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**Tourette's Syndrome children: Significant achievement and  
social behavior variables**

**Gallina, Nancy Burleigh, Ph.D.**

**City University of New York, 1989**

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TOURETTE'S SYNDROME CHILDREN: SIGNIFICANT ACHIEVEMENT  
AND SOCIAL BEHAVIOR VARIABLES

by

NANCY GALLINA

A dissertation submitted to the Graduate Faculty  
in Educational Psychology in partial fulfillment  
of the requirements for the degree of Doctor of  
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Abstract

TOURETTE'S SYNDROME CHILDREN: SIGNIFICANT ACHIEVEMENT  
AND SOCIAL BEHAVIOR VARIABLES

by

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Professor Alan Gross  
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For this comparison achievement study, 27 subjects with Gilles de la Tourette's Syndrome (TS), 27 normal control subjects (NC), and 27 subjects with Attention Deficit Hyperactivity Disorder (ADHD), were evaluated for mathematics achievement, using the Wide Range Achievement Test - Revised (WRAT-R) Arithmetic subtest and two forms of the Metropolitan Achievement Test (MAT 6) Mathematics subtest, one given under the standard timed condition and the other under an untimed

condition, and were evaluated for social behavior using the ADD-H Comprehensive Teacher Rating Scale (ACTeRS) in an attempt to differentiate TS subjects from ADHD and NC subjects. It was found, consistent with previous research, that TS subjects performed poorly on the WRAT-R Arithmetic subtest and on the form of the MAT 6 administered under the timed condition. TS subjects administered the MAT 6 under the untimed condition, scored in the average range. The results of the ACTeRS revealed TS subjects to have good social skills and little oppositional behavior when compared to ADHD subjects. These results suggest that timed administration of the WRAT-R Arithmetic subtest is a significant variable in assessing mathematics achievement in TS subjects, and that the WRAT-R Arithmetic subtest is inappropriate for assessing mathematics achievement in TS children. It is further suggested that increased frequency and duration of ticking behavior adversely affects attention in TS subjects while apparently not negatively affecting social skills and oppositional behavior.

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## INTRODUCTION

In the past, Gilles de la Tourette's syndrome (TS) has been considered a rare, bizarre phenomenon with mysterious overtones. For example, there is an assertion in the literature (Olds, 1975) that the case which formed the basis of the book and film, "The Exorcist", had, in fact, involved a TS youngster! Our current perspective on the malady is that it is not so extraordinary.

TS symptoms were first reported by Bouteille in 1810. The first case history of a TS patient was the Marquise de Dampiere as related by Itard in 1825 (Shapiro, Shapiro, Bruun & Sweet, 1978). Gilles de la Tourette, a French physician, published nine case histories with a careful delineation and description of the symptoms (Bauer & Shea, 1984). Our understanding of the disorder increased very little until there was a resurgence of interest during the past 40 years.

Symptom management has increased dramatically with the use of psychotropic medication involving dopamine and norepinephrine neurotransmitters. Further, public awareness and education regarding the disorder are now growing through the work of the Tourette Syndrome Association.

The present study was engendered by the growing salience of the Tourette's syndrome (TS) in contemporary life. The proverbial man or woman on the street is not familiar with the label nor the malady. It could be argued that increased prevalence reflects increased awareness or a change in diagnostics. In any case, educators must face the reality that growing numbers of these special students are present in the classroom. Current estimates of TS in the population range from .05% to .15% (Shapiro & Shapiro, 1980).

An increasing number of individuals with Tourette's syndrome are school-age children. Public Law 94-142, the "Education for All Handicapped Children Act", federally mandates appropriately meeting the educational needs of these children. Understanding the effects of TS on the school-age population is of further importance because of the characteristic age of onset of TS, and the fact that early symptoms may be first detected within the school environment. The American Psychiatric

Association (1980) has reported that one out of every four children has some kind of history of tic or involuntary movements. Matthews and Barabas (1985) point out that "professionals in an educational setting can expect to encounter tic syndromes frequently" (p.182). In addition, the unusual nature of Tourette's syndrome frequently generates problems both for the individual and the school, which must be handled effectively. If an appropriate Individual Educational Plan (IEP) is not rapidly implemented, these children may suffer additional educational and emotional trauma because they are usually considered emotionally disturbed. Parents, teachers, and physicians frequently believe that the early symptoms of this disorder are common habits that will disappear with time (Torup, 1962). The prevalence of misdiagnosis was reported by Golden (1977), who presented data on 15 Tourette subjects. Of these TS subjects, 10 were misdiagnosed initially as having nervous habits or attention-getting behaviors, two as having simple tics, and two as having organic disorders, with only one subject correctly diagnosed initially as Tourette. Since Tourette's syndrome is often characterized by motor dysfunctions and hyperactivity, it is frequently misdiagnosed as a behavior disorder. The apparent presence of learning

disabilities and Attention Deficit Hyperactivity Disorder (ADHD) further complicates the appearance of these youngsters in school. It has been reported that about 60% of children with TS have some kind of difficulty functioning adequately in school, and more serious learning disabilities (LD) are reported for 30% of these students (Davidovicz, 1984). Approximately 24% to 55% of TS subjects have ADHD (Shapiro & Shapiro, 1982). Subtle neurological deficits were found in 59% of TS subjects tested (Sweet, Solomon, Wayne, Shapiro, & Shapiro, 1973). Such children are, therefore, of special concern to educators and school psychologists, who frequently find it difficult to formulate effective educational approaches.

Teachers are encountering and will continue to encounter students with TS. There is a definite need to develop a research-supported body of literature covering the management of TS children including instructional and curricular recommendations. This need is clearly unmet given our contemporary knowledge of TS.

#### Definition of Tourette's Syndrome

Tourette's syndrome is a neurological disorder of the central nervous system (CNS), but, to date, there is no direct evidence that permits identification of the biochemical or structural locus of the pathology. The

most prominent speculation is that the simple and complex movements in TS represent an alteration of neurotransmitter function, primarily affecting basal ganglia connections (Singer, Butler, & Tune, 1982). More specifically, dopaminergic mechanisms have been implicated in the patho-physiology of TS. The dramatic ability of haloperidol and other dopamine receptor blocking agents to suppress tic symptoms, and the exacerbation of tic symptoms by dopamine agonists have led to a hypothesis that TS might, in some ways, result from overactivity of one or more central dopaminergic systems (Shapiro & Shapiro, 1982).

Shapiro and Shapiro (1982) provide a detailed description of the disorder. The essential features of TS are recurrent, involuntary, repetitive, rapid movements which may include multiple vocal tics. Tics are defined as involuntary movements, usually contractions of skeletal muscle groups that are functionally related. They may occur in one or more parts of the body. Vocal tics are involuntary noises or words. The tics are chronic, brief in duration, rapid in onset, suddenly experienced, totally unexpected to the individual, repetitive, totally out of context, and inappropriate to the environmental situation in which the individual finds himself/herself, and completely

irresistible. Their intensity may vary, they may occur at totally irregular intervals, and may involve several numbers of muscle groups.

With great effort, and at the price of experiencing tremendous stress, these movements can be suppressed for minutes and sometimes hours. The location, the frequency, and the intensity of these symptoms may vary from time to time over a period of days, weeks, or months.

Age of onset of TS ranges from two years to approximately thirteen years of age, with both the mean and median at seven years. Approximately 90% of subjects develop this syndrome by 11 years of age (Shapiro & Shapiro, 1982).

The tics usually involve the head, upper torso, and upper and lower limbs. The movements described decrease during non-anxious distraction, or when the individual's concentration is focused strongly on some other, usually external, event. Although the tics were thought to disappear during sleep, it has now been shown that TS subjects do, indeed, have tics during their sleep (Glaze, Frost & Jankovic, 1982). Tics increase with stress (Ferrari, Matthews, & Barabas, 1984).

The vocal tics include a variety of sounds that may include words, coughs, wheezing sounds, sniffs, yelps,

barks, grunts, and clicks. The vocal tics are, therefore, quite variable and can include virtually any inarticulate noise, sounds, or emphasis on some segment of a word when speaking. These symptoms may include coprolalia, an irresistible urge to utter obscenities, which is present in about 60% of the cases with the usual onset just after the age of puberty. Symptoms can also include palilalia (the repeating of the speaker's own last word or phrase or sentence) and echolalia (the repeating of the last word or phrase of others).

Initial symptoms are variable. Tics usually begin about the neck or head, and tics of the eye are the first presentation in about 26.9% of cases. Tics of the head and neck are present in about 19.5% of cases. About 55% of Tourette individuals have abnormal movements of the lower limbs and body. Only about 1% of subjects report an initial symptom of coprolalia and most of these are during adolescence. Many subjects have multiple initial symptoms which include combinations of motor or vocal tics.

In addition to these frequent symptoms, other associated features have been observed. These include echokinesis (imitation of the movements of someone who is being observed), mental coprolalia (thinking about curse words), compulsive impulses to touch things and to

perform complicated movements such as twirling, squatting, or deep knee bends.

Initial symptoms usually disappear during early school age, but will progress and change over a three-month period of time. Old symptoms are frequently replaced by new ones and, although new symptoms can remain for some time, they will usually spontaneously change.

The course of these symptoms is variable, though the disorder is usually lifelong. There may be brief periods of remission, and there have been cases reported in which symptoms disappear before adulthood.

These signs and symptoms are summarized by the Diagnostic and Statistical Manual of Mental Disorders, Third Edition (DSM III, American Psychiatric Association, 1980) in six diagnostic criteria for the Tourette disorder:

1. Age of onset is between two and fifteen years.
2. Presence of recurrent, involuntary, repetitive, rapid, purposeless motor movements affecting multiple muscle groups.
3. Multiple vocal tics.
4. Ability to suppress movement voluntarily from minutes to hours.

5. Variations in the intensity of the symptoms over weeks or months.
6. Duration of more than one year.

## REVIEW OF THE LITERATURE

The study of Tourette's syndrome has been approached from diverse yet limited perspectives by researchers who were working within their own specific area of interest. Psychological and neuropsychological examinations, as well as investigations of etiology and past medical history, have been made. This approach has provided us with a potpourri of equivocal data.

Much of the individual research is problematic because: (1) many studies have been hampered by a small sample size, (2) control groups have not always been used, (3) the medication status of TS subjects has been reported only occasionally even though research has indicated that haloperidol, the most frequently used drug for the treatment of TS, can cause cognitive "blunting" when initially taken or when the dose given is high (subject specific), (4) there is diversity and inconsistency in the diagnostic description of the signs

and symptoms, etiology, and cognitive performance of TS subjects, and (5) operational definitions rarely are provided. Terms such as learning "disability", "deficit", "disorder", and "difficulty" are used interchangeably without reference to quantifiable criteria.

This review of the literature focuses on numerous aspects of Tourette's syndrome, including organic factors and intelligence, language, visuopractic ability, attention and memory, academic performance, Attention Deficit Hyperactivity Disorder, and social skills and aggressive behavior.

#### Organic Factors and Intelligence in TS Subjects

A number of studies have examined organic factors and cognitive difficulties in TS subjects. Lucas, Kaufman, and Morris (1967) studied fifteen TS subjects for a wide range of neurologically based cognitive difficulties\*. The subjects were described as being of normal IQ, however, the range was from dull-normal (85) to superior (146). Since not all subjects were given the WISC, a mean IQ score could not be calculated and scatter and sub-test scores could not be assessed.

\*Interestingly, Shapiro (1978) considered this a "comparatively large sample of carefully diagnosed patients" (p.154).

Further, the term "learning deficits" (p. 718) was used to describe difficulties including distractibility, low frustration tolerance, marked difficulty in conceptualization and abstraction, and difficulty in shifting (these were reported for 9 subjects). Moderate to severe "learning deficits" and obscure school difficulties also were reported. No operational definitions were given for these learning or school problems.

In addition, no control group was used. Symptom severity was not measured and there was no indication of whether the subjects were tested on or off medication.

Notwithstanding the methodological flaws, the study revealed great fluctuation in the cognitive difficulties described. The data, based on interpretations of the Bender-Gestalt test, report definite signs of "encephalopathy", or organic brain damage, in four subjects, suggestive signs of "encephalopathy" in four subjects, and no signs of "encephalopathy" in the remaining seven subjects.

Multiple organic factors were also studied by Shapiro et al. (1978), who compared a group of fifty TS subjects and a psychiatric clinic control group, matched for Full Scale IQ, sex, and age. All IQ's were reported as falling within the normal range. Despite

similarities in Full Scale IQ's between the TS and the control group, 50% of the TS group evidenced verbal intelligence quotients (VIQ) of more than 15 points higher than performance intelligence quotients (PIQ). There also were significant abnormalities in the Bender-Gestalt (using the Koppitz, 1963 method for scoring) for 40% of the TS subjects who were 11 years of age and under. Information concerning specific difficulties on the Bender-Gestalt was not provided. In addition, the authors do not indicate whether these findings of organicity were for the same TS subjects, who evidenced performance IQ decrements.

Verbal-Performance IQ discrepancies of this magnitude and greater in some subjects have been confirmed by subsequent research (Bornstein, King, & Carroll, 1983; Ferrari et al., 1984; Golden, 1984; Incagnoli & Kane, 1982; Sutherland, Kolb, Schoel, Whishaw, & Davies, 1982). These data and reports of poor performance by TS subjects on the Category Test and the Time score on the Tactual Performance Test, subtests of the Halstead - Reitan Neuropsychological Test Battery (Bornstein et al, 1983), suggest that there is a greater deficit in non-verbal spatial tasks among TS subjects. Thompson, O'Quinn, and Logue (1979) also used the Reitan-Indiana Neurological Battery to assess cerebral

dysfunction. Heterogeneity was again demonstrated by the findings of static dysfunction of the left hemisphere for two subjects, of the right hemisphere for one subject, and normal findings for one subject. Motor skills which did not involve a visual perceptual component were reported to be the most consistent areas of impairment. The sample size of this research (N=4) was extremely small, no control group was used, assessment of symptom severity was not made, use of medications was not indicated, and no attempt was made to explain the diverse findings.

A further contribution to the wide array of findings among TS subjects was provided by Incagnoli and Kane (1982) who reported a smaller percentage of impaired subjects than Shapiro et al., (1978). Scores on the Halstead-Reitan Neurological Psychological Battery for Children (using the Selz-Reitan criteria for interpretation) were in the range indicating learning disability for one subject, in the range of brain damage for another subject, while all other subjects scored in the unimpaired range. Although the sample size in this study was larger (N=13), severity of ticking was not assessed, no control group was used, and use of medication was not indicated. Homogeneous symptom complexes were unsuccessfully sought in this, as well as

in previous studies. Thus, previous studies have assessed TS subjects in the normal range of intelligence, with some deficits in non-verbal spatial tasks, but no clearly defined homogenous cognitive deficits, although findings are suggestive of organically based neurological dysfunction in some subjects.

#### Language in TS Subjects

Prior research has also examined language ability in TS subjects. Despite the interjection of vocal tics, complex sounds, and coprolalic utterances, specific and consistent deficits in language skills are largely unreported. This would seem to be in agreement with higher verbal IQ than performance IQ noted above. Some studies, however, have reported language difficulties. In general, these have been reported either with single case studies or studies with small numbers of subjects.

Among the reported language difficulties are:

(a) Difficulty with verbal expressive skills and short term memory of sentences of gradually increasing length (N=1), impaired verbal fluency, immediate auditory-verbal memory, phoneme-grapheme matching, and oral arithmetic (N=1) (Jaschko & Rourke, 1982). (b) Significant receptive vocabulary skill deficits (N=10), (age range 7.2 to 14.4 years). A pattern of

developmental deterioration on receptive vocabulary skills with age was suggested (Ferrari et al., 1984). (c) Significant speech and language deficits and problems in written language (N=5), (O'Quinn & Thompson, 1980). (d) Confusion in the interpretation of complex linguistic clues involving spatial and temporal concepts or inverted grammar (N=9) (Golden, 1984). (e) Verbal tics tend to occur at points of low information or uncertainty in sentences, such as before conjunctions and pronouns (N=1) (Martindale, 1977) and at the end of a clause before a pause (N=1) (Frank, 1978).

The exceptions to the small N studies which reported language difficulties are Sutherland et al. (1982), who reported decreased verbal fluency (N=38) and Ludlow, Polinsky, Caine, Bassich, and Ebert (1982), who reported deficiencies in language expression (N=45).

Research in this area has also been marred by the failure to use a control group (the exception being Sutherland et al., 1982, and Ludlow et al., 1982). Ticking severity was not assessed and only Sutherland et al. (1982) and Ferrari et al. (1984) indicated whether subjects were tested on or off medication. In summary, these data support what appears to be a wide diversity of functioning of TS subjects in the area of language, including some difficulty with verbal expressive skills

and receptive vocabulary, as well as problems with written language and verbal fluency.

#### Visuopractic Abilities in TS Subjects

Deficits in visuopractic performance, such as eye hand coordination, also are frequently reported. In addition to a significantly lowered Performance IQ (noted under "Organic Factors and Intelligence", page 12), Shapiro et al., (1978), working with an adult TS population, also reported a marginally significant deficit in Block Design, a timed test which measures spatial relationships, when an analysis of sub-test scores on the WAIS (Weschler Adult Intelligence Scale) was made. In the Block Design subtest, the subject works directly from block models and printed cards to reproduce designs. Abnormal Digit Symbols on the WAIS also were reported by a number of investigators (Harcherik, Carbonairi, Shaywitz, Shaywitz & Cohen, 1982, and Sutherland et al., 1982). The Digit Symbol subtest measures motor speed and visual motor coordination by testing the subject's ability to associate numbers with non-verbal symbols.

Interestingly, Shapiro et al. (1978) reported no significant abnormalities on any sub-test of the WISC (Weschler Intelligence Scale for Children) for younger subjects. In contrast, Thompson et al. (1979) and

Incagnoli and Kane (1982) found low WISC sub-test scores for Coding, a timed subtest. The Coding subtest measures attention, concentration, and distractibility by having the subject match scrambled figures with figures that are properly arranged. But Sutherland et al. (1982) reported deficits in copying and drawing from memory. Visuopractic deficits also were reported by Hagin, Beecher, Pagano and Kreeger (1982). Impaired performance on the Bender-Gestalt Test and the Purdue Pegboard Test, as well as difficulties with Finger Schema and poor figure-ground discrimination also were reported. The Bender-Gestalt Test, a pencil and paper test, requires the subject to copy a series of geometric figures, and then to reproduce them from memory. The Purdue Pegboard Test requires the subject to insert the pegs separately with both his/her dominant and non-dominant hand, and with both hands together. The Finger Schema test measures sensory perception by requiring the subject to correctly identify the outline of figures drawn on various parts of the subjects's hand.

Although all of these findings suggest a generalized visuopractic deficit, the picture is confounded by Golden (1984), who noted that half of his subjects demonstrated superior motor skills and the other half showed impaired performance. Once again, the

equivocal nature of these data is apparent, although the performance of TS subjects seems clearly impaired by a combination of visual motor, attention and concentration deficits associated with high levels of distractibility.

#### Attention and Memory in TS Subjects

Shapiro and others have repeatedly suggested an association between Tourette's syndrome and Attention Deficit Hyperactivity Disorder (ADHD). Some children with this disorder are variously described as having short attention spans, being easily distracted, having difficulty concentrating and "sticking to" one activity, often acting without thinking, having difficulty organizing work and awaiting their turns in games (Shapiro & Shapiro, 1982). Also, inappropriate attention, impulsivity, as well as hyperactivity, may be present in TS subjects.

Matthews (1988) stated that more than half of TS subjects show ADHD symptoms. Comings and Comings (1984) reported that ADHD is present in as many as 70% of severe TS patients, in more than one half of moderate TS patients, and in nearly a third with mild TS. Unfortunately these data were obtained retrospectively, often after many years. Prevalence of TS subjects with ADHD range from 25% to 55% (Shapiro & Shapiro, 1982). However, research in this area has been marred by

serious methodological flaws, such as inconsistent methods of diagnosing ADHD. For example, at the time of the early Shapiro studies, the Diagnostic and Statistical Manual of Mental Disorders, Third Edition (DSM III, American Psychiatric Association, 1980) criteria were not available. In the earliest Shapiro study, ADHD had been operationalized by descriptive information supplied by parents and in later research by reviewing available school and clinical records and parent descriptions. No family or subject was clinically examined for ADHD by the investigators. In fact, these researchers concluded that this portion of their investigation contained "serious psychometric limitations" and that "the reliability and validity of our ratings could not be demonstrated" (Shapiro et al., 1978, p.115). Furthermore, Bornstein et al. (1983) have reported that although teachers of the TS subjects participating in their research (N=7) described the TS subjects as having messy or incomplete schoolwork, poor concentration, or being distractible, only one subject satisfied the diagnostic criteria for attention deficit disorder.

Since 1980, the diagnostic criteria used to operationally define ADHD have been determined by the DSM III. Using this formulation, Harcherik et al.

(1982) found no increase in ADHD in TS subjects when comparing 15 Tourette's syndrome children with mild symptom severity, with normal controls. Comparisons with respect to criteria were not made. Thus, although prior studies describe poor attention span and distractibility in TS subjects, these studies also indicate that most TS subjects do not meet the DSM III (American Psychiatric Association, 1980) criteria for Attention Deficit Hyperactivity Disorder, ADHD.

#### Academic Performance in TS Subjects

Academic performance of subjects with Tourette's syndrome has received scant attention until quite recently. Except for finishing assignments and writing fast enough, few academic problems were reported by Hagin et al. (1982). The subjects in this sample (N=10) were considered handicapped, not in terms of their educational skills, but rather in terms of demonstrating their skills. The authors admit that the sample was, perhaps, biased in that the TS subjects had a mean Full Scale IQ of  $110.9 \pm 19.38$ , which is considerably higher than the average (mean IQ  $100 \pm 15$ ). The descriptions of the TS subjects suggest further that they were also better functioning in terms of school adjustment and achievement, and resolution of family crises regarding diagnosis, educational planning, and adjustment to

symptoms, than other subjects described in the literature.

Notwithstanding Hagin's findings, Davidovicz (1984) estimated that 60% of children with TS have difficulty functioning adequately in school, and serious learning problems are present in an estimated 30% of TS subjects. Shaywitz, Wolf, Shaywitz, Loomis, and Cohen (1982) state that learning disorders and poor academic achievement and the need for some special academic assistance were present in 40% of the children in their investigations. Likewise, Cohen, Detlor, Shaywitz, and Leckman (1982) estimated that 65% of the 100 school-age children with TS whom they studied, failed to progress academically in spite of normal intellectual abilities. Clearly definable disturbances in cognitive processing, visual discrimination, coding, decoding, figure ground definition, and the organization of isolated thoughts into coherent whole structures, particularly when this requires written expression, were found in 30% of these 100 TS children. Jagger, Prusoff, Cohen, Kidd, Carbonairi, and John (1982) found that in a study of self-reports of 75 TS subjects, 11.3% reported that their school performance was severely affected by the syndrome.

In addition to visuopractic difficulties and

difficulties with written expression, the academic weakness most frequently reported is in mathematics (Matthews & Barabas, 1982). Bornstein et al. (1983), Golden (1984), Hagin et al. (1982), Incagnoli and Kane (1982), Jaschko and Rourke (1982), and Plaisted and Bingham (1983), all report arithmetic achievement scores on the Wide Range Achievement Test (WRAT)-Arithmetic subtest, a timed test, to be significantly below expected grade level. These findings are in marked contrast to performance on the arithmetic subtest of the WISC-R, an untimed test, which is in the normal range. One exception to this finding is the study by Golden (1984) which presented evidence for poor performance on both of these tests for half of his subjects (N=9). Consistently reported poor performance on the WRAT-Arithmetic subtest has led some researchers to consider "isolated" dyscalculia to be a feature of Tourette's syndrome (Caine, Polinsky, Ludlow, Ebert, & Nee, 1982).

The WRAT-Arithmetic subtest is a written test which requires the subject to solve as many problems as possible within 10 minutes. The type of problems on the WRAT-Arithmetic subtest include single or double digit addition, subtraction, multiplication and division, including fractions, decimals, and percentages in the above calculations. Elementary algebra, including

factoring, roots and square roots, reduction of polynomials, and logarithmic problems are included. In contrast, the Arithmetic subtest of the WISC-R requires the subject to solve a series of questions mentally without the use of pencil and paper. Problems include counting, single and double digit adding, subtracting, multiplying and dividing, including fractions. The different results on the WRAT and WISC-R have been explained by proposing that TS subjects have difficulty with arithmetic only when visuomotor skills are required (Bornstein et al., 1983).

#### Social Skills and Aggressive Behavior in TS Subjects

In addition to low attention span, poor concentration and high distractibility, prior research has also led to speculation concerning the presence of aggressive and poor social behavior in TS subjects. Barkley (1981) asserts that aggressiveness, whether physical or verbal, is observed frequently in many, though not all, ADHD children. He describes these children as noncompliant and as having poor self-control and poor social problem-solving skills.

Ross and Ross (1976) noted that social skills of ADHD children are generally described as inadequate, even for relatively uncritical peer groups. Paterson, James, Whittier, and Wright (1965) have suggested a

hypothesis that links hyperactivity to poor social skills. Parents of TS subjects have often seen tics as oppositional behavior and have had difficulty accepting the child's inability to control symptoms. Ostfield (1988) has stated that loss of self-control may reduce a subject's confidence, and motivation to interact with peers. Peer rejection and a resulting loss of self esteem have also been reported. These difficulties are in marked contrast to the finding that 72% of subjects in a self-report measure indicated that they had a best friend, and 92% indicated that they had at least some friends (Jagger et al., 1982).

#### Present Research

It is the position taken in this study that previous TS research, which focuses on academic performance and the role of the attention factor, is too general and nondefinitive and may, in fact, be misleading. Accordingly, the present research has targeted two issues in the TS literature for intensive study. One involves the question of mathematics achievement for TS youngsters. The other addresses the degree of relationship between TS and Attention Deficit Hyperactivity Disorder (ADHD). Both issues directly relate to the performance and management of TS youngsters in the classroom.

Prior research in the area of mathematics achievement, documented above, strongly suggests a pervasive cognitive processing difficulty in mathematics. In reaching this conclusion, researchers have consistently used the Wide Range Achievement Test-Revised (WRAT-R) Arithmetic subtest to measure achievement in mathematics. It must, therefore, be determined whether poor performance on this timed test (10 minutes) is an artifact of the test itself, that is, the timed condition. There is no prior research which examines the possible relationship that exists between ticking behavior and academic achievement. It is necessary to investigate whether ticking behavior is inherently distracting, and adversely impacting upon performance on this measure. Matthews and Barabas (1985) have stated that anxiety and apprehension exacerbate tics. Barkley (1981) also has noted that stress, excitement, and anxiety can temporarily worsen symptoms. It is important to investigate if a timed test condition will exacerbate ticking behavior and possible distractibility, thereby impairing performance on the test. An achievement test must be utilized that has two parallel forms which can be administered in the timed and untimed condition.

Furthermore, an important question is whether TS

children truly have an inherent attention deficit, or are highly distracted by recurrent ticking behavior. In addition to the hyperactivity and deficits in attention, DSM III (American Psychiatric Association, 1980) notes that "aggressive and anti-social behavior often accompany ADHD". (Conduct problem - unsocialized - aggressive) Robins (1966) and Quay (1979) have also reported the frequent association of ADHD with anti-social behavior.

Therefore, in an attempt to distinguish TS from ADHD children, an examination of whether TS children experience these aggressive, unsocialized, conduct problems will be made. A new scale that measures hyperactivity, attention, oppositional behavior, and social skills, will be used for this purpose.

## Hypotheses

### Hypothesis 1

It is hypothesized that the TS sample will obtain an averaged grade equivalent score on the Wide Range Achievement Test-Revised (WRAT-R) Arithmetic subtest which will be below the sample's actual grade placement.

Rationale: This hypothesis is being investigated to replicate previous research cited in the literature review section.

### Hypothesis 2

It is hypothesized that there will be a group by measure interaction. The three groups are TS, ADHD and NC. The three measures are the WRAT-R (Wide Range Achievement Test-Revised) subtests which are: Reading, Spelling and Arithmetic.

Rationale: This hypothesis is being investigated to replicate previous research cited in the literature review section.

### Hypothesis 3

It is further hypothesized that the TS sample will obtain a WRAT-R Arithmetic subtest score which will be significantly below the sample's scores for the WRAT-R Reading and Spelling subtests.

Rationale: This hypothesis is being investigated to replicate previous research cited in the literature review section.

### Hypothesis 4

It is hypothesized that the TS sample will obtain a significantly higher score on the untimed form versus the timed form of the Metropolitan Achievement Test (MAT 6) Mathematics subtest.

Rationale: This hypothesis is being investigated to provide a potential explanatory variable for the consistent finding that TS subjects perform poorly on the WRAT-R Arithmetic subtest.

### Hypothesis 5

It is hypothesized that for the TS sample, scores will be higher under the timed condition than under the untimed condition in the administration of the Metropolitan Achievement Test (MAT 6) Mathematics subtest with respect to the following two dependent variables: The first dependent variable (DV1) is the frequency or the proportion of the number of tics, to the time to complete the test.

The second dependent variable (DV2) is duration or the proportion of the total amount of time spent ticking, to the time to complete the test.

DV1 = number of tics / time to complete test

DV2 = total time spent ticking / time to complete  
test

Rationale: This hypothesis is being investigated to provide a potential explanatory variable for the consistent finding that TS subjects perform poorly on the WRAT-R Arithmetic subtest.

### Hypothesis 6

Using the Hyperactivity scale of the ACTeRS, the following ordering of the three groups is hypothesized:

1. The ADHD sample will score highest, where a high score demonstrates the most hyperactivity problems.
2. The TS sample will score lower than the ADHD sample.
3. The NC sample will score lowest.

Rationale: This hypothesis is being investigated to provide information concerning the hyperactivity factor in a typical Tourette's syndrome (TS) child, compared to the normal control child (NC), and to a classified Attention Deficit Hyperactivity Disorder child (ADHD).

### Hypothesis 7

Using the Attention scale of the ACTeRS the following ordering of the three groups is hypothesized:

1. The NC sample will score the highest, where a high score demonstrates good attention skills.
2. The TS sample will score lower than the NC sample.
3. The ADHD sample will score the lowest.

Rationale: This hypothesis is being investigated to provide information concerning the attention factor in a typical Tourette's syndrome (TS) child, compared to the normal control child (NC), and to a classified Attention Deficit Hyperactivity Disorder child (ADHD).

#### Hypothesis 8

Using the Social Skills scale of the ACTeRS, the following ordering of the three groups is hypothesized:

1. The TS sample and the NC sample will score higher than the ADHD sample, where a high score demonstrates good social skills.
2. The ADHD sample will score lowest.

Rationale: This hypothesis is being investigated to provide information concerning the social skills factor in a typical Tourette's syndrome (TS) child, compared to the normal control child (NC), and to a classified Attention Deficit Hyperactivity Disorder child (ADHD).

## Hypothesis 9

Using the Oppositional scale of the ACTeRS, the following ordering of the three groups is hypothesized:

1. The ADHD sample will score highest, where a high score demonstrates a high level of oppositional behavior.
2. The TS sample and the NC sample will score lower than the ADHD sample.

Rationale: This hypothesis is being investigated to provide information concerning the oppositional factor in a typical Tourette's syndrome (TS) child, compared to the normal control child (NC), and to a classified Attention Deficit Hyperactivity Disorder child (ADHD).

## Method

### Subjects

Eighty-one children participated in this study through assignment to one of three groups: (1) a Tourette's syndrome sample, (2) an Attention Deficit Hyperactivity Disorder sample, and (3) a Normal Control sample, (Table 1). Subjects from the three groups were matched by age and sex. Subjects ranged in age from 7 years 1 month to 13 years 8 months. There were 24 male and 3 female subjects in each group, reflecting the normal epidemiological preponderance of males as compared to females in the TS population. The subjects were from mixed racial and ethnic backgrounds and came from low, middle, and upper middle socioeconomic families. The subjects came from 16 urban and suburban communities in Bergen and Passaic New Jersey counties. All subjects had average or above average cognitive functioning using a criterion of 90 as a minimum score on the Peabody Picture Vocabulary Test, Revised (PPVT-R, Dunn & Dunn, 1981).

Table 1

## Sex and Number of Subjects in each Comparison Group

| <u>Label</u> | <u>Groups of Subjects</u>                   | <u>Total</u> | <u>Males</u> | <u>Females</u> |
|--------------|---|--------------|--------------|----------------|
| TS           | Tourette's syndrome                         | 27           | 24           | 3              |
| ADHD         | Attention Deficit<br>Hyperactivity Disorder | 27           | 24           | 3              |
| NC           | Normal Control                              | <u>27</u>    | <u>24</u>    | <u>3</u>       |
|              |   | 81           | 72           | 9              |

---

(Note: Ages ranged from 7 years 1 month to 13 years 8 months)

Tourette's Syndrome Sample. This sample consisted of 27 children who had been referred to a suburban learning center for psychoeducational, psychological, and/or neuropsychological evaluation by either the diagnosing physician, the school district Child Study Team, the individual parents of the TS child, or through the New Jersey Tourette Syndrome Association. All subjects were in mainstream class placement, but were experiencing varying degrees of academic difficulties. None of the subjects were on medication at the time of the assessment.

Attention Deficit Hyperactivity Disorder Sample. This sample consisted of 27 children who had been diagnosed ADHD by a neuropsychiatrist using clinical criteria set forth in DSM III (American Psychiatric Association, 1980) and a Conners Teacher Rating Scale (TRS) (Conners, 1973). These children also were referred for psychoeducational, psychological, and/or neuropsychological evaluation. All subjects were in mainstream class placement, but were experiencing varying degrees of academic difficulties. None were on medication at the time of the assessment.

Normal Control Sample. This sample consisted of 27 children who had no history of learning or behavioral difficulties, no identified attention or hyperactivity

problems using the Conners Teacher Rating Scale (1973) and no subject or family history of TS or tic disorder as reported by parents. These subjects were described by teachers and/or parents as average students. These subjects were recruited for this study from the patient list of a local group of pediatricians and the 16 referring school districts.

#### Instruments

##### Peabody Picture Vocabulary Test, Revised (PPVT-R).

The PPVT-R (Dunn & Dunn, 1981) is an individually administered, wide-range measure of receptive vocabulary for ages 2 years 6 months to adult. The PPVT-R contains a graduated series of 175 four-picture plates bound into an easel.

##### Conners Teacher Rating Scale (TRS).

The TRS (Conners, 1973) is a 39-item scale which groups items into three general classes: group participation, classroom behavior, and attitude toward authority. The scores are derived by assigning 0, 1, 2, or 3 points to the answers of "not at all", "just a little", "pretty much", and "very much", respectively, for each item. The points for each item assigned to each factor are then summed and divided by the number of items in that factor or category to get the factor score. The TRS can be scored for the hyperactivity index (10 items), with a

mean score of 1.5 or higher, generally accepted as indicating hyperactivity. However, for this study, the suggestion made by Barkley (1981), that a score of two standard deviations above the mean for age as a more rigorous criteria for defining hyperactivity in the classroom be used, was followed. Norms for the TRS were provided by the work of Goyette, Conners and Ulrich (1978).

Tourette Syndrome Symptom List-Revised (TSSL-R).

The TSSL-R (Cohen, Leckman & Shaywitz, 1985) was used to obtain a listing of specific motor and phonic ticking behavior as well as to measure the frequency of each individual ticking behavior. This scale utilizes information from the subject and/or parent(s) to rate from 0 (not at all) to 5 (almost always) a series of simple motor, complex motor, simple phonic, complex phonic and behavioral tics.

Tourette Syndrome Global Scale (TSGS).

The TSGS (Harcherik, Leckman, Detlor & Cohen, 1984) was used to make an assessment of the disruption in the TS subject's school life caused by the ticking behavior. This scale rates the frequency of simple motor, complex motor, simple phonic and complex phonic ticks from 0 (none) to 5 (always) as well as the disruption of these tics from 1 (camouflaged) to 5 (cannot function). This scale

likewise measures behavior, motor restlessness, school problems, and work and occupational problems.

Wide Range Achievement Test-Revised (WRAT-R).

The WRAT-R (Jastak & Wilkinson, 1984) is a pencil and paper test consisting of three subtests which measure the basic skills of reading, written spelling, and computational arithmetic. The reading subtest consists of recognizing and naming letters and pronouncing words out of context. The spelling subtest consists of copying marks resembling letters, writing the name, and writing single words to dictation. The arithmetic subtest consists of counting, reading number symbols, solving oral problems and performing written computations. There are two separate forms of the test. Level 1 is designed for use with subjects between the ages of 5 years 0 months and 11 years 11 months. Level 2 is intended for subjects from 12 years 0 months through adulthood. Level 1 and level 2 each require from 20 to 30 minutes to administer. Ten minutes are given for two pages of written computations on the arithmetic subtest.

Metropolitan Achievement Test (MAT-6). The MAT-6 (Prescott, Balow, Hogan, & Farr, 1986) Mathematics subtest is a pencil and paper achievement test consisting of three parts: concepts, problem solving,

and computation. The following five levels of each form of the test were used: Primary 1, Primary 2, Elementary, Intermediate, and Advanced. Primary 1 included 78 items and 67 minutes were allowed for completion under the standard timed condition. Primary 2 included 84 items and 65 minutes were allowed for completion under the timed condition. Elementary included 95 items and 75 minutes were allowed for completion under the standard timed condition. Advanced 1 included 95 items and 83 minutes were allowed for completion under the standard timed condition.

ADD-H: Comprehensive Teacher Rating Scale

(ACTeRS). The ACTeRS (Ullmann, Sleator, & Sprague, 1986) is a 24-item scale divided into four sections: attention, hyperactivity, social skills, and oppositional behavior. There are six items under each of the four sections. Points from 1 through 5 are assigned to each item corresponding to the range from "almost never" to "almost always". Subtotals are obtained for each of the four sections by totaling the number of points circled for each of the six items in that section. Normative scales provide a corresponding percentile rank in each of the four sections depending upon the total points accumulated in that section. This scale, therefore, shows the extent of deviation from the

norm of each subject for each of the four types of behaviors defined in the DSM-III (American Psychiatric Association, 1980) for ADHD: hyperactivity, attention, oppositional behavior, and social skills.

#### Procedure

The present study involved two phases. During the initial phase, all subjects were screened individually by the same school psychologist, using the Peabody Picture Vocabulary Test-Revised (PPVT-R, 1981). In addition, the classroom teacher of each subject completed the Conners Teacher Rating Scale (TRS, 1973). The parents of each TS subject received individual instruction from a trained psychiatric nurse and were given two weeks in which to observe and complete the Tourette Syndrome Symptom List-Revised (TSSL-R, Cohen et al., 1985) and the Tourette Syndrome Global Scale (TSGS, Harcherik et al., 1984).

The TSSL-R (1985) was used to obtain a listing of specific motor and phonic ticking behavior as well as to measure the frequency of each individual ticking behavior. The TSGS (1984) was used to make an assessment of the disruption in the TS subject's school life caused by the ticking behavior. These two scales were returned to the psychiatric nurse at least two weeks prior to the second phase of the study. The

psychiatric nurse used these scales to familiarize herself with each TS subject's specific ticking behavior. Permission to participate in the study was obtained from all parents at the time of the initial contact, after it was explained that the purpose of this testing was to accumulate data purely for research purposes.

The second phase of the study involved testing each subject individually using the Wide Range Achievement Test-Revised (WRAT-R, Jastak & Wilkinson, 1984), given under standard timed conditions, and two forms (L and M) of the Metropolitan Achievement Test (MAT 6, Prescott et al., 1986) Mathematic subtest, one form given under standard timed conditions, the other under untimed conditions. All tests were administered by the same New Jersey state certified learning disabilities specialist.

In phase two of the study, all testing for the three groups took place in a viewing room with an inconspicuous one-way mirror. The MAT 6 (1986) was administered first in the untimed condition. Each subject was clearly told that he/she would have all of the time needed to complete the test in a comfortable fashion. Each subject was specifically told "not to rush". No clock was present in the room.

Following this testing session, each subject was given a 10-minute break. Each subject was then returned to the same testing room, and was administered all three subtests (Spelling, Reading, and Arithmetic) of the WRAT-R (1984), under the standard condition. A large clock was conspicuously present on the wall to underscore the timed condition of the test. Timing was accomplished by the use of a hand stop watch which was held by the examiner.

After the testing session, a lunch break was provided, including a one-hour time period in which toys, games, video-games, a television set, an outdoor play area and a rest area were made available to each subject.

Upon return to the waiting area, each subject was complimented for his/her earlier performance, with emphasis placed on each subject's having tried hard. Each subject was then brought back into the same testing room, with the large clock still prominently present on the wall. Standard directions for the MAT 6, including that for the timed condition, were given to each subject. Timing was again accomplished by the examiner with a hand stop watch.

During all three testing sessions, the same psychiatric nurse performed as a trained informed

observer. The nurse had previously familiarized herself with each subject's ticking behavior, and observed each TS subject's testing sessions from behind the one-way mirror. The subject was unaware of the observer's presence. The observer measured the frequency and cumulative duration of ticking behavior during all three testing sessions, utilizing a stop watch with interval timing capability. The frequency and cumulative duration of ticking behavior was then recorded for each subject.

Upon completion of the last testing session, all subjects were rewarded for their cooperation with tokens to be used for video games.

After all of the testing was completed, the ADD-H: Comprehensive Teacher Rating Scale (ACTeRS, Ullmann et al., 1986) was sent to each subject's teacher. Follow-up phone calls were made to classroom teachers to insure prompt response.

#### Data Analysis

Hypothesis I was tested by comparing Grade Equivalent means on the Wide Range Achievement Test-Revised (WRAT-R) Arithmetic subtest with Grade Placement mean for the TS sample using a one-tailed t-test for correlated data.

Hypothesis II was assessed using a repeated measures ANOVA with one between groups factor (3 levels: TS, ADHD, and NC) and one within-subject factor (3 levels of the Wide Range Achievement Test-Revised: WRAT-R Reading, WRAT-R Spelling and WRAT-R Arithmetic). An F test was computed for the group by measure interaction.

Using the TS group, two separate a priori comparisons of the WRAT-R Arithmetic subtest scores, WRAT-R Reading and Spelling subtest scores were tested using correlated t-tests for Hypothesis III.

Timed performance was operationalized through the timed and untimed administrations of the Metropolitan Achievement Test (MAT 6), Mathematics subtest. Frequency and duration of the ticking behaviors were assessed through comparison of the timed versus untimed results on the MAT 6 using correlated t tests.

These ACTeRS were used: the hyperactivity scale for Hypothesis VI, the attention scale for Hypothesis VII, the social skills scale for Hypothesis VIII, and the oppositional scale for Hypothesis IX. For each of the four dependent variables, two a priori comparisons were tested using t-tests.

## Results

A separate analysis was conducted for each of these hypotheses:

### Hypothesis I

The first hypothesis predicted a replication of the literature finding that the TS sample's average grade equivalent score on the WRAT-R Arithmetic subtest would be significantly below the sample's corresponding averaged grade placement. In the present study, the mean WRAT-R Arithmetic grade equivalent for this TS sample was 4.17 with a standard deviation of 1.56. The averaged grade placement for the TS sample was 5.62 with a standard deviation of 1.84. The correlated t test yielded a value of 13.89 which was highly significant ( $p < .001$ ). The hypothesis was supported and the finding again replicated. (See Table 2, Figure 1).

### Hypothesis II

The second hypothesis predicted an interaction among the three subject groups and the three WRAT-R measures. The means and standard deviations for each of the three groups on each of the three measures can be found in Table 3. A representation of this data can be found in Figure 2.

Table 2

## Hypothesis I

Comparison of the WRAT-R Arithmetic Subtest  
Grade Equivalent Score with Average Grade Placement  
for the Tourette's Syndrome Group  
(n=27)

|      | <u>Grade Equivalent<br/>on WRAT-R Arith.</u> | <u>Average Grade<br/>Placement</u> | <u>t</u> |
|------|--|------------------------------------|----------|
| Mean | 4.17   | 5.62                               | 13.89*   |
| SD   | 1.56   | 1.84                               |          |

\*  $p < .001$

(See Figure 1)

(Refer to Table 2 for figures)

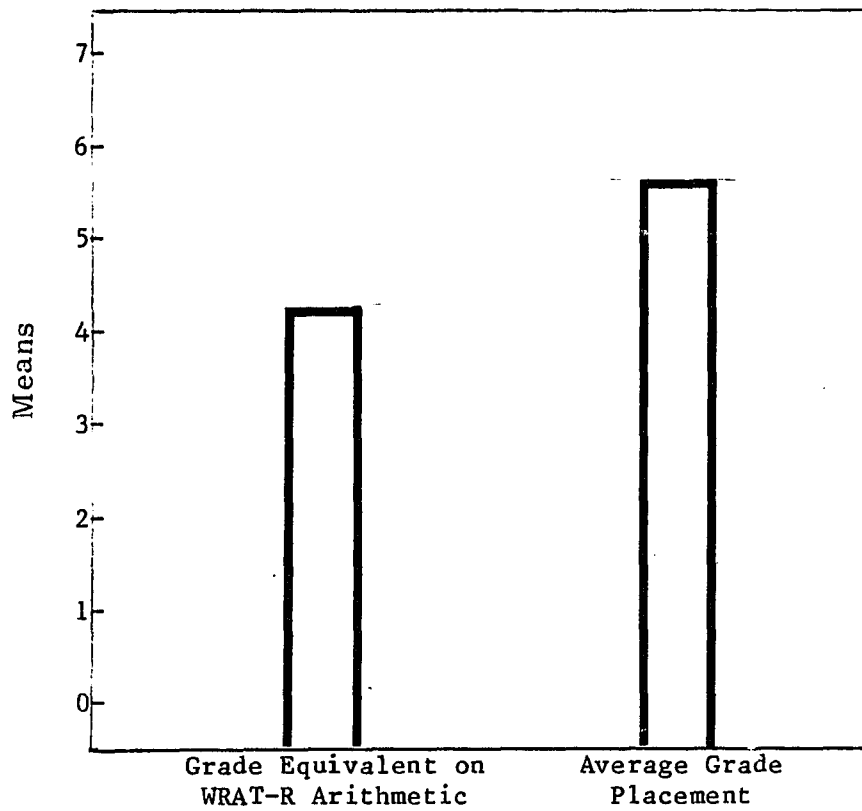


Figure 1. Comparison of the WRAT-R Arithmetic Subtest Grade Equivalent Score with Average Grade Placement for the Tourette's Syndrome Group.

Table 3

## Hypothesis II

Means and Standard Deviations of WRAT-R Reading, Spelling,  
and Arithmetic Standard Scores for TS Group

| Group | n  | Reading |      | Spelling |      | Arithmetic |      |
|-------|----|---------|------|----------|------|------------|------|
|       |    | Mean    | SD   | Mean     | SD   | Mean       | Sd   |
| TS    | 27 | 102.30  | 3.31 | 101.18   | 3.25 | 86.11      | 5.55 |

Means and Standard Deviations of WRAT-R Reading, Spelling,  
and Arithmetic Standard Scores for ADHD and NC groups

| Group | n  | Reading |      | Spelling |      | Arithmetic |      |
|-------|----|---------|------|----------|------|------------|------|
|       |    | Mean    | SD   | Mean     | SD   | Mean       | Sd   |
| ADHD  | 27 | 99.81   | 3.29 | 98.70    | 3.50 | 98.33      | 4.08 |
| NC    | 27 | 101.59  | 2.82 | 102.44   | 3.37 | 101.56     | 3.32 |

(See Figure 2)



(Refer to Table 3 for figures)

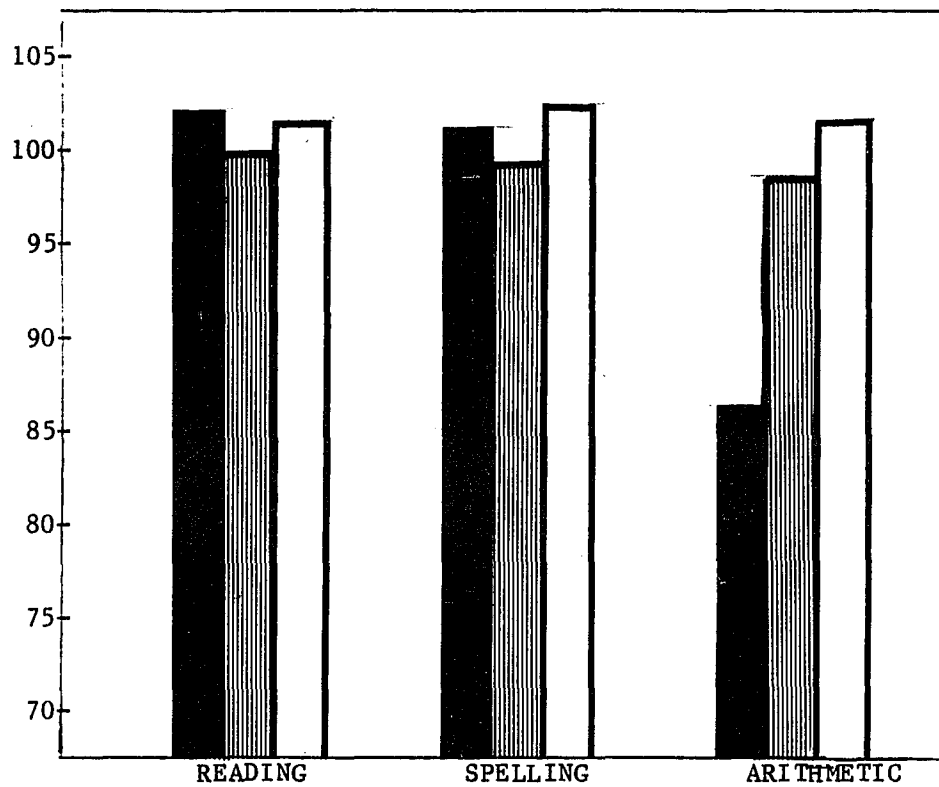


Figure 2. Comparison of WRAT-R Reading, Spelling and Arithmetic Standard Scores for TS, ADHD and NC groups.

Table 4 presents the results of a repeated measures analysis of variance for the TS, ADHD, and NC samples with WRAT-R Reading, Spelling, and Arithmetic standard scores. There were significant outcomes for the main effects of Group and of the Measures. The hypothesis predicted a significant interaction term; the group by Measures interaction yielded a highly significant F ratio of 121.47 ( $p < .001$ ). The explanation for the significant interaction can clearly be seen by looking at the means presented in Table 3.

#### Hypothesis III

Hypothesis three predicted more specifically that the TS sample would obtain a WRAT-R Arithmetic subtest score which would be significantly below this sample's scores for the WRAT-R Reading and Spelling subtests. A Scheffé procedure was employed as the post hoc analysis. As predicted, the TS sample's Arithmetic mean (86.11) was significantly lower ( $p < .05$ ) than the sample's Reading mean (102.30) and the Spelling mean (101.18). (Table 3). There were no differences between the Reading mean and the Spelling mean.

#### Hypothesis IV

The fourth hypothesis predicted that the TS sample would obtain a significantly higher score on the untimed form versus the timed form of the Metropolitan Achievement

Table 4

## Hypothesis III

ANOVA Study of Interaction among the TS, ADHD and NC Groups  
and the Three WRAT-R Measures  
(n=81)

| <u>Source</u>     | <u>Sum of Squares</u> | <u>df</u> | <u>Mean Square</u> | <u>F</u> |
|-------------------|-----------------------|-----------|--------------------|----------|
| Group             | 1012.85               | 2         | 506.42             | 17.28*   |
| Error             | 2286.15               | 78        | 29.31              |          |
| Measures          | 1622.45               | 2         | 831.23             | 145.08*  |
| Group by Measures | 2783.77               | 4         | 695.94             | 121.47*  |
| Error             | 893.78                | 156       | 5.73               |          |

\*  $p < .001$

Test (MAT 6) Mathematics subtest. The MAT 6 scaled scores range from 269 through 829. As can be seen in Table 5, the mean scaled score for the untimed form was 619.44 with a standard deviation of 36.85. The mean scaled score for the timed form was 596.96 with a standard deviation of 35.51. The t value of 13.41 was clearly significant ( $p < .001$ ), supporting the hypothesis. Figure 3 provides a representation of the data.

The mean grade level for the TS sample was grade 5. The mean scaled score of 596.96, obtained under the timed condition, represented mathematics performance at the 37th percentile for grade 5. The mean scaled score of 619.44, obtained under the untimed condition, represented mathematics performance at the 61st percentile for grade 5.

#### Hypothesis V

The fifth hypothesis predicted that the TS sample would demonstrate increased frequency and duration of ticking behaviors during the timed versus the untimed form of the MAT 6 Mathematics subtest. The results for this hypothesis can be seen in Table 6. Figure 4 provides a representation of the data. Average testing time under standard administration (timed) across the different levels of the MAT 6 averaged 77 minutes with a standard deviation of 6.05. Average time on task for the untimed

Table 5

## Hypothesis IV

Comparison of Timed Versus Untimed Form of MAT 6 Math#  
for the Tourette's Syndrome Sample (n=27)

| Timed  |       | Untimed |       | t      |
|--------|-------|---------|-------|--------|
| Mean   | SD    | Mean    | SD    |        |
| 596.96 | 35.51 | 619.44  | 36.85 | 13.41* |

\*  $p < .001$

# Note: MAT 6 scaled score ranged from 269 through 829.

(See Figure 3)

(Refer to Table 5 for figures)

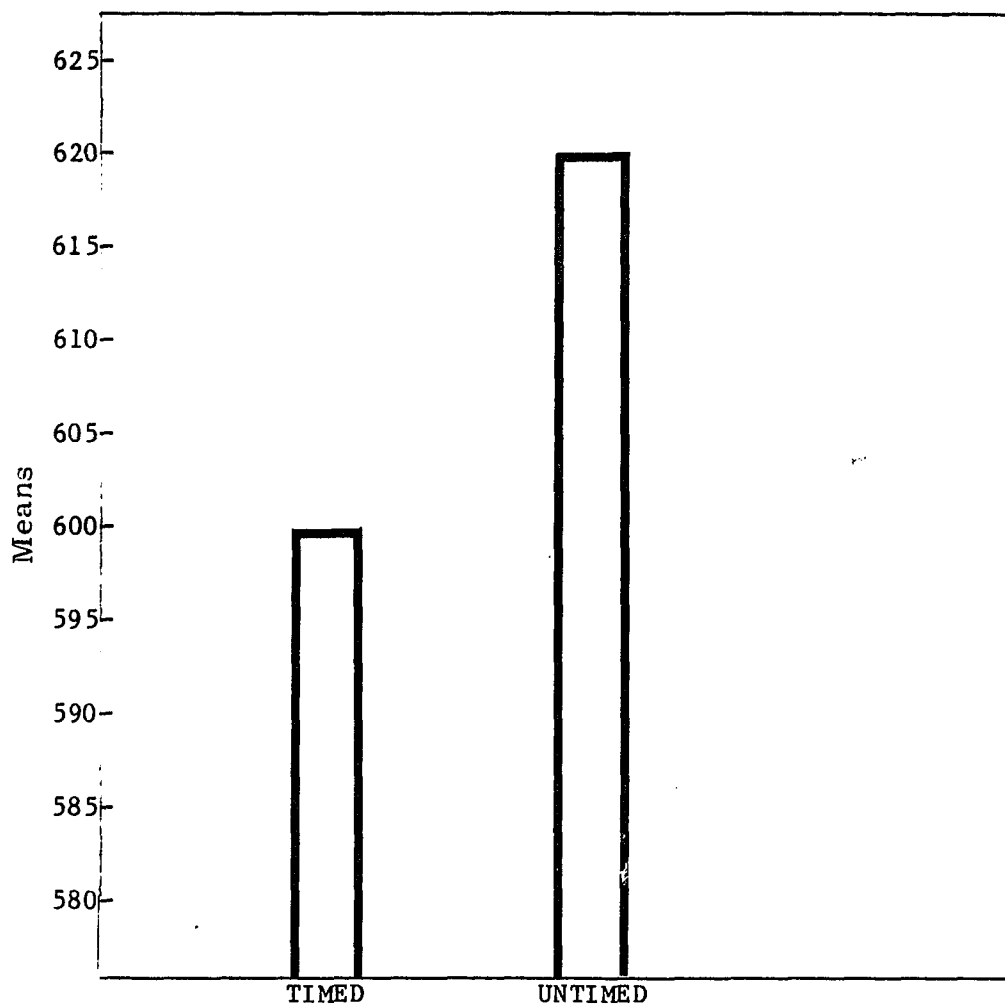


Figure 3. Comparison of Timed versus Untimed form of MAT 6 Math for the Tourette's syndrome sample.

Table 6

## Hypothesis V

Comparison of Timed and Untimed MAT 6 Mathematics Subtest  
Testing of the TS sample (n=27)

|  | Timed |        | Untimed |        | t#    |
|--|-------|--------|---------|--------|-------|
|  | Mean  | SD     | Mean    | SD     |       |
| Average Testing Time<br>(minutes)                      | 77    | 6.05   | 87      | 8.07   |       |
| Average Number of Tics<br>(frequency)                  | 382   | 229.92 | 346     | 174.07 |       |
| Average duration of tic<br>(seconds)                   | 1.34  | .74    | 1.28    | .66    |       |
| Averaged tics<br>(per minute)                          | 4.96  | 2.97   | 3.98    | 1.99   | 3.97* |
| Average Time spent<br>ticking<br>(duration in minutes) | 8.55  | 4.62   | 7.4     | 3.69   | 5.89* |

\*  $p < .001$

# Note t tests adjusted for variability of testing time

(See Figure 4)



(Refer to Table 6 for figures)

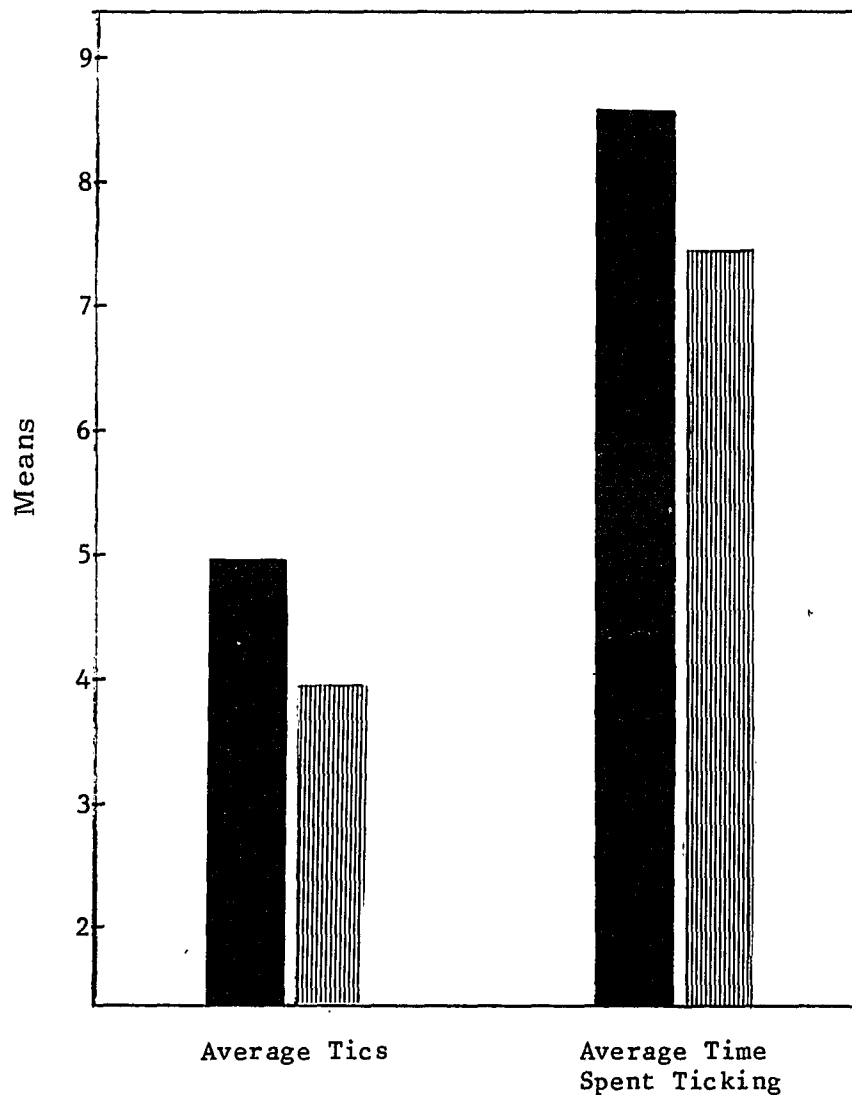


Figure 4. Comparison of Timed and Untimed MAT 6 Mathematics Subtest Testing of the TS sample.

form across these levels averaged 87 minutes with a standard deviation of 8.07. Observation yielded 382 tics with a standard deviation of 229.92 on average for the timed form and 346 tics with a standard deviation of 174.07 on average for the untimed form. Average duration of a tic for the timed form was 1.34 seconds (standard deviation of .74). Average duration for the untimed form was 1.28 seconds (standard deviation of .66).

Since testing time was not comparable, formal statistical analysis employed ratio scores of number of tics/testing time and duration of tics/testing time. The hypothesis was supported with the correlated t test for the number of tics/testing time ratio for timed and untimed forms yielding a value of 3.97 ( $p < .001$ ). The TS sample averaged 4.96 tics (standard deviation of 2.97) per minute on the timed form and 3.98 tics (standard deviation of 1.99) per minute on the untimed form. The correlated t test for the duration of tics/testing time ratio for timed and untimed forms yielded a value of 5.89 ( $p < .001$ ). The TS sample spent 8.55 minutes ticking (standard deviation of 4.62) during the timed form and 7.4 minutes ticking (standard deviation of 3.69) during the untimed form. (See Figure 4).

The basic data suggest support for the hypothesis, since there was both a greater frequency of

ticking behavior and longer ticking duration for the timed form. For both measures the *t* statistics were significant.

#### Hypothesis VI

The sixth hypothesis predicted that the ADHD sample would score higher than the other two groups on the Hyperactivity factor of the ACTeRS Scale, and the TS sample would score higher than the NC sample. Table 7 presents the results of a one way analysis of variance testing this prediction. Figure 5 provides a representation of the data. The *F* ratio of 27.86 was highly significant ( $p < .001$ ). The mean score for the ADHD group was 16.07 with a standard deviation of 3.59. The mean score for the TS sample was 13.15 with a standard deviation of 2.03. The mean score for the NC sample was 9.81 with a standard deviation of 3.39. Formal post hoc analysis using the Scheffé procedure ( $p < .05$ ) supported the hypothesis' ordering of hyperactive problems among the three groups.

#### Hypothesis VII

The seventh hypothesis predicted that the ADHD group would score lower on the Attention factor than the other two groups. The TS sample was predicted to score lower than the NC sample on Attention. Table 8 presents the results of a one way analysis of variance for the Attention

Table 7

## Hypothesis VI

## One Way ANOVA on Hyperactivity Factor of ACTeRS Scale

Groups = TS, ADHD and NC, n=81

| Source         | Sum of Squares | df | Mean Square | F      |
|----------------|----------------|----|-------------|--------|
| Between groups | 529.65         | 2  | 264.83      | 27.86* |
| Within Groups  | 741.33         | 78 | 9.50        |        |

\*  $p < .001$ Ordering of the Three Groups on the Hyperactivity Factor  
of the ACTeRS Scale

| ADHD<br>(n=27) |      | TS<br>(n=27) |      | NC<br>(n=27) |      |
|----------------|------|--------------|------|--------------|------|
| Mean           | SD   | Mean         | SD   | Mean         | SD   |
| 16.07          | 3.59 | 13.15        | 2.03 | 9.81         | 3.39 |

(See Figure 5)

(Refer to Table 7 for figures)

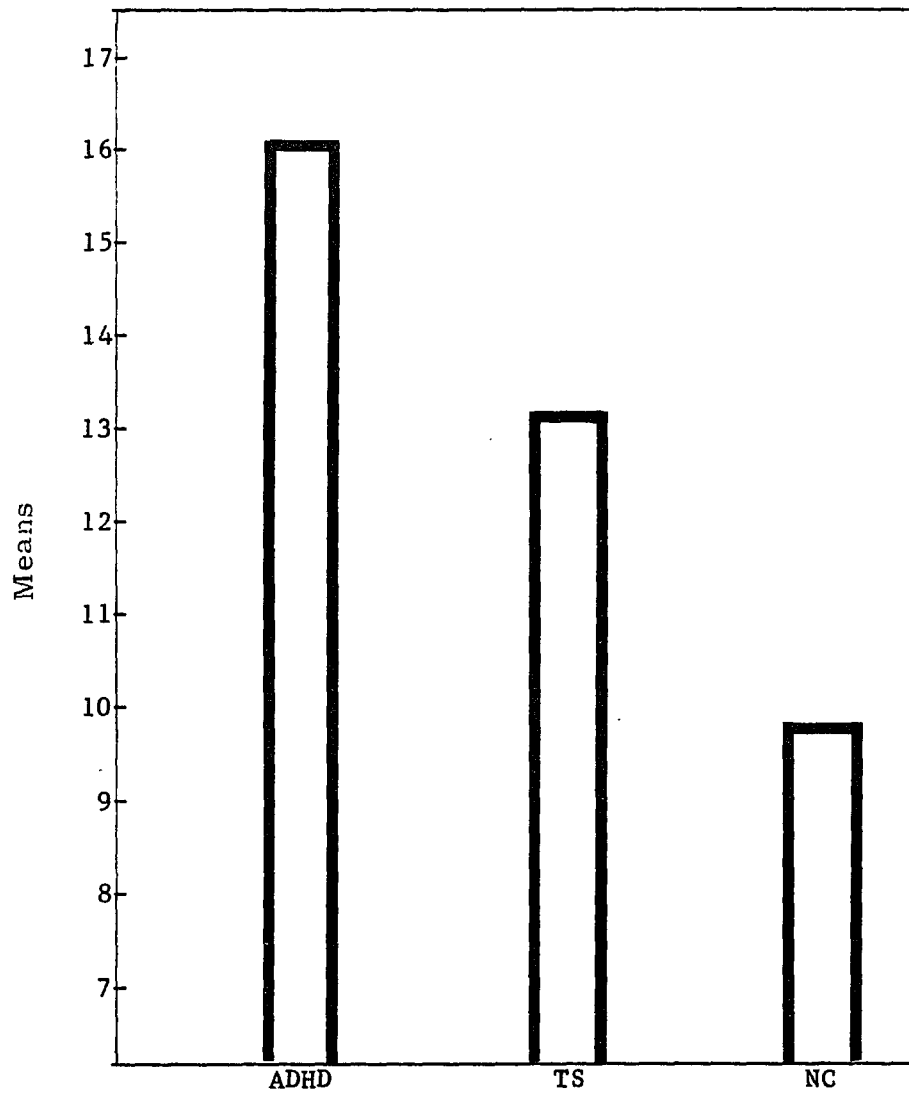


Figure 5. Ordering of Hyperactive Problems among the Three Groups, using the ACTeRS Scale.

Table 8

## Hypothesis VII

One way ANOVA on Attention Factor of ACTeRS Scale  
(n=81)

| Source         | Sum of Squares | df | Mean Square | F      |
|----------------|----------------|----|-------------|--------|
| Between Groups | 538.84         | 2  | 269.42      | 31.32* |
| Within Groups  | 671.04         | 78 | 8.60        |        |

\*  $p < .001$

Ordering of the Three Groups on the Attention Factor  
of the ACTeRS Scale

| ADHD<br>(n=27) |      | TS<br>(n=27) |      | NC<br>(n=27) |      |
|----------------|------|--------------|------|--------------|------|
| Mean           | SD   | Mean         | SD   | Mean         | SD   |
| 17.78          | 3.81 | 19.59        | 2.24 | 23.93        | 2.51 |

(See Figure 6)

(Refer to Table 8 for figures)

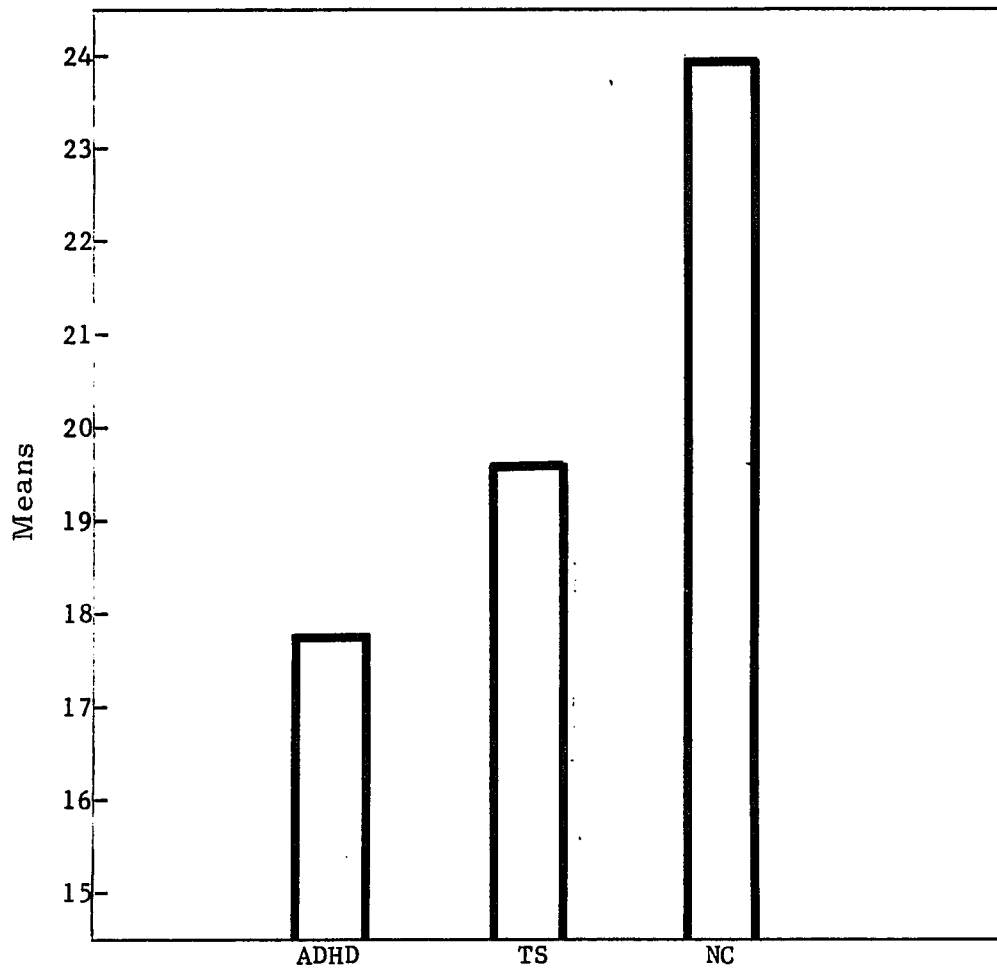


Figure 6. Ordering of the Three Groups on the Attention Factor of the ACTeRS Scale.

factor of the ACTeRS Scale. Figure 6 provides a representation of the data. The F ratio of 31.32 was highly significant ( $p < .001$ ). The mean score for the ADHD group was 17.78 with a standard deviation of 3.81. The mean score for the TS sample was 19.59 with a standard deviation of 2.24. The mean score for the NC sample was 23.93 with a standard deviation of 2.51. Although the means are all in the predicted order, formal post hoc testing employing the Scheffé procedure ( $p < .05$ ) offers partial support for the hypothesis. Both the ADHD and the TS sample are significantly different from the NC sample. However, the ADHD and TS samples are not significantly different in attention problems.

#### Hypothesis VIII

The eighth hypothesis predicted that the ADHD sample would score lower than the other two groups on the Social Skills factor of the ACTeRS Scale. Table 9 presents the results of a one way analysis of variance for this hypothesis. Figure 7 provides a representation of the data. The F ratio of 17.42 was highly significant ( $p < .001$ ). The mean score for the ADHD sample was 21.78 with a standard deviation of 4.96. The mean score for the TS group was 26.33 with a standard deviation of 3.34. The mean score for the NC sample was 27.59 with a standard deviation of 2.78. The means are in the predicted order.

Table 9

## Hypothesis VIII

## One Way ANOVA on Social Skills Factor of ACTeRS Scale

(n=81)

| Source         | Sum of Squares | df | Mean Square | F      |
|----------------|----------------|----|-------------|--------|
| Between groups | 505.36         | 2  | 252.68      | 17.42* |
| Within Groups  | 1131.19        | 78 | 14.50       |        |

\* p &lt; .001

Ordering of the Three Groups on the Social Skills factor  
of the ACTeRS Scale

| ADHD<br>(n=27) |      | TS<br>(n=27) |      | NC<br>(n=27) |      |
|----------------|------|--------------|------|--------------|------|
| Mean           | SD   | Mean         | SD   | Mean         | SD   |
| 21.78          | 4.96 | 26.33        | 3.34 | 27.59        | 2.78 |

(See Figure 7)

(Refer to Table 9 for figures)

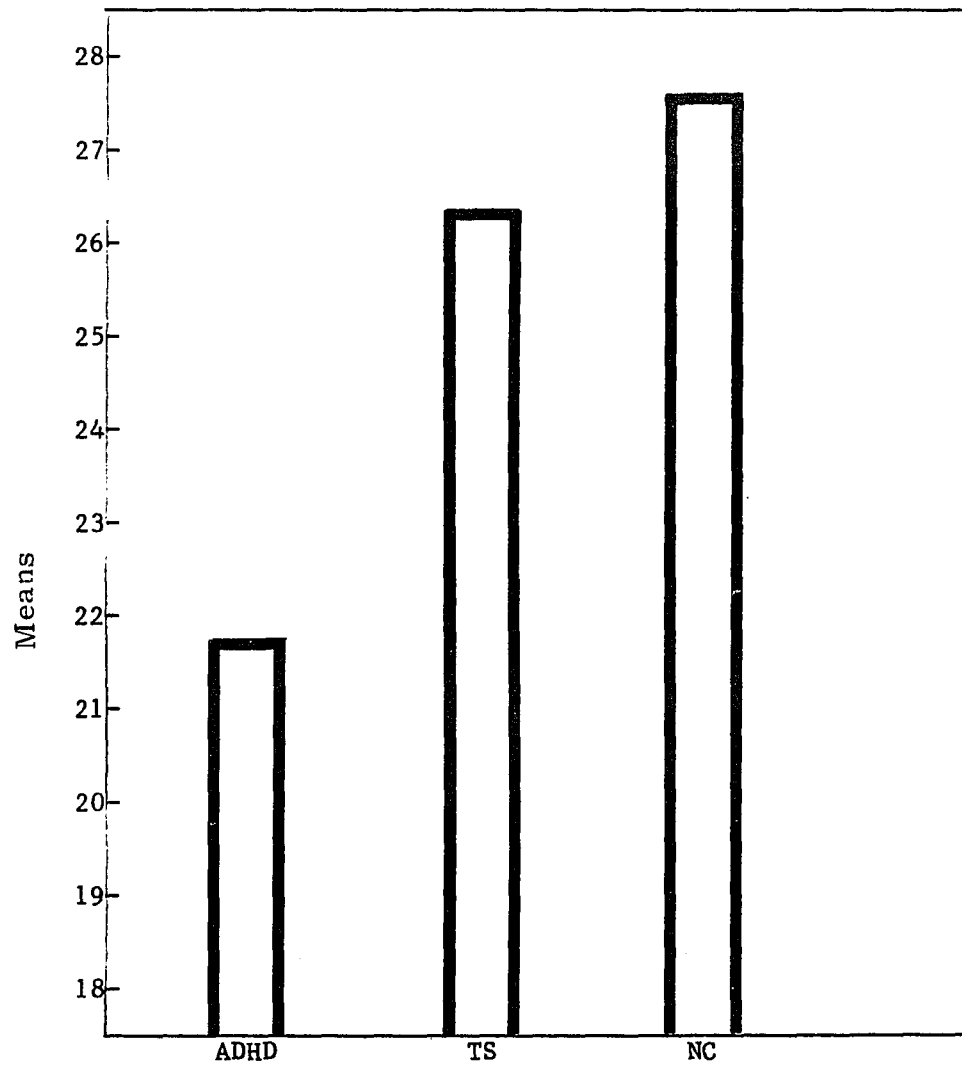


Figure 7. Ordering of the three groups on the Social Skills factor of the ACTeRS Scale.

### Hypothesis IX

The ninth hypothesis predicted that the ADHD sample would score higher than the other two groups on the Oppositional factor of the ACTeRS Scale. Table 10 presents the results of the one way analysis of variance testing this hypothesis. Figure 8 provides a representation of the data. The F ratio of 32.71 was highly significant ( $p < .001$ ). The mean score for the ADHD group was 12.07 with a standard deviation of 4.98. The mean score for the TS sample was 6.15 with a standard deviation of .46. The mean score for the NC sample was 6.44 with a standard deviation of 1.63. The means give face validity to the hypothesis. Formal post hoc analysis employing the Scheffe procedure ( $p < .05$ ) supports the predicted outcome.

Table 10

## Hypothesis IX

One Way ANOVA on Oppositional Factor of ACTeRS Scale  
(n=81)

| Source         | Sum of Squares | df | Mean Square | F      |
|----------------|----------------|----|-------------|--------|
| Between Groups | 602.07         | 2  | 301.04      | 32.71* |
| Within Groups  | 717.93         | 78 | 9.20        |        |

\*  $p < .001$

Ordering of the Three Groups on the Oppositional factor  
of the ACTeRS Scale

| ADHD<br>(n=27) |      | TS<br>(n=27) |     | NC<br>(n=27) |      |
|----------------|------|--------------|-----|--------------|------|
| Mean           | SD   | Mean         | SD  | Mean         | SD   |
| 12.07          | 4.98 | 6.15         | .46 | 6.44         | 1.63 |

(See Figure 8)

(Refer to Table 10 for figures)

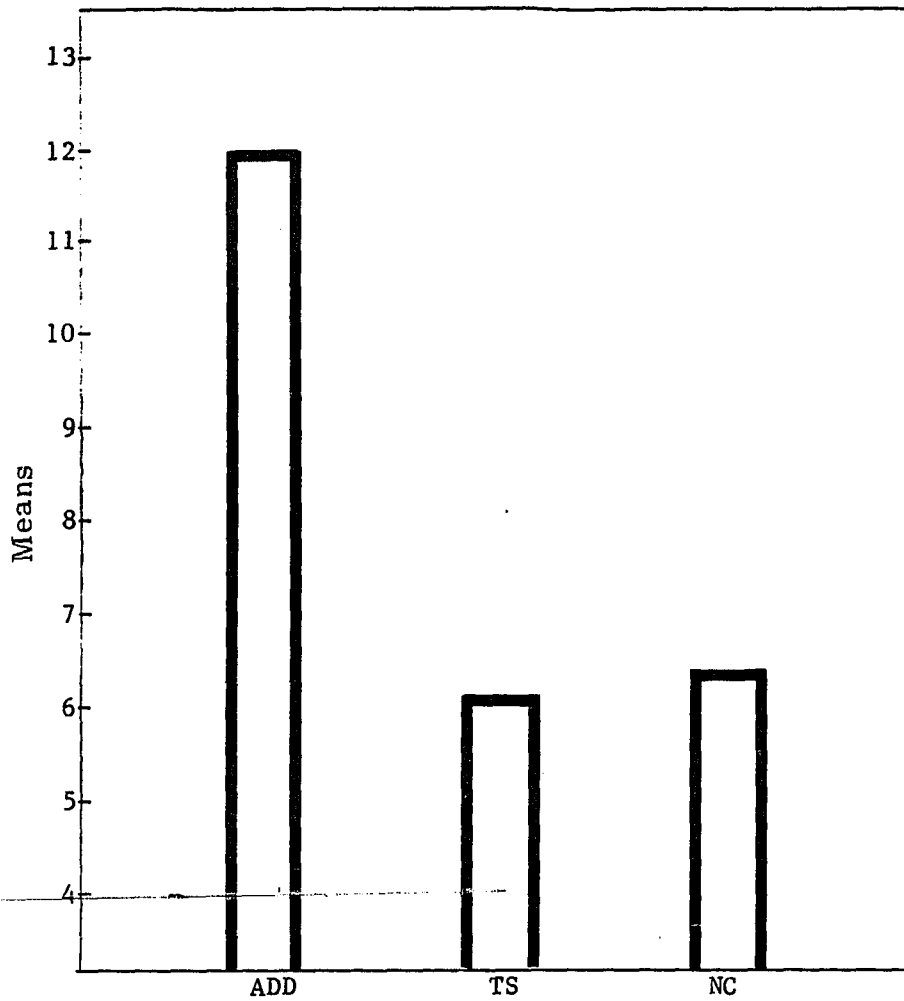


Figure 8. Ordering of the three groups on the Oppositional factor of the ACTeRS Scale.

## Discussion

### Statement of the Problem

The primary goal of the present study was to investigate mathematics achievement for TS children, and the nature of the relationship between TS and Attention Deficit Hyperactivity Disorder (ADHD), with regard to mathematics achievement and social skills. Both of these issues have a direct bearing on the educational performance and management of TS youngsters in a school setting. Prior research has strongly suggested the presence of "isolated" dyscalculia (Caine et al., 1982) in the TS school-age population. Previous studies have not examined either the influence of the timed condition on mathematics performance, or the possible relationship between ticking behavior and mathematics achievement. Ticking behavior has never been examined as inherently distracting, nor has the impact of ticking behavior upon performance been measured. One purpose of this study

was to determine if a timed test condition were associated with increased ticking behavior, increased distractibility, and impaired performance on mathematics tests.

Prior research has not determined if TS children have an inherent attention deficit, or if their recurrent ticking behavior is highly distracting to them. An additional goal of this study was to distinguish TS children from ADHD children based on an examination of aggressive and anti-social behavior, specifically an evaluation of oppositional behavior and social skills (ACTeRS, 1986).

#### Principal Findings

Results of analyses with respect to Hypotheses I, II and III replicate previous literature findings regarding mathematics achievement as measured by the WRAT-R Arithmetic subtest of TS subjects, (Hagin et al., 1982; Incagnoli & Kane, 1982; Jaschko & Rourke, 1982; and Plaisted & Bingham, 1983). In the present studies, as hypothesized, the TS sample's WRAT-R Arithmetic subtest achievement is clearly below average (Hypothesis I) and differentiated from WRAT Reading and Spelling achievement subtests (Hypotheses II and III).

Results of analyses with respect to Hypotheses IV and V shed light on potential explanatory variables for

the consistent finding that TS subjects perform poorly on the WRAT Arithmetic subtest. These studies advance our understanding of poor achievement by pinpointing timed administration of the WRAT-R Arithmetic subtest as a significant variable in assessing mathematics achievement in TS subjects. Further, the use of a different measure (MAT 6) to demonstrate superior performance on the untimed form (Hypothesis IV) increases the generalizability of the timed performance explanation of this study. The MAT 6 Arithmetic subtest does differ in structure from the WRAT-R Arithmetic subtest in that the MAT 6 is a much longer test and may allow subjects more time to settle into a rhythm of working, and may also be somewhat more forgiving than the WRAT-R Arithmetic subtest in that it has more items for each testable skill than does the WRAT-R Arithmetic subtest. These findings, nonetheless, present strong documentation that the WRAT-R Arithmetic subtest is inappropriate for assessing mathematics achievement in TS children, because of the timed administration.

Why does timed administration result in a consistent performance decrement for Tourette's syndrome children? As hypothesized, the results of Hypothesis V provide strong evidence that time pressure increases the frequency and duration of ticking behavior for TS

children. Inherent in the preceding statement is the assumption that increased frequency and duration of ticking behavior interferes with academic performance. Although there is no prior research assessing the impact of frequency and duration of ticking behavior on academic achievement, this study constitutes an initial investigation into such a relationship.

Results of analyses with respect to Hypotheses VI, VII, VIII and IX provide information concerning the social-emotional presentation of a typical Tourette's syndrome child compared to the "normal" (nonclassified) child and to a classified Attention Deficit Hyperactive Disorder child. As predicted, the ADHD sample demonstrated the most hyperactivity problems. The TS sample exhibited more hyperactivity than the NC sample. The analysis of results of Hypothesis VI confirms the prediction made in this hypothesis.

A similar prediction in ordering was made for the attention factor, that is, that the NC sample would score highest, the TS sample would score lower than the NC sample and the ADHD sample would score lowest. Only partial support was obtained. The NC sample did produce the fewest attention problems. The ADHD and TS samples were not significantly discriminable on this factor. Tourette's syndrome children are subject to attention

problems. As previously discussed, this study provides concomitant evidence that increased frequency and duration of ticking behavior adversely affect attention.

As predicted, the TS and NC samples were similar on the social skills and oppositional factors. The ADHD sample clearly demonstrated fewer social skills and more oppositional behavior.

#### Mathematics Achievement

Several studies have reported marked deficits in TS subjects' achievement in mathematics. Each has noted significant, below grade-level scores obtained by TS subjects on the WRAT Arithmetic subtest.

Prior research has also revealed age appropriate normal scores obtained by TS subjects on the Arithmetic subtest of the WISC-R. The explanation given by researchers for the contrast in scores between the WRAT Arithmetic subtest and the Arithmetic subtest of the WISC-R, is that TS subjects have difficulty with arithmetic when visuomotor and visuospatial skills are required. Investigators have reached this conclusion since the WRAT Arithmetic subtest is a written test which requires the subject to solve as many problems as possible within 10 minutes, while the Arithmetic subtest of the WISC-R requires the subject to solve a series of questions mentally, without the use of pencil and paper.

Poor performance by TS subjects on several other neuropsychological tests of visuomotor and visuospatial skills has further encouraged investigators to reach this conclusion, associating visuomotor difficulties with poor arithmetic performance by TS subjects. Tests of visuomotor ability on which TS subjects do poorly, include the Category Test and the Time Score on the Tactual Performance Test, both part of the Halstead-Reitan Neuropsychological Battery. Frequently reported poor performance by TS subjects in the Object Assembly (a measure of visuospatial organization) and the Block Design (a measure of visuospatial ability) subtests of the WISC-R has further reinforced the conclusion of researchers that poor performance by TS subjects on the WRAT Arithmetic subtest is the result of impaired visuomotor and visuospatial skills.

Generally good performance by TS subjects on the Peabody Picture Vocabulary Test - Revised (PPVT-R), a visuoprocessing task, and good performance by TS subjects on the WRAT Reading and Spelling subtests, have led researchers to conclude that TS subjects perform poorly on nonverbal tasks requiring spatial or motor components, such as the written component required on the WRAT - Arithmetic subtest.

The present research, in addition to replicating

previous research that demonstrated TS subjects' poor performance on the WRAT Arithmetic subtest, further illuminates our understanding of that poor achievement by isolating timed administration of the WRAT-R Arithmetic subtest as a significant variable in assessing mathematics achievement in TS subjects that has been overlooked in previous TS research. The use of the MAT 6 in the present study to demonstrate superior performance on the untimed form (Hypothesis IV), further demonstrates that timed administration results in consistently poor mathematics achievement by TS children.

The results of Hypothesis V, showing that time pressure increases the frequency and duration of ticking behavior for TS children, raises the issue that timed testing produces distractibility associated with such ticking behavior, which further produces poor academic performance by TS subjects on timed tests, such as the WRAT-R Arithmetic subtest. Thus, the TS subject's fidgetiness, restlessness, and poor concentration, may be directly related to the increased motor tic activity produced in TS subjects by the timed test condition. It also can be speculated that although it may be less apparent, the TS subject's distractibility might be related to increased mental tics produced under the

timed test condition. These could include sudden intrusive thoughts that cannot be ignored or suppressed by the TS subject. Such internal and external distractions could interfere with the TS subject's ability to sustain attention on tasks, and could also impede the TS subject's ability to follow through on instructions or on the essential elements of goal-oriented problem-solving activities, such as those involved on the WRAT-R Arithmetic subtest. The distractibility associated with increased ticking behavior by TS subjects under the timed test condition may therefore be associated with poor academic achievement, particularly in the area of mathematics as measured by the WRAT-R Arithmetic subtest. The existence of "isolated" dyscalculia in TS subjects must be placed in serious doubt, especially in view of normal mathematical achievement on the untimed test (MAT 6). An alternative interpretation of these results is possible, relating to the fatigue factor in subjects associated with the fact that all tests were administered in the same order on the same day.

Many of the neuropsychological subtests on which TS subjects have performed poorly in previous studies, (i.e., Block Design and Object Assembly subtests of the WISC-R and the Category Test and the Time Score of the

Tactual Performance Test subtests of the Halstead-Reitan Neuropsychological Test Battery), are also administered under time pressure, and so it may be inferred that the distractibility associated with increased ticking behavior by TS subjects under these time pressures may account for TS subjects' poor performance on these neuropsychological tests. It is questionable, therefore, whether poor performance on these subtests is actually indicative of visuomotor and visuospatial deficits, or rather are related to distraction factors associated with increased ticking behavior caused by the timed administration of these tests.

The results of the present study are strongly indicative of the inappropriateness of the WRAT-R Arithmetic subtest for assessing mathematics achievement in TS children. The appropriateness of any test for measuring academic achievement or neuropsychological functioning in TS subjects that is administered under the timed condition, must be seriously questioned.

Some variability in ticking behavior does exist among TS subjects. Symptom severity ranges from "mild to severe", with fluctuation in frequency and duration of ticking behavior among different subjects. Some subjects, therefore, may begin with a higher base level of ticking behavior and possibly a higher initial level

of distractibility than other subjects. This factor may account for the wide variability in standard deviation scores obtained.

#### Attention Deficit Hyperactivity Disorder (ADHD)

Prior research has not determined if TS children have an inherent attention deficit, or if their recurrent ticking behavior is highly distracting to them. In TS subjects, fidgetiness and difficulty in remaining seated in the classroom may be related to the hyperactivity associated with an inherent attention deficit disorder, or may be directly related to the motor tic activity. The results of this study clearly document that the ADHD sample demonstrated the most hyperactivity problems, and the TS sample demonstrated more hyperactivity than the NC sample. It is also noted that the NC sample produced the fewest attention problems, while the ADHD and TS samples could not be significantly differentiated on this factor.

The increased external and internal distractions, associated with increased frequency and duration of ticking behavior in TS subjects, can interfere with the TS subject's ability to sustain attention. Diminished attention can negatively impact upon the teacher's perception of the TS subject's behavior in the classroom, resulting in teacher reports that the TS

subject is hard to control in the school setting and in the TS subject's being labeled by school personnel as "hyperactive".

In addition, the results of this study clearly differentiate the TS and NC samples from the ADHD sample in the social skills and oppositional factors. The ADHD sample clearly demonstrated fewer social skills and more oppositional behavior, while the TS and NC samples were similar in the social skills and oppositional factors. It is thus highly questionable whether TS subjects have any primary behavior disorder associated with their attention deficit, as do ADHD children. It can be inferred that psychological intervention for ADHD children would be significantly effective in maximizing the ADHD child's classroom behavior and family functioning. However, the effectiveness of psychological intervention for the amelioration of the TS child's attentional problems, associated with ticking behavior, may be minimal.

Since data assessing social skills and oppositional factors are essential in distinguishing the TS sample from the ADHD sample, it is essential that a measurement scale be utilized which includes these two factors, as well as an assessment of hyperactivity and attention. The ACTeRS, which provides measurement of

all four factors, has been demonstrated in this study to be an effective instrument in distinguishing TS subjects from ADHD subjects, based on social skills and oppositional behavior, while still accurately assessing the factors of poor attention span and increased hyperactivity common to both TS subjects and ADHD subjects.

### Educational Implications

The outcomes of this present research engender several significant implications for educational practice. The presence of "isolated" dyscalculia comes into serious doubt, as does interpretation of TS subjects' poor test scores (on the WRAT-R Arithmetic subtest) as representing poor mathematics achievement. In formulating an Individual Educational Plan (IEP) for TS subjects, educators must be aware of the possibility for normal mathematical ability and achievement by TS subjects when evaluated under the untimed condition.

The effect of the timed condition of the WRAT-R Arithmetic subtest in producing distractibility related to increased frequency and duration of ticking behavior, renders the WRAT-R Arithmetic subtest an unacceptable measure for TS children. In addition, educators must be aware that reports of poor visuomotor and visuospatial integration based upon neuropsychological tests administered under the timed condition may also be

distorted by the inherent effect of the timed condition itself, which may produce increased distractibility in TS subjects associated with increased frequency and duration of ticking behavior, thereby contributing to poor test results. The TS child's Individual Educational Plan (IEP) cannot, therefore, include components which presume the presence of such visuomotor or visuospatial defects in TS children, based on the results of tests administered under the timed condition.

The results of the present research also seriously question the use of any educational or neuropsychological test administered to TS subjects under the timed condition. This implication includes standardized tests of achievement commonly used in higher grades, such as the Scholastic Aptitude Test (SAT), frequently used to predict success in college. Variability may be noted in subject response to tests administered under the timed condition, depending upon TS subject symptom severity.

Educators must also be aware of the possible effect of time pressures associated with other educational tasks, such as homework and classroom assignments. This research strongly reinforces the conclusion that such educational tasks should be assigned to TS subjects without time restraints, if

maximum academic performance is to be achieved by these children. Timed measures and time restraints, in general, are educationally biased against TS children, and alternate educational assessments and modalities of instruction should be considered.

It is further implied that any educational practice or procedure which increases the frequency and duration of ticking behavior for TS children should be identified, reviewed, and, if possible, modified. The poor attention span and distractibility associated with increased ticking behavior by TS children not only diminishes academic performance, but also serves to impact negatively upon the teacher's view of TS children's behavior in the classroom. This results in false teacher reports of the TS child as being "hyperactive, a behavior problem, or emotionally disturbed".

School psychologists must, therefore, be aware that psychological intervention designed to ameliorate attentional and behavioral difficulties associated with ticking behavior may be minimally successful. Classroom procedures which tend not to increase the frequency and duration of ticking behavior in TS children, such as the elimination of time pressure for educational tasks, may help to improve classroom behavior in TS subjects.

Educators should also be aware that TS children are similar to their peers in evincing good social skills and lack of oppositional behavior.

### Future Research

Future research may find useful the paradigm employed in this study: increased time pressure causes increased ticking behavior resulting in mathematics achievement decrement. This can result in the study of other areas of educational achievement, in addition to mathematics.

Future research can also assess the effects of stress on ticking behavior and on academic performance. Future investigation can also determine if a correlation exists between severity of ticking behavior, reduced attention span, and diminished academic performance.

Future investigators can also determine if TS subjects perform better on neuropsychological tests of visuomotor and visuospatial (e.g., the Category Test and Time Score of Tactual Performance Test of the Halstead-Reitan) integration when these tests are administered in the untimed condition.

Future research should also compile an inventory of variables, other than time pressure, which may cause increased ticking behavior in TS subjects. The influence of such increased ticking behavior in TS subjects on their academic performance must also be determined.

Future research can also assess the effects of tic reduction techniques, such as relaxation exercises, bio-feedback, self-instruction and self-reinforcement techniques on academic performance.

Future studies should also take into account subject fatigue, which may have occurred in this present study due to the full day of testing. The testing should be scheduled over several days.

In addition, future studies should take into account variability in initial symptom severity in the frequency and duration of ticking behavior among TS subjects.

## Appendix

## Abbreviations

|         |  |
|---------|--|
| ACTeRS  | - ADD-H Comprehensive Teachers Rating Scale                            |
| ADHD    | - Attention Deficit Hyperactivity Disorder                             |
| CNS     | - Central Nervous System   |
| DSM III | - Diagnostic and Statistical Manual of Mental Disorders, Third Edition |
| DV1     | - First Dependent Variable   |
| DV2     | - Second Dependent Variable  |
| IEP     | - Individual Educational Plan  |
| LD      | - Learning Disabilities  |
| MAT 6   | - Metropolitan Achievement Test  |
| NC      | - Normal Control subject   |
| PIQ     | - Performance Intelligence Quotient                                    |
| PPVT-R  | - Peabody Picture Vocabulary Test                                      |
| TRS     | - Conners Teacher Rating Scale   |
| TS      | - Tourette's syndrome  |
| TSGS    | - Tourette Syndrome Global Scale                                       |
| TSSL-R  | - Tourette Syndrome Symptom List - Revised                             |
| VIQ     | - Verbal Intelligence Quotient   |
| WAIS    | - Weschler Adult Intelligence Scale                                    |
| WISC    | - Weschler Intelligence Scale for Children                             |
| WRAT-R  | - Wide Range Achievement Test - Revised                                |

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