average" range of math performance. Thus, even though the WRAT-3 arithmetic performance of the Poor Math group is significantly lower than the average of their reading and spelling performance, in an absolute sense their math scores are not exceedingly "poor." It still could be that math ability falls along a continuum, but that this study was unable to capture the lower end of this continuum in order to reveal associated personality differences among the groups. Although, when Pearson product-moment correlations were calculated between the math ability groups and the subtests of the WAIS-R, a significant, moderate positive correlation was obtained for the Arithmetic subtest, which suggests that as the ability level of the groups increased, so did their Arithmetic subtest scaled scores.

The present findings indicate, therefore, that individuals with Poor Math ability do not possess personality differences that would be revealed by completing the MMPI-2. Although it was hypothesized these people would be more maladjusted due to possible neuropsychological deficits, this does not seem to be the case. Several suppositions have been offered as to why the hypothesized results were not obtained, and supplementary research would be necessary to verify these hypotheses.

Future Research

More research is needed into social-emotional functioning of NLD individuals, specifically adults. This should examine the influence of other variables usually associated with social dysfunction as possible necessary but not sufficient causes of social-emotional disorders in persons with NLD.

Another avenue for research would be by comparing individuals with NLD to those with other clinical and/or medical conditions that share commonalities with NLD. For example, research has shown that the clinical features of Asperger's syndrome overlap to some degree with NLD (Klin, Volkmar, Sparrow, Cicchetti, & Rourke, 1995). Perhaps some of the psychiatric literature pertaining to Asperger's syndrome might provide new insights on NLD. Investigating the overlap between NLD and Asperger's syndrome, may help to further clarify the mechanisms that underlie NLD and provide opportunities to create more stringent diagnostic criteria for NLD.

Researchers in the field of learning disabilities need to aim for more consensus in their measurement and methodologies. Although subtyping research is a step in the right direction in understanding the very heterogeneous entity of learning disabilities, this research seems to be comprised of a multitude of independent efforts all striving toward the same goal. Better progress would ensue if theses researchers pooled their efforts into creating a single classification nosology for the field.

Finally, it is unclear whether the research method used in the identification of NLD individuals - academic/school-based criteria versus clinical neuropsychological assessment - plays a role in the subtyping outcomes of individuals with NLD, and consequently with subsequent correlations with social-emotional functioning. Further research comparing these methodologies may provide more clarity and insight.

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Appendix

Consent Form

My signature on this sheet indicates I agree to participate in a study by Lisa Linders of Lakehead University, on PERSONALITY CHARACTERISTICS OF ADULTS WITH NONVERBAL LEARNING DISABILITY SUBTYPES and it also indicates that I understand the following:

1. I am a volunteer and I can withdraw at any time from the study.
2. There is no risk of physical or psychological harm.
3. The contributions I provide will be confidential.
4. I will receive a summary of the project, upon request, following the completion of the project.

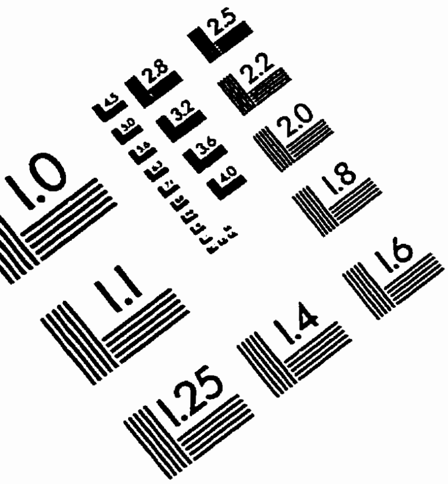
I have received information about the nature of the study, its purpose, and procedures and it was explained to me to my satisfaction.

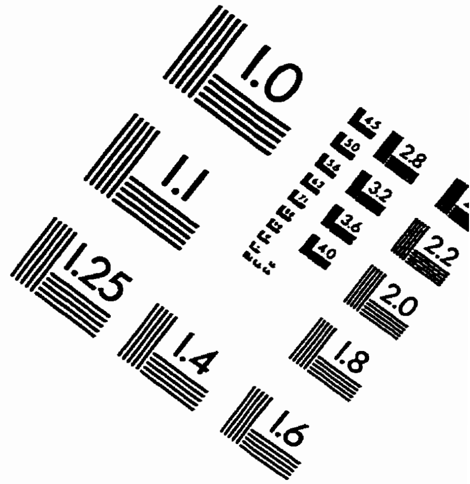
Name (Print): ______________________________

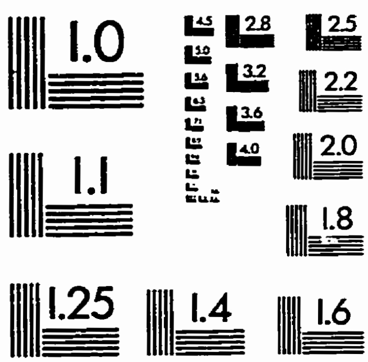
Signature: ________________________________

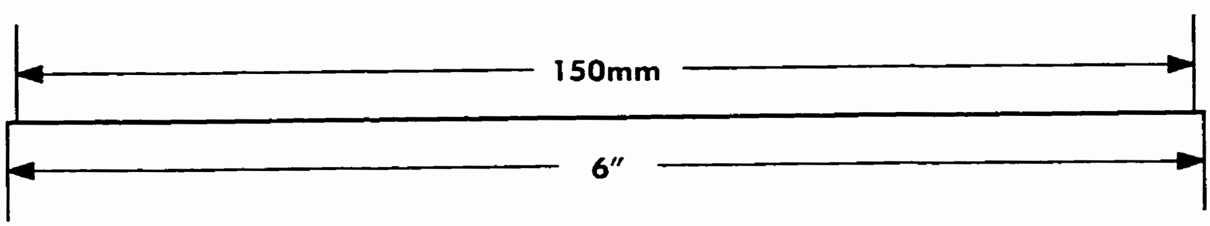
Date: ____________________________________

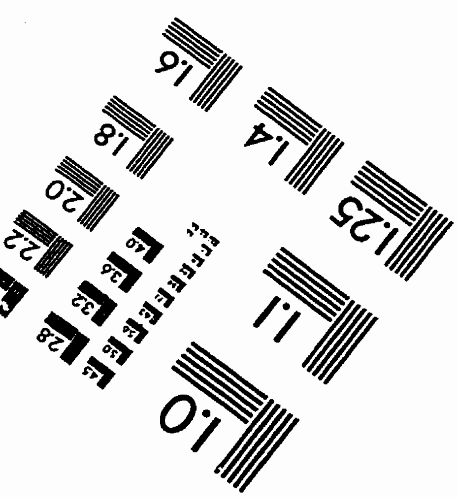
IMAGE EVALUATION TEST TARGET (QA-3)

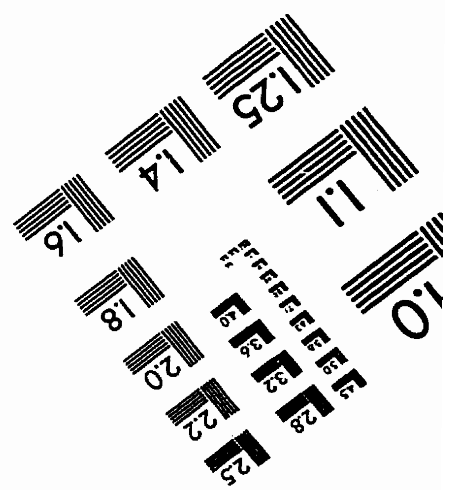












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