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**Identification of Gifted Students**  
**Using a**  
**Neuropsychophysiological Paradigm:**  
**An Exploratory Study ©**

**by**  
**Dianna Shaffer**

**Thesis submitted to the School of Graduate Studies**  
**of the University of Ottawa**  
**in partial fulfilment of the requirements for**  
**the degree of**  
**Doctor of Philosophy in Education**  
**Ottawa, Canada, 1999**

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## **ABSTRACT**

The development of an accurate assessment paradigm that identifies students as capable of high performance in a variety of areas is urgently needed in education. Current strategies tend to identify only those students who are intellectually or academically gifted. Gifted students who possess other strengths or pupils who exhibit atypical behavior are often overlooked or misidentified in the process.

A few educational theorists/practitioners believe that current practice should be supplemented by some of the testing protocols typically associated with the field of neuropsychophysiology (i.e. neurology, psychology, physiology). This study develops a neuropsychophysiological paradigm that differentiates high average, gifted, and gifted students with perceived behavior problems.

Sixty-six students, 10-12 years of age, participated in the study. After being screened for incidents of psychopathology, each student completed 14 timed/untimed relaxation and performance conditions while being monitored by EEG and biofeedback technology. The data were analysed quantitatively using three non-parametric tests.

The results of the data analysis suggest that high average, gifted, and gifted students with perceived behavior problems can be differentiated using a neuropsychophysiological paradigm. Foremost in the conclusions is the suggestion that gifted students may excel in two domains - intellectual and psychophysiological, and that gifted students with perceived behavior problems may be a legitimate subgroup of the larger population.

## **ACKNOWLEDGEMENTS**

Appreciation is extended to my thesis supervisor, Dr. Janice Leroux, for her inspiration, critical analysis, and guidance, to Dr. Jean-Paul Dionne and Michel Brabant for their expertise and assistance in quantitative analysis, to Dr. Hendrick Bütter for his knowledge of neuropsychophysiology and his dedication to science, to Dr. Marianna McVey for her sensitivity in matters of political and editorial accuracy, and to the administrators, parents, and pupils in the Ottawa Board of Education and the Association for Bright Children (Ottawa and Kingston), for supporting this research by their interest and participation.

This study was supported by an Ontario Graduate Scholarship and a University of Ottawa doctoral scholarship. Sincere appreciation is extended to the University of Ottawa and the provincial government.

To my family and closest friends I extend my heartfelt gratitude. They remain the brightest stars in my own personal universe of destiny.

**DEDICATION**

**This thesis is dedicated to my parents, Austin and Dorothy Shoup,  
who taught me to recognize people of personal integrity,  
and cherish pursuits of academic excellence.**

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## CHAPTER ONE

### Introduction

*“There is something that is much more scarce, something rarer than ability. It is the ability to recognize ability”.*

*-E. Hubbard*

(Cited in Clasen, Middleton, & Connell, 1994, p. 27)

### Statement of the Problem

In Education, the process of identification of students with special needs often precedes and informs efforts by school personnel to design curricula and programs which are more compatible with the learning styles of the target population (Passow & Frasier, 1994; Stanley, 1993; Treffinger & Feldhusen, 1996). The identification of special groups in schools is usually dependent upon the definition adopted by the selection team and, to some degree, dependent upon the team's restrictiveness or breadth of perspective. Thus, students considered exceptional and in need of special programming by one educator may not, necessarily, be considered exceptional by another (LaFrance, 1993; McBride, 1992; Tyler-Wood & Carri, 1991).

The identification and labelling of any distinct group apart from those considered normative by conventional standards is, at best, problematic (Moulton, Moulton, Housewright, & Bailey, 1998). Often the identification process “results in a change in parent and teacher expectations, as well as in the self-concept of the child” (Clark, 1992, p. 234). In spite of such concerns, the process of identification continues throughout North America because many educators believe that the needs of individual students can best be served by instructing groups of children who have similar strengths and weaknesses.

The identification of gifted students as a distinct group is not immune to the problems associated with the process. Generally, the process is framed by a specific definition of giftedness which has been adopted by the selection team (Braggett, 1997; Hunsaker, 1994). As well, it is affected by the school system's philosophical perspective about the process itself. Questions such as: "What is the definition of giftedness?" and "Should the process be largely inclusionary or exclusionary in design?" affect all subsequent practical decisions made by the education community (Renzulli & Purcell, 1996).

Identification practices considered to be inclusionary by design, for instance, tend to be based on the broadest, most-defensible definition of giftedness available. Educational practitioners who adhere to the philosophy of inclusion often use a number of assessment instruments (e.g. standardized tests, self-report inventories, teacher check-lists) to identify gifted learners. By using a number of assessment instruments it is hoped that almost no candidate will be overlooked by the system. Advocates of inclusive practices believe that the danger of false negatives is a real one, but the danger of false positives is not (Borland, 1978; Coleman & Gallagher, 1995; Sternberg, 1995).

The definitional and philosophical problems associated with the identification of gifted students by educators are compounded in a number of ways by the nature of the population itself. First, although gifted students are often presented as a homogeneous group, in reality, they are not (Gagné, 1998; Kirschenbaum, 1998a, 1998b; Winner, 1996). Indeed, "the personalities and individual characteristics of gifted children vary tremendously ... Even in studies where particular temperaments or learning styles are shown to be characteristic of a group of gifted students ... not every child in the study exhibits the same characteristics" (Roedell, 1986, pp. 18-19). Added to

the realities of unique and diverse personality types are other developmental or cultural conditions which further challenge the myth of gifted homogeneity (Rogers, 1996). A review of the literature recognizes many subpopulations within the larger group. These include, but are not limited to, such subpopulations as gifted students with behavior disorders (Reid & McGuire, 1995), attention deficit disorder (Cramond, 1994), and learning disabilities (Bees, 1998).

Second, although the literature supports the characterization of superior youngsters as basically well adjusted and immune to the psychological problems experienced by other populations, in reality, some are not (González, 1997; Pendarvis, Howley, & Howley, 1990; Rimm, 1990; Weisse, 1990). In fact, some authors suggest that profoundly gifted individuals may be among those most likely to experience social maladjustment (Cornell, Delcourt, Bland, Goldberg, & Oram, 1994; Simonton, 1997). The most extreme form of maladjustment, suicide, is also prevalent among gifted students (Educational Communications, 1994; Metha & McWhirter, 1997).

Third, although all forms of thinking are individualistic, research from the field of neuropsychophysiology suggests that the thinking patterns of gifted students may be dramatically different from those of their peers in type and intensity (Beardsley, 1998; Gottfried, Gottfried, Bathurst, & Guertin, 1994; Mills, Coffey-Corina, & Neville, 1994; O'Boyle, Benbow, & Alexander, 1995). Gifted pupils tend to 1) demonstrate "cognitive flexibility and complexity" (Maniatis, Cartwright, & Shore, 1998, p. 83), 2) "encode and process data in non-intrenched, creative, novel, and insightful ways" (Gallucci, 1989, p. 757), and 3) "master and interiorize culturally constructed abstract representations of thought early in their developmental trajectory"

(Morelock, 1996, p.11). Thus, perhaps more than any other single feature, it is this cognitive difference that separates gifted learners from other populations.

Finally, although many adults believe that gifted pupils, by virtue of their natural ability, are protected from the usual complement of stresses and strains endured by the rest of the populous, in reality, this is not necessarily the case (McCluskey, Baker, O'Hagan, & Treffinger, 1998; Shawn & Lovett, 1994). In fact, some authors suggest that gifted students are not only subjected to the same stresses faced by all people, but that some of their stress and discomfort may be directly related to their giftedness (Swiatek, 1995; Tolan, 1992). As Hannell (1991) has observed, " ... it is sometimes the case that an exceptionally high level of ability can, in itself, create more difficulties" (p. 127).

Although all of the stressors outlined above affect the type and quality of behavior observed by educators as they attempt to identify gifted learners, it is the last stressor (the disparity which exists between social acceptability and academic success) which is particularly problematic and confounding to the process. This stressor is troublesome because it is the students themselves who actively attempt to camouflage their abilities, particularly during their pre-teen and adolescent years (Frey, 1998; Gross, 1998). Like all students, gifted children need to feel welcomed and accepted by a social network which lies beyond the family unit. Authors refer to this condition as 'fitting in' (Gallagher, 1990; Hadaway & Marek-Schroer, 1992; Sapon-Shevin, 1994). Although the job of fitting in, finding oneself, and developing a unique identity is challenging for most teens, the process can be very arduous for gifted students who have, for several years, been encouraged to substitute academic excellence for social development (Ford, 1992; Sowa, McIntire, May, & Bland, 1994).

Further, gifted students may discover that many social groups consider their greatest strength (i.e. academic excellence) of marginal value (Clasen & Clasen, 1995; Ford, 1993). Thus, the natural ability to excel academically suddenly becomes "an embarrassment of riches" (Farrell, 1989, p. 136). Faced with the prospect of social isolation, many intellectually gifted students decide to camouflage their abilities (Comer, 1990; Hebert, 1991). Such purposeful efforts to appear 'average' confound the identification process. Thus, many gifted students remain undiscovered and misidentified (Clark, 1992).

Identification of the gifted learner in Ontario is based upon the Ontario Ministry of Education and Training's definition of giftedness as "an unusually advanced degree of general intellectual ability that requires differentiated learning experiences of a depth and breadth beyond those normally provided in the regular school program to satisfy the level of educational potential indicated" (Ontario Ministry of Education, 1985, p. 6). Since the Ministry's definition focuses on intellectual ability to the apparent exclusion of all other forms of excellence, many school boards in the province have framed their procedure for identifying gifted students around one or more tests of intelligence. Although the revised version of the Wechsler Intelligence Scale for Children - Revised (Wechsler, 1974) is the test used most often by identification teams throughout the province because it is considered to be a "reasonable measure of where a youngster is currently able to function" (Rosner & Seymour, 1983, p. 83), other tests such as the Stanford-Binet (Terman & Merrill, 1973), the Slossen Intelligence Test - Revised (Slossen, Nicholson, & Hibpshman, 1991), the Canadian Cognitive Abilities Test (Wright & Thorndike, 1988), and the Woodcock-Johnson Psycho-educational Battery (Woodcock & Johnson, 1977) are also used for the purposes of identification.

Regardless of the tests used, educators and theorists alike recognize the difficulties in obtaining an accurate measure of intelligence (Shaughnessy & Fickling, 1993; Tyler-Wood & Carri, 1991). Before administering any test it is important to consider, not only the information that will be collected as a result of testing, but also the information that will be omitted by the process. Intelligence tests may provide the examiners with information about the capabilities that a pupil has acquired in the past, but deprive them of any information that could be used to predict a pupil's potential in the future (Clark, 1992; Feuerstein, 1978). Standardized tests, for instance, often do not have high enough ceilings to describe accurately the abilities of gifted learners. Thus, the potential for underestimating their true potential is greatly increased (Moon & Dillon, 1995; Scott, Deuel, Jean-Francois, & Urbano, 1996; Wiggins, 1996).

In addition to intelligence tests, some school boards also consult other sources of information such as report cards, teacher recommendations, parent checklists, peer nominations, and self-report inventories. Although many theorists believe that this more eclectic and comprehensive approach to identification is more inclusive by design (Clasen, Middleton, & Connell, 1994; Griffin, 1992; Hadaway & Marek-Schroer, 1992), others challenge this assumption. Some feel that the information collected by such sources may be products of personal bias and misperception, thereby putting the accuracy of the entire process in question (Kolb & Jussim, 1994; McCallister, Nash, & Meckstroth, 1996; Whybra, 1992). Others believe that it is the combination of the various strategies used in the assessment process that may be detrimental (Richert, 1997; Silverman & Kearney, 1992). As Alvino, McDonnel, and Richert (1981) note, "many tests/instruments are being used for purposes and populations completely

antithetical to those which they are intended and were designed" (p. 128). From this, Clark (1992) concludes, "such data may only serve to confuse the identification process" (p. 216).

To confound the issue, educators are faced with the arduous task of expanding their identification test repertoire to include assessment instruments which identify several types/profiles of giftedness. Betts and Neihart (1988), for instance, were able to identify six profiles of the gifted using a combination of tests designed to target various types of giftedness and Frasier (1991, 1994) revised the Frasier-Talent Assessment Profile (F-TAP) to integrate results from such multiple sources in order to identify potentially gifted minority students (LaFrance, 1993). In addition, Coleman and Gallagher (1995) reported eight types of giftedness included in the policy documents of three mid-western states. The task of finding or developing a test repertoire sufficient in size and diversity to identify the many profiles of giftedness is enormous.

Although there has been an almost Herculean effort in the last half century to develop tests and procedures which identify the various types of giftedness, the progress made to date has been minimal (Matthew, Golin, Moore, & Baker, 1992; Stanley, 1993). In spite of repeated cautions to the contrary (Gardner, 1993b; Purcell, 1996; Sternberg et al., 1995), it appears that most of the decisions made regarding the identification of gifted learners still depend almost exclusively on the scores obtained on standardized tests of intelligence (Barbour, 1992; Callahan, 1996; Passow & Rudnitski, 1993; Shore, Cornell, Robinson, & Ward, 1991).

Many advocates of gifted education continue to judge current identification practices as severely lacking (Callahan, Lundberg, & Hunsaker, 1993; Frasier, 1991; Goodlad, 1994; Passow, 1991; Pendarvis & Howley, 1996). Although few have been able to pinpoint the dominant causal

factor for the deficiency, a review of the literature suggests that opinions have coalesced around four major areas of concern. First, that a comprehensive and accurate assessment strategy which identifies children as capable of high performance in the areas of general intellectual ability, specific academic ability, creative or productive thinking, leadership ability, and superior aptitude in the visual and performing arts has not been developed to date (Woodward & Kalyan-Masih, 1990). Second, that current identification strategies such as standardized tests, teacher observations, peer/parent nominations, and self-report inventories tend to identify only those students who are academically gifted (Sternberg & Clinkenbeard, 1995). Third, that many gifted children, particularly those from minority, culturally different or special needs populations, remain undiscovered and thus underdeveloped because of identification practices currently in use (Saccuzzo & Johnson, 1994; Shaklee, 1992). Fourth, that gifted students who exhibit atypical or nonconformist behavior patterns, such as gifted students with real or perceived behavior problems, are often overlooked or misidentified in the assessment process (Cross & Coleman, 1991).

The problems associated with the identification of gifted students are real and complex. Current practice is, at best, incomplete. Perhaps, it is time to add something new to the assessment base (May, 1994; McCallister, Nash, & Meckstroth, 1996; Passow & Frasier, 1994).

A few educational theorists (Bireley, Languis, & Williamson, 1992; Clark, 1992; Morelock, 1996; Viljoen, 1993) believe that the assessment procedures currently used to identify gifted students should be supplemented by some of the testing practices typically associated with the field of neuropsychophysiology (i.e. neurology, psychology, physiology). It is their belief that such test practices, which depend upon electroencephalographic (EEG) and biofeedback

technologies to collect and analyse data, would provide educators with a more complete and holistic picture of students as they respond to visual, auditory, and tactile stimuli in their environment. This study is designed to produce more evidence on this issue.

### Purpose of the Study

Using EEG and biofeedback technologies in simulated test situations (both timed and untimed), this study attempts to identify three groups of students: those who are high average, those who are gifted, and those who are gifted with perceived behavior problems. The research questions that direct the inquiry are:

- 1) What are the neuropsychophysiological patterns in individual assessments which differentiate students who are gifted from those of high average ability?
- 2) What criteria can be drawn that will be helpful in the identification of students who are gifted with perceived behavior problems?

## CHAPTER TWO

### Review of the Literature

*“Confrontation with a significant and long-standing problem is a precondition for the emergence of a new orientation”.*

*-J. Renzulli & J. Purcell (1996, p. 175)*

This chapter discusses some of the classical and contemporary conceptual models and definitions of giftedness, and highlights some of the specific identification procedures used to recognize gifted students. In addition, it presents an alternative method of identification that is new to the field.

### Conceptualizations and Definitions

#### Giftedness

The identification of gifted students as a distinct group is, at best, an extremely difficult task. Finding valid and reliable identification procedures that can recognize the many ‘faces of giftedness’ poses some formidable problems. One of the most pressing problems in gifted education today stems from a confusion in the field about: “What is giftedness and how should it be defined?” (Margolin, 1996; Merrell & Gill, 1994; Morelock, 1996). Since many of the decisions made regarding the identification of gifted students are based upon individual or collective views of giftedness, a serious effort should be made to consider a variety of conceptualizations/definitions of the term before beginning the identification process. As

McBride (1992) has observed, “the conception of the nature of giftedness and talent is at the heart of all planning efforts” (p. 19).

Over the years, a number of definitions and conceptualizations of the gifted construct have been developed by members of the education community to inform their practice. Terman’s (1926) famous longitudinal studies of eminence, for instance, were based upon a single-criterion definition of giftedness that had been framed around his personal and professional beliefs about superior intelligence and standardized test practice (Hastorf, 1997; Tannenbaum, 1991). To participate in the Terman Studies, subjects had to be within the highest one percent in general intelligence as measured by the Stanford Binet and Terman Group Tests. Thus, for Terman, “general intellectual ability as measured on a standardized scale, was the single attribute which defined [giftedness]” (Wells, 1982, p. 285).

Hollingworth (1926), a research contemporary of Terman, generally supported his beliefs about intelligence and eminence (Hollingworth, 1942). However, her enthusiasm for defining giftedness solely as a measure of general intelligence (i.e. IQ scores) decreased when she realized that the scores were selected arbitrarily and could be changed by convenience (Pritchard, 1951).

In 1931, Hollingworth proposed the following definition:

**By a gifted child we mean one who is far more educable than the generality of children are. This greater educability may lie along the lines of one of the arts, as in music or drawing; it may lie in the sphere of mechanical aptitude; or it may consist in surpassing power to achieve literacy and abstract intelligence (cited in Pritchard, 1951, p. 49).**

By including a number of specific talent areas in her definition, Hollingworth began to cautiously challenge the practice of using one criterion, IQ scores, to identify gifted children.

Witty's (1958) response to the many definitions of giftedness that were based solely upon IQ scores was typical for the time. He believed that children should be considered gifted if their "performance in a potentially valuable line of human activity was consistently remarkable" (p. 62). Witty's contribution to the field was significant because his definition introduced a new variable into the vision - the quality of performance over time.

Marland (1972), United States Commissioner of Education, submitted to the U.S. Congress the Marland Report which presented a revolutionary conceptualization/definition of giftedness. This proved to be a turning point in the history of gifted education. According to the report:

Gifted and talented children are those identified by professionally qualified persons, who, by virtue of outstanding abilities, are capable of high performance (p. ix).

Children capable of high performance include those with demonstrated achievement and/or potential ability in any of the following areas, singularly or in combination:

1. general intellectual ability;
2. specific academic aptitude;
3. creative or productive thinking;
4. leadership ability;
5. visual and performing arts;
6. psychomotor ability (cited in Passow, 1981, p. 5).

The report's definition was revolutionary because it "broadened the conceptualization of giftedness drastically" (Ackerman, 1993, p. 10). In addition, by identifying several profiles/types of giftedness: intellectual, academic, and non-academic, it "depicted a more flexible attribution of [the phenomenon]" (Wells, 1982, p. 185). Fuelled by the fires of political support and

recognition, members of the gifted community intensified their efforts to answer the question: “What is giftedness?”

Renzulli’s (1977) response to the question came in the form of the Triad Model of Giftedness. The model, which was multidimensional in design, was framed around three clusters of gifted traits that were interconnected with equal importance and intensity. The traits were: 1) above-average ability; 2) creativity; and 3) task commitment. According to Renzulli, “gifted and talented children are those [who possess or develop] this composite set of traits and [then apply] them to any potentially valuable area of human performance” (Renzulli, 1978, p. 261).

By including intellectual, non-intellectual, and performance abilities in his conceptualization of giftedness, Renzulli was able to synthesize many of the ideas of his predecessors. Specifically, Renzulli’s above-average ability and task commitment traits strengthened Terman’s (1926) and Witty’s (1950) beliefs about intelligence and performance respectively. In addition, his creativity trait, which reinforced the work of Torrance (1962), provided a conceptual window for some of the diverse areas of excellence and ability listed in Marland’s (1972) report to the United States Congress.

Although Renzulli was one of the first theorists to develop a multidimensional conceptualization/definition of giftedness, he was not the last to do so. By the mid-1990’s, the literature was replete with conceptualizations and definitions that had been framed around a number of intellectual, specific-ability, and performance-based constructs. The following definitions by Roeper (1982), Feldhusen (1986), and Gagné (1991) respectively are typical of those developed during this period of time:

**“ ... giftedness is a greater awareness, a greater sensitivity, and a greater ability to understand and to transform perceptions into intellectual and emotional experiences” (Roeper, 1982, p. 21).**

**“ ... giftedness then includes (a) general intellectual ability, (b) positive self-concept, c) achievement motivation, and d) talent” (Feldhusen, 1986, p. 112).**

**“Giftedness corresponds to competence that is distinctly above average in one or more domains of human aptitude [intellectual, creative, socio-affective, sensorimotor]” (Gagné, 1991, p. 66).**

Such definitions were important to the field because they helped educators focus on the needs of the whole child (e.g. intellectual, academic, social/emotional, physical).

One of the most ambitious attempts to develop a comprehensive conceptualization of giftedness during this period of time was made by Sternberg (1985) in his Triarchic Theory of Intelligence. The model, which stressed the importance of the intellectual construct, identified three main types of giftedness - analytical, synthetic, and practical (Sternberg, Ferrari, & Clinkenbeard, 1996). Analytical giftedness is “expressed in the ability to dissect problems and understand their parts” (Ackerman, 1993, p. 6). Synthetic giftedness involves one’s ability to be “...insightful, intuitive, creative, or just adept at coping with relatively novel situations” (Sternberg, 1991, p. 5). Practical giftedness is manifested in the person “who can go into an environmental setting, figure out what needs to be done to succeed in that setting, and then does it” (Sternberg, 1991, p. 46).

In addition, the model also described several components of intelligence that contribute to the three main types of giftedness. These included: 1) eight metacomponents which are used to plan, monitor, and evaluate problem solving behaviors; 2) numerous performance components

that actually do the problem solving once it has been determined what is essential to the task; and 3) a variety of knowledge acquisition components that are used to learn new information (Ackerman, 1993; Sternberg, 1991).

Sternberg's (1985) attempt to develop a conceptual model of giftedness that both respected the complexity of the construct, and described the diversity of its population was commendable. After describing the numerous layers that were associated with the construct, Sternberg concluded that it was naive "to sum up an individual's intellectual giftedness in a single number, an IQ score" (Ackerman, 1993, p. 7).

Sternberg's (1985) view of intellectual giftedness as a complicated construct that cannot be measured solely by an IQ score was reinforced by Gardner's Theory of Multiple Intelligences (1983). Based upon his work with such diverse populations as prodigies, gifted individuals, brain-damaged patients, normal children, and adults, Gardner identified seven independent profiles/types of intelligence (linguistic, logical-mathematical, spatial, bodily-kinesthetic, musical, interpersonal, intrapersonal) (Gardner, 1993a, 1993b; Rosselli, 1998). Recently, Gardner has expanded his list to include an eighth intelligence - naturalist (Gardner, 1998). Currently, in his newest book, *The Disciplined Mind: What all Students Should Understand*, Gardner (1999) alludes to the possible existence of a ninth intelligence - existential thinking. Since traditional intelligence tests generally tap into only two of the eight types of intelligence (i.e. linguistic, logical-mathematical), Gardner discouraged their use as the sole indicator of giftedness (Rogers, 1998).

Thus, over the years, a number of multidimensional conceptualizations/definitions of giftedness have been created (Morelock, 1996; Passow, 1994; Renzulli & Purcell, 1996). By

developing a large repertoire of definitions that respect some of the unique cognitive, psychological, social, and emotional aspects of its population, theorists have provided members of the gifted community with a large and diverse theoretical framework. Since the framework tends to be inclusive by design, it has helped educators identify specific subpopulations within the larger group.

Such populations include, but are not limited to 1) gifted students who are culturally diverse, socioeconomically disadvantaged, or profoundly capable (Harslett, 1996; Tomlinson, 1995; Yewchuk, 1995), 2) gifted students who demonstrate exceptional strength in the areas of leadership, social interaction, or creativity (Oakland, Falkenberg, & Oakland, 1996; Smith, 1995; Sternberg & Todd, 1993), 3) gifted students who are affected by attention deficit disorders, behavior problems, or learning disabilities (Baum, Olenchak, & Owen, 1998; Rohrer, 1995; Yates, Berninger, & Abbott, 1995), and 4) gifted students who are underachievers or child prodigies (Baker, Bridger, & Evans, 1998; Shavinina, 1999). Of particular relevance to the current study are conceptualizations/definitions of gifted students with behavior problems.

### Gifted Students with Behavior Problems

A review of the literature related to gifted students with behavior problems revealed a number of issues. First, that there is a paucity of documentation specifically related to this population. Second, that there is a dearth of information in education regarding gifted students whose behavior problems are related to specific forms of psychopathology (e.g. schizophrenia, paranoia, manic-depression, acute obsession/compulsion, hysteria) (Cornell, Delcourt, Bland, Goldberg, & Oram, 1994; Jeon, 1993). And third, that there is a movement in education to

catalogue student behaviors/characteristics that, according to the perceptions of teachers, signal the presence of giftedness, immaturity/nonconformity, or deviance. Table 2.1 presents a number of examples of student behaviors/characteristics that teachers tend to perceive as signals of giftedness, immaturity/nonconformity, or deviance within the school environment. The table is an abbreviated version of Appendix A.

Although Table 2.1 attempts to differentiate clearly among behaviors/characteristics that signal the presence of giftedness, immaturity/nonconformity, and deviance, in reality, the distinction is far more opaque (Porath, 1996; Rohrer, 1995). Since the interpretation of student behaviors is largely a matter of personal perception and bias, behaviors that signal the presence of deviance for some teachers, for instance, may be only suggestive indicators of individuality for others (Lovecky, 1992; Westby, 1997). Some of the behaviors that have been recognized by teachers as signals of both immaturity/nonconformity and deviance include: 1) verbal assertiveness (Sowa, McIntire, May, & Bland, 1994); 2) mild/moderate resistance to authority (Griffin, 1992); and 3) independence, stubbornness, and determination (MacRae & Lupart, 1991). Thus, in spite of efforts to link specific behavior patterns with labels of giftedness, nonconformity, and deviance, there remains considerable confusion in the field about the nature of both.

Since students who become associated with repeated displays of behavioral deviance are often labelled as trouble makers, misfits, or behavior problems by school personnel (Gridley, 1990), the implications of perceptual variance by teachers are profound (Jussim & Eccles, 1992; Kolb & Jussim, 1994; Merrell & Gill, 1994). As Manor-Bullock, Look, and Dixon (1995) have observed, once a perception or label is operating, "it matters little if it is real or not, simply

**Table 2.1**

**Examples of Student Behaviors/Characteristics as Perceived by Teachers that Signal Giftedness, Immaturity/Nonconformity, or Deviance**

| Classification           | Behaviors/Characteristics  |
|--------------------------|--|
| Giftedness               | <ol style="list-style-type: none"> <li>1. Academic success</li> <li>2. Model behavior</li> <li>3. High motivation</li> <li>4. Superior metacognitive ability</li> </ol>  |
| Immaturity/Nonconformity | <ol style="list-style-type: none"> <li>1. Uneven development - cognitive, emotional, or social</li> <li>2. Exceptional overexcitability to the environment</li> <li>3. Difficulty interacting successfully with others</li> <li>4. Verbal assertiveness - outspoken, challenges authority</li> </ol> |
| Deviance                 | <ol style="list-style-type: none"> <li>1. Acute procrastination, laziness</li> <li>2. Overactivity, distraction of others</li> <li>3. Physical aggression</li> <li>4. Petty crime, vandalism, destruction or defacement of property</li> <li>5. Lack of control</li> </ol>                           |

because people believe it is present is enough to disrupt normal social interactions” (p. 320).

Thus, the importance of teacher perception as a very real cognitive event, should not be trivialized during the process of identification (Herskovits & Gefferth, 1992; Roldan, 1996).

To confound the issue, there is a growing body of knowledge to suggest that the very nature of schools as somewhat academically boring, restrictive, and regimented environments tends to ignite the fires of resistive and unacceptable behavior in certain members of the gifted population (Freeman, 1994; May, 1994; McCallister, Nash, & Meckstroth, 1996; Soriano de Alencar, 1995). Such behaviors are called situational behaviors because they usually dominate the students' behavioral repertoire only when they are asked to perform in an academic environment that does not meet their individual needs. Such environments tend to be framed around curricula that is not sufficiently challenging for the accelerated abilities of gifted learners (Baum, Olenchak, & Owen, 1998; Feldhusen, 1994; Reis, Westberg, Kulikowich, & Purcell, 1998; Renzulli & Gubbins, 1997).

When students are asked to perform in a learning environment that does not harmonize with their individual expectations or needs, the stage is set for a wide range of behaviors to occur (Kolb & Jussim, 1994; Parker, 1997). Behaviors that challenge or question the system, for example, are often perceived by members of the school community as a disrespect for authority and an unwelcomed attempt to break with tradition, instead of a symptomatic reaction to an unmet need (Morgan, 1996). About this, Hickson (1992) states:

**“The attitudes of educational personnel toward the gifted are negative, particularly [when] many gifted pupils adopt a highly active and questioning approach toward issues. Consequently, it may be perceived that the gifted are displaying an “oppositional” rather than cooperative approach in the learning environment” (p. 93).**

Thus, although many educators share Terman’s (1926) view of gifted learners as students who are academically advanced and in harmony with the school’s milieu, in reality, many are not. In their efforts to “fight boredom, seek a challenge, or experiment with the unknown” (McVey & Snow, 1988, p. 106) many gifted children in a classroom environment “resist routine [and] exhibit nonconformist behavior” (Clark, 1992, p. 203). Such students are often at risk of being misidentified as behavior problems.

A review of the literature revealed only one definition of gifted students with behavior problems. According to the definition, gifted students with behavior problems are those “so visible in their nonconformity to class rules that their ability is obscured ... ” (Rohrer, 1995, p. 280). In addition, it is important to note that the phrase ‘gifted students with perceived behavior problems’ did not appear in the literature.

### **Definitions Used in the Study**

As noted in Chapter One, the Ontario Ministry of Education and Training defines giftedness as:

**“an unusually advanced degree of general intellectual ability that requires differentiated learning experiences of a depth and breadth beyond those normally provided in the regular school program to satisfy the level of educational potential indicated” (Ontario Ministry of Education, 1985, p. 6).**

Since the Ministry's definition focuses on intellectual ability to the apparent exclusion of all other forms of excellence, most school boards in the province use the results of standardized intelligence tests as their sole indicator of giftedness. Generally, in Ontario, students are considered gifted if 1) their Full Scale score (IQ) on tests such as the Wechsler Intelligence Scale for Children - Revised (Wechsler, 1974), is 130 or above, or 2) their overall percentile rank on such tests as the Canadian Cognitive Abilities Test (Wright & Thorndike, 1988) is 95 percent or above. While appearing to be arbitrary in nature, these cut-off scores mirror those suggested in the literature emanating from the 50's to 70's (Matthew, Golin, Moore, & Baker, 1992; Miller, Silverman, & Falk, 1994; Scott, Perou, Urbano, Hogan, & Gold, 1992; Shaughnessy & Fickling, 1993).

The definition of gifted students used in this study is almost identical to those used throughout the province to identify gifted learners. In the study, students are considered gifted if 1) their Full Scale score (IQ) on the Wechsler Intelligence Scale for Children - Revised (Wechsler, 1974) is 130 or above, or 2) their percentile ranks on all subscales of another standardized test of intelligence are 95 percent or above.

Since the phrase 'gifted students with perceived behavior problems' did not appear in the literature, the following operational definition for this population was developed for the purposes of this study:

**Gifted students who, in the absence of incidents of psychopathology, demonstrate a variety of in-school behaviors of such a nature as to warrant repeated corrective or punitive action (both verbal and non-verbal) by school officials.**

Although very much 'a work in progress', a review of the literature suggests that this definition may be one of the first attempts to develop a definition that distinguishes between students with 'real'-trait behavior problems (i.e. those related to incidents of psychopathology) from students with 'perceived'-state behavior problems (i.e. those related to aspects of the learning environment). The distinction may be important since labels such as 'behavior problems' often suggest, implicitly or explicitly, the presence of clinically-significant character or personality deficiencies in the student (i.e. the presence of incidents of psychopathology).

#### Identification Procedures - Single Criterion

The number of single-criterion assessment instruments (e.g. standardized intelligence tests) used in the field of education is surpassed only by their diversity in structure, content, and protocols of delivery. The assessment terrain is crowded with 'families' of verbal and non-verbal tests that 1) can be administered to individuals or groups, 2) are appropriate for students operating at similar or different stages of development, and 3) recognize issues of socioeconomic, cultural, and gender difference (Ackerman, 1993).

Juxtaposed against tests such as the Stanford-Binet (Terman & Merrill, 1973) and the Wechsler Intelligence Scale for Children - Revised (WISC-R) (Wechsler, 1974), which must be administered by trained personnel (Karnes & Collins, 1981), are tests such as the Canadian Cognitive Abilities Test (CCAT) (Wright & Thorndike, 1988) and the Slossen Intelligence Test - Revised (Slossen, Nicholson, & Hibpshman, 1991), that can be administered by educators and professionals who have a thorough understanding of the test manual (Ackerman, 1993). Brief

descriptions of the WISC-R and the CCAT will be provided in the following section as examples of the single-criterion assessment instruments traditionally used by educators to identify gifted learners (Avant, 1987; Roid, 1990).

### Intelligence Tests

The Wechsler Intelligence Scale for Children - Revised (WISC-R) (Wechsler, 1974) is one of the most widely used intelligence tests for children ages 6.0 through 16.11 years (Feldhusen & Van Tassel-Baska, 1989; Sattler, 1982). It is an individually administered test that takes approximately one hour to complete. The test is comprised of twelve timed and untimed subtests that have been designed to elicit a variety of verbal and performance behaviors from testees (see Appendix B).

Whereas, scores from the first six subtests (Information, Similarities, Arithmetic, Vocabulary, Comprehension, Digit Span), provide the Deviation Intelligence Quotient (IQ) for the Verbal Scale, scores from the last six subtests (Picture Completion, Picture Arrangement, Block Design, Object Assembly, Coding, Mazes), provide the IQ for the Performance Scale. In addition, a mathematical computation applied to the entire battery of scores produces the Full Scale Intelligence Quotient. Thus, three distinct quotients of intelligence (Verbal IQ, Performance IQ, Full Scale IQ) can be computed from the test data (Moon & Dillon, 1995; Wechsler, 1991).

Although educators are interested in all three quotients of intelligence (Verbal IQ, Performance IQ, Full Scale IQ), most of the decisions made about the identification and placement of gifted learners are based upon the Full Scale IQ. For educators, Full Scale IQ

scores of 130 or above usually signal the presence of giftedness (Sevier, Bain, & Hildman, 1994; Shaughnessy & Fickling, 1993; Shaughnessy, Stockard, Stanley, & Siegel, 1996).

The Canadian Cognitive Abilities Test (CCAT) (Wright & Thorndike, 1988) is a multilevel, timed intelligence test that can be administered to groups of children in grades three through twelve. Like the WISC-R, the CCAT is comprised of a number of subtests that have been designed to elicit a variety of responses from testees. Unlike the WISC-R, which provides examiners with three intelligence quotients (IQs), the mathematical computations applied to the CCAT subtest data produce three subscale scores (i.e. Verbal, Quantitative, Non-Verbal) which are expressed in percentile ranks (Bittker, 1991; Thorndike & Hagen, 1987; Tyler-Wood & Carri, 1991). To review, the literature suggests that average percentile ranks of 95 percent or above tend to be accepted as indicators of giftedness (Hany & Heller, 1996; Tomlinson, 1995).

### *Critique*

Although the IQ scores generated by intelligence tests provide educators with quantifiable evidence of ability (Tolan, 1992), their acceptance as legitimate measures of giftedness remains controversial. While one school of thought believes that IQs are the only valid and justifiable measure of the construct, others dismiss the scores as completely irrelevant (Ormrod, 1985; Tannenbaum, 1997). In 1989, for instance, “an ABC evening newscast announced publicly that the concept of IQ had been shown to be entirely worthless” (Tolan, 1992, p. 14).

Fortunately, while such cavalier and oppositional statements do appear in the literature, they do not represent the voices of the majority. A review of the literature suggests that discussions related to the nature of intelligence and its measurement tend to focus on the

various strengths and weaknesses of intelligence tests so that, eventually, their role in the identification process may be clarified (Pyryt, 1996).

Standardized tests of intelligence have valuable psychometric properties. They predict academic achievement with moderate success and are useful to educators who must make legal decisions about the identification and placement of gifted learners (Kaufman, 1992; Pyryt, 1996; Sternberg, 1995). In spite of these strengths, “over the last quarter of a century, educators, researchers, and others have questioned the validity of [intelligence] tests to predict the complex phenomenon of human capabilities and potentialities” (Purcell, 1996, p. 248).

Three major criticisms of the strategy exist. First, although intelligence tests tend to have predictive power in some academic settings, their ability to calculate success outside the educational context into adulthood is minimal (Pendarvis & Howley, 1996; Subotnik, Kassar, Summers, & Wasser, 1993).

Second, although the IQ scores attained within a particular test tend to be quite stable, the scores obtained across tests of similar design vary drastically. Sevier, Bain, and Hildman’s (1994) research comparing WISC-R and WISC-III scores, for instance, revealed a 14 point difference between the two tests. Thus, students identified as gifted by one standardized measure may not, necessarily, be considered gifted by another.

Third, while the multiple-subscale design of intelligence tests often helps educators identify some forms of disability and underachievement (e.g. gifted learning disabled students) (Moon, Kelly, & Feldhusen, 1997; Silverman, 1997), most of the individual items contained within the tests are culturally biased. “An item is biased if equally able members of different groups have unequal chances of success on an item” (Stinespring, 1989, p. 59). Because of the

cultural bias present in standardized tests of intelligence, gifted students from economically stressed or culturally different environments tend to be overlooked or misidentified in the assessment process (Coleman & Gallagher, 1995; Frasier, 1997a; Maker, 1996; Plata & Masten, 1998; Tomlinson, Callahan, & Lelli, 1997).

Finally, although “official” definitions of giftedness often include statements about levels of motivation, creativity, and leadership, intelligence tests do not reflect these capabilities of humankind (Pendarvis & Howley, 1996; Renzulli & Gubbins, 1997). Thus, for a variety of reasons, “[intelligence] tests are highly prone to false negatives” (Tolan, 1992, p. 14).

To confound the issue, in spite of repeated cautions to the contrary (Gardner, 1993b; Sternberg et al., 1995), most of the decisions made regarding the identification and placement of gifted learners depend almost exclusively on the scores obtained on standardized tests of intelligence (Kirschenbaum, 1998b; Tannenbaum, 1996). While educators do not feel entirely comfortable with this truism, they usually resist suggestions of wholesale replacement. In time, those closest to the identification process hope to moderate the dominating influences of intelligence tests by adhering to the principles of multidimensional assessment (Frasier, 1997b; Silverman, 1997). To summarize, Wright and Borland (1993) state:

“We want to make it clear that we are not advocating the wholesale replacement of standardized measures. [Instead], we feel ... [that] nontraditional forms of assessment deserve a more prominent place in our practice, a place in no way inferior to that accorded standardized measures” (p. 209).

### Identification Procedures - Multidimensional

There are a number of differences between single-criterion and multidimensional identification procedures. First, whereas single-criterion procedures focus on intellectual ability as the sole indicator of giftedness, multidimensional procedures recognize a variety of abilities that contribute to the construct (Csikszentmihalyi, Rathunde, & Whalen, 1993; Treffinger & Feldhusen, 1996). Second, whereas single-criterion procedures are based upon rather specific, narrow, and exclusionary definitions of giftedness, multidimensional procedures tend to be founded upon the broadest, most-defensible, and inclusive definitions available (Johnsen & Ryser, 1994; Young & Fouts, 1993). Finally, whereas single-criterion procedures are framed around one specific assessment strategy (i.e. standardized intelligence tests), multidimensional procedures engage a number of strategies in their design (Callahan, 1996; Reyes, Fletcher, & Paez, 1995).

Although it is impossible to review all of the assessment strategies related to multidimensional identification practices, brief descriptions of several will be presented here. The strategies were selected for review because they are typical of those used by educators who seek alternative sources of information when the results of traditional forms of identification are in question (Milgram & Hong, 1993; Moon & Dillon, 1995).

#### Assessment of Gifted Typologies

As previously described, in 1972 The Marland Report identified six different profiles/types of giftedness. Eventually, one profile, psychomotor ability, was removed from the

'official' list. Thus, by the turn of the decade (1970-1980), theorists/practitioners were faced with the awesome responsibility of developing an assessment repertoire sufficient in size and diversity to differentiate among children who were capable of high performance in five distinctly different areas: 1) general intellectual ability; 2) specific academic ability; 3) creative or productive thinking; 4) leadership ability; and 5) the visual and performing arts.

In response to the challenge, professional psychometricians continued to develop an impressive library of standardized tests to identify children who were capable in the area of general intellectual ability (i.e. typology one), and educational psychometricians, theorists, and practitioners intensified their efforts to develop identification procedures that would differentiate among populations who excelled in the remaining four typological areas. Soon the field was populated by:

- 1) a large number of tests such as the lower level of the Secondary School Admission Test (Lupkowski-Shoplik & Assouline, 1993) and the intermediate level of the School and College Ability Test (Educational Testing Service, 1980), that had been designed to identify a variety of specific academic aptitudes (e.g. literary, scientific, mathematical);
- 2) a moderate selection of assessment instruments such as the Torrance Tests of Creative Thinking (Torrance, 1974) and the tests of divergent thinking included in the Structure of the Intellect battery (Meeker & Meeker, 1979), that had been framed around some of the constructs of creativity (e.g. fluency, flexibility, originality, elaboration); and
- 3) a limited supply of identification strategies such as the Leadership Skills Inventory (Karnes & Chauvin, 1986) and the Talent Identification Instrument (Baum, Owen, & Oreck, 1996), that had been developed to highlight a variety of leadership and artistic qualities in youth (e.g. communication skills, problem-solving skills, artistic sensitivity, creative expressiveness).

Additionally, living in the shadow of a mountain of identification procedures designed to highlight a specific typology, are a number of multi-typological strategies developed to simultaneously assess all five gifted profiles (Marland, 1972). The Gifted and Talented Screening Form (Johnson, 1979), a 24-item scale that measures six content areas (i.e. intelligence, academics, creativity, leadership, visual-performing arts, psychomotor-athletics); and the Eby Gifted Behavior Index (Eby, 1989), a rating scale and paper-pencil checklist that assesses six talent areas (i.e. verbal, math-science-problem-solving, musical, visual-spacial, social-leadership, mechanical-technical-inventiveness), are typical of identification strategies developed for this purpose (Oakland, Falkenberg, & Oakland, 1996; Sweetland & Keyser, 1991).

Since the concept of 'giftedness' is largely one of social construction (Hubbard, 1996; Sapon-Shevin, 1994, 1996; Tannenbaum, 1997), identification procedures designed to assess a variety of social/emotional constructs also exist. Examples of these tests include: 1) the Adjective Checklist (Gough & Heilbrun, 1983), a self-report instrument consisting of 300 personal attribute descriptors; and 2) the Social Coping Questionnaire for Gifted Students (Swiatek, 1995), an individually administered rating scale consisting of 35 items related to various social aspects of giftedness (e.g. the need for popularity, the fear of failure, denial of giftedness).

### *Critique*

While many believe that the field of education has been almost buried by an avalanche of tests, questionnaires, inventories, checklists, and rating scales related to Marland's (1972) five areas of giftedness, others express frustration because the number of identification procedures

for youth in the areas of creativity, leadership, and the visual and performing arts is severely lacking (Feldhusen & Pleiss, 1994; Haroutounian, 1995; Marek-Schroer & Schroer, 1993; Roach, 1999). Since, as Gagné (1995) has observed, “the bread and butter of our gifted and talented programs is ... the IGAT (intellectually gifted and academically talented)” (p. 110), the issue of unequal availability of tests for the five typologies remains problematic.

To confound the issue, many of the assessment procedures developed to identify the five gifted typologies do not adhere to the rigorous standards of psychometric design. Thus, test developers continue to be questioned about the validity, reliability, and generalizability of their tests (Hadaway & Marek-Schroer, 1992; Messick, 1994; Miller & Legg, 1993; O’Neil, 1992). No doubt, as more and more typologies such as cultural giftedness and social giftedness become theoretically and politically legitimized (Coleman & Gallagher, 1995; Smith 1995), it will be increasingly difficult to develop and maintain a balanced repertoire of accurate assessment strategies to identify the various profiles/types of giftedness, individually or in combination.

### Assessment of Creative Production

In 1981, Renzulli, Rimm, and Smith created the Revolving Door Identification Model (RDIM). The model, which is founded upon Renzulli’s three-ring conceptualization of giftedness (i.e. above-average ability, creativity, task commitment), was developed to identify a large “talent pool” of students (i.e. 15-20% of the pupil population) who, in addition to their regular academic program, were potentially capable of designing and producing other creative products within a school year (Renzulli, 1978, 1986). Since Renzulli believes that “giftedness is not a fixed ability ... but one that emerges in some people, in some areas, and under some

circumstances” (Renzulli & Purcell, 1996, p. 174), the RDIM allows students to “revolve into” specialized areas of pursuit when their interest is high, and “revolve out” of the program when their individual project or investigation has been completed. Thus, unlike many of its contemporaries, the Revolving Door Identification Model “recognizes that there are many children who have the ability to be producers and that not all are sufficiently motivated to be high-level producers all of the time” (Maker, 1982, p. 212).

The Revolving Door Identification Model utilizes four types of information: psychometric, developmental, sociometric, and performance. Psychometric information is data that has been gathered through the assessment of human traits (e.g. intelligence, aptitude, creative achievement), developmental information is data that describes and documents behaviors that are above or below peer-aged norms for a particular category, sociometric information is data that has been gathered from members of an individual’s peer group, and performance information includes final products that have been created by the individual under study (Ackerman, 1993).

In addition, as part of the model, an extensive list of assessment instruments such as the Scales for Rating the Behavioral Characteristics of Superior Students (Renzulli, Smith, White, Callahan, & Hartman, 1976) also exists. Whereas, assessment strategies such as standardized tests and rating scales of motivation are listed as appropriate sources of psychometric and developmental information respectively, strategies such as peer nomination forms and ‘best-work’ student portfolios are recommended as sources of sociometric and performance-based information.

To understand fully the Revolving Door Identification Model, two other types of information (i.e. status, action) must be defined. According to Renzulli, Rimm, and Smith (1981), status information is “any and all types of information that can be prerecorded (‘put down on paper’) prior to the time that a student actually gains entrance to (or is revolved into) a special program” (p. 31), and action information is “the dynamic interactions that take place when a student becomes extremely interested in or excited about a particular topic, ... issue, idea, or event in [any] school or non-school environment” (p. 36). Generally, status information provides insight into a student’s level of intellectual ability, and action information provides data about his/her inclination towards creativity and task commitment. With few exceptions, the Revolving Door Identification Model allows above-average ability students who demonstrate a keen interest in a particular area of study to ‘revolve into’ specialized areas of pursuit that encourage gifted behaviors in young people (e.g. individual or small group projects and investigations) (Renzulli & Purcell, 1996).

### *Critique*

The Revolving Door Identification Model (RDIM) is attractive to educators for a number of reasons. First, since the model does not officially identify students as gifted, or by implication, not-gifted, problems associated with issues of labelling are almost completely avoided (Renzulli & Purcell, 1996; Renzulli, Rimm, & Smith, 1981). Second, since the RDIM treats giftedness as a designation that is related to ability, effort, and interest instead of an act of nature that is forever fixed in time and space, charges of elitism are largely unfounded (Ackerman, 1993; Renzulli, 1984). Third, since the model bases its determinations about identification and placement on a variety of assessment strategies instead of relying exclusively

on one (i.e. standardized tests of intelligence), concerns of cultural test bias are greatly reduced (MacRae & Lupart, 1991; Schlichter & Brown, 1985). Finally, since the RDIM encourages the creation of tangible, original products, it can be integrated into a variety of educational settings with relative ease (Delisle, Reiss, & Gubbins, 1981; Kaufman, 1995).

Although the Revolving Door Identification Model (RDIM) is an excellent example of an open-ended program that “adapts itself [easily] to the idiosyncrasies of any school population, culture, or philosophy” (MacRae & Lupart, 1991, p. 54), it is not completely immune to criticism. While many believe that Renzulli’s multiple-construct, multidimensional approach to identification is more comprehensive and inclusive by design, others question the wisdom of using a smorgasbord of identification strategies in, apparently, random combination to identify the many ‘faces’ of giftedness (Clasen, Middleton, & Connell, 1994; Griffin, 1992; Hadaway & Marek-Schroer, 1992; Silverman & Kearney, 1992).

Since “many tests/instruments are being used for purposes and populations completely antithetical to those [for] which they [were] intended” (Alvino, McDonnel, & Richert, 1981, p. 128), “such data may only serve to confuse the identification process” (Clark, 1982, p. 216). Although Renzulli’s Revolving Door Identification Model is not the only identification procedure to use a variety of assessment strategies in its design, it is certainly one of the most popular to do so.

### **Assessment of Multiple Intelligences**

Although the Multiple Intelligence Assessment Technique (MIAT) was developed by Udall and Passe in 1993, it was based upon the work of Project Spectrum at Harvard University

and, with modifications, the research of Maker at the University of Arizona (Maker, Nielson, & Rogers, 1994; Maker, Rogers, & Nielson, 1992). The technique, which consists of 13 performance-based activities rated on a three point scale ranging from “not evident” to “extremely evident”, was designed to measure student performance in four of Gardner’s (1983) eight intelligences.

The intelligences assessed by the instrument include: spacial, logical-mathematical, linguistic, and interpersonal. Of the 13 activities included in the strategy:

- 1) five correspond to spacial intelligence (i.e. spacial teacher checklist, 3-D puzzle construction, mechanical pump assembly, tangram manipulation activity, artwork);
- 2) three correspond to logical-mathematical intelligence (i.e. math-logical teacher checklist, bus board game activity, mathematical problem-solving activity);
- 3) three correspond to linguistic intelligence (i.e. linguistic teacher checklist, story-telling activity with props, pictorial or written story activity); and
- 4) two correspond to interpersonal intelligence (i.e. interpersonal teacher rating checklist, interpersonal skills observation checklist).

In addition, a package of support materials containing a materials list, teacher-observer scripts, and a scoring rubric are available for each activity (Plucker, Callahan, & Tomchin, 1996).

Since performance-based assessment strategies such as the Multiple Intelligence Assessment Technique are dominated by activities that encourage performance in “true-to-life” settings, such strategies are often used in classrooms to evaluate student growth. In 1990 a study by the Center for Research on Evaluation, Standards, and Student Testing (CRESST) revealed that 23 states were either using, developing, or considering the use of performance-based assessment at a state-wide level (Aschbacher, 1991).

*Critique*

Although relatively new to the field, the Multiple Intelligence Assessment Technique (MIAT) has already been recognized as a performance-based, intelligence-fair assessment strategy that enhances ecological validity (Ackerman, 1993). According to Ramos-Ford and Gardner (1991) intelligence-fair assessment refers to the appropriateness of an assessment instrument for a particular intelligence, and ecological validity refers to the degree to which an assessment situation resembles actual working conditions.

Although performance-based assessment strategies such as the MIAT have been used throughout the United States and abroad to garner valuable information about the individual learning styles of students, the techniques are not without controversy (Maeroff, 1991; Nuttall, 1992; Plucker, Callahan, & Tomchin, 1996). Whereas, the MIAT has been criticized specifically for such logistical failings as increased cost, the need for intensive teacher/observer training, more involved scoring, and a balance of breadth and depth of coverage (Frechtling, 1991; Guskey, 1994; Marzano, 1994), performance-based assessment, in general, has been attacked for failings in the areas of research support and psychometric design (Burger & Burger, 1994; Haertel, 1994). While some authors question whether traditional standards of reliability and validity should be applied to alternative forms of assessment (Linn, Baker, & Dunbar, 1991), others believe that the protocols of psychometric design are essential. As Worthen (1993) states:

**“ ... some evidence that the technical quality of the assessment is good enough to yield a truthful picture of student abilities is essential. To succeed, alternative assessment must show that its tasks and measures are authentic (not merely authentic-looking) assessment. Otherwise, the promise it holds for improving teacher and learning will go unfulfilled.” (p. 448).**

Recently, Goleman (1995) identified another type of intelligence: emotional intelligence. Emotional intelligence includes self-awareness, impulse control, persistence, zeal, self-motivation, empathy, and social deftness. According to Goleman, these are the qualities that mark people who excel in life. The importance of emotions to the overall quality of life and the creative process also has been discussed in the works of Csikszentmihalyi (1990, 1993).

Undoubtedly, with each successive addition to the ‘intelligence family’, issues of logistical appropriety and psychometric standardization will be revisited. As Pyryt (1996) points out, “... it is easy to propose new abilities, it is a challenge to validate them” (p. 256).

### Assessment of Gifted Students with Behavior Problems

A review of the literature suggests that assessment strategies specifically designed to identify gifted students with behavior problems (GB) are conspicuous by their absence. Given the number of definitions related to the GB population (i.e. one), this deficiency is not entirely unexpected. Additional research and investigation will be required to address these gaps in theory and practice.

### Summary

Over the years, efforts to develop fair, accurate, and defensible assessment strategies to identify gifted learners have been steeped in controversy. Whereas single-criterion assessment strategies have been applauded for their attention to psychometric detail (Pyryt, 1996), multidimensional strategies have been criticized for their lack of standardization and research support (Moore, 1993). And, whereas multidimensional identification procedures have been recognized for their ability to identify various subpopulations within the larger group (Tyler-Wood & Carri, 1991), single-criterion procedures have been chastened for misidentifying and overlooking specific populations because of issues related to test and cultural bias (Gallagher & Gallagher, 1994). In spite of an almost Herculean effort to do so, the question “How should gifted students be identified?” remains unanswered (Callahan, Lundberg, & Hunsaker, 1993).

The literature is replete with critical comment on current practice (MacRae & Lupart, 1991). Generally, there are four major areas of concern:

- 1) that a comprehensive and accurate assessment strategy that identifies children as capable in the five gifted typologies has not been developed to date (Passow, 1991);
- 2) that current identification strategies tend to identify only those students who are academically gifted (Zhang & Sternberg, 1998);
- 3) that gifted students from special populations are often overlooked or misidentified in the identification process (Zorman, 1997); and
- 4) that, in spite of efforts to the contrary, decisions of identification and placement for gifted learners still depend almost exclusively on IQ scores (Sternberg et al., 1995).

With so much disenchantment in the field, it is not surprising to find educators who are willing to approach the problems of identification from a new perspective (Clark, 1992; Viljoen, 1993). This study, for instance, presents an alternative method of identification that has been framed around some of the testing protocols typically associated with the field of neuropsychophysiology (i.e. neurology, psychology, physiology). A review of the literature suggests that this orientation may be new to the field of gifted education.

### Neuropsychophysiology and Education

A review of the literature regarding studies which have attempted to intersect some of the questions posed by educators with some of the electroencephalographic (EEG) and biofeedback technologies in medicine suggests two things. First, that research is very limited in this area, and second, that most of the theoretical or practical attempts to apply the principles of neuropsychophysiology to education have involved special needs populations.

One population that has been studied from a neuropsychophysiological perspective is gifted children with learning disabilities. The term 'learning disability' refers to specific developmental disorders such as dyscalculia, dyslexia, and dysgraphia (Ayres, 1972).

In 1992, Bireley, Languis, and Williamson used a 20 channel computerized EEG system with Electro-Cap to investigate the thinking patterns of 11 gifted students (ages 8-14). Significant differences in amplitude (i.e. cortical power) and hemispheric symmetry were observed in the population.

Concurrently, the work of Ollo and Squires (1986) highlighted the importance of activity-selection when using electroencephalographic and biofeedback equipment. Apparently, activities which are varied and complex tend to be more discriminating than those deemed simple or repetitive (Lubar, Mann, Gross, & Shively, 1992). Since problem-solving activities such as those found in the Halstead-Reitan Battery (Reitan, 1979) stimulate the brain to respond to complex stimuli, such activities are often included in the EEG testing protocols designed by clinical neuropsychophysiologicalists (Bireley, Languis, & Williamson, 1992).

Gifted students have also been studied from a neuropsychophysiological perspective. Bütter's (1988) work with eight gifted and average ability elementary school children (ages 8-13), for instance, suggests that this type of investigation may be promising in the future. Based upon Horowitz and O'Brien's (1986) conceptualization of giftedness as an individual-difference phenomena, Bütter's study attempted to answer the following question: "What neuropsychophysiological individual-difference phenomena exist between gifted and normal control elementary school children?"

To answer the question, the neuropsychological reactivity patterns of each student were monitored by a Grass Sixteen Channel Electroencephalograph (Grass Instrument Co., 1977) and the psychophysiological reactivity patterns of each student were monitored by the Davicon Medac System/3 (NeuroDyne Medical Corp., 1994) during four experimental conditions. The conditions were 1) relaxation, 2) signal stimuli presentation - 10 slides of the Halstead Category Concept Formation Task (Reitan, 1979), 3) a stressful condition which consisted of counting backwards by seven, and 4) a period of five minutes post-relaxation.

Bütter's (1988) decision to incorporate a psychophysiological assessment procedure into his research design was based on his belief that the ability of the cerebrum to participate in complex cortical activity is inversely proportional to increases in stress level. Six psychophysiological factors were monitored throughout the procedure. These included: 1) heart rate; 2) skin conductance; 3) electromyographic (muscle tension) readings at two sites, the forehead and the forearm; 4) skin temperature; and 5) pulse height. The factors were selected for the study because of the large body of empirical evidence suggesting a relationship between changes in psychophysiology and stress-enhancing stimuli (Dembroski, MacDougall, Slatts, Eliot, & Buell, 1981; Scholwinski & Reynolds, 1985; Toomin & Toomin, 1972).

Results showed that gifted children manifested a more reactive and adaptable neuropsychophysiological structure than the control group. This finding concurs with the results of Kimmel and Debrosky (1978) who reported that intellectually gifted children differed from intellectually average ones in their initial reactions to innocuous stimuli.

Across all experimental conditions, gifted children continued to manifest lower mean values for all six psychophysiological subscales examined in Bütter's (1988) study. This would suggest that gifted students were less susceptible to stress than average ability students. Based on this small, limited study, it seems that there are some psychophysiological differences between gifted and average ability students.

Shaffer (1994) examined the neuropsychophysiological reactivity patterns of six junior/intermediate students (ages 10-13) who were either average ability, gifted, or gifted with perceived behavior problems. Results of this pilot study supported many of the conclusions drawn from the previous investigation (Bütter, 1988). In particular, the results of both studies

suggested that gifted students were less susceptible to stress than average ability students. Since the literature is very sparse regarding the identification of gifted students from a neuropsychophysiological perspective, there is little empirical evidence regarding this approach in education. Thus, initial research questions arising from the problems form the basis of this inquiry. To review, the questions are:

- 1) What are the neuropsychophysiological patterns in individual assessments which differentiate students who are gifted from those of high average ability?
- 2) What criteria can be drawn that will be helpful in the identification of students who are gifted with perceived behavior problems?

The following chapter describes the research methodology used in the study.

## CHAPTER THREE

### Methodology

*"The brain is the central organ of behavior,  
... peripheral systems reflect the outflow of [its] influence".*

*-J. Andreassi (1980, p. 11)*

The purpose of Chapter Three is to report on the research methodology by describing 1) the terms of reference, 2) the sample, 3) the measuring instruments, 4) the factors, and 5) the procedures used for data collection. The chapter concludes with a glossary of terms (Table 3.5) and a brief statement of how the data is used to answer the two research questions that form the basis of the inquiry.

### Terms of Reference

As noted in Chapter Two, for the purposes of the study, gifted students are defined as those pupils who possess "an unusually advanced degree of general intellectual ability that requires differentiated learning experiences of a depth and breadth beyond those normally provided in the regular school program to satisfy the level of educational potential indicated" (Ontario Ministry of Education, 1985, p. 6). This definition was adopted because it was current at the time of sample selection.

In situations where a school board used the Wechsler Intelligence Scale for Children - Revised (WISC-R) (Wechsler, 1974) for identification purposes, students are considered gifted if their Full Scale Intelligence Quotient score (IQ) is 130 or above. In situations where another

standardized test of intelligence has been administered instead of the WISC-R, scores at or above the 95th percentile on all subscales are required.

Gifted students with perceived behavior problems are defined as gifted students who, in the absence of incidents of psychopathology, demonstrate a variety of in-school behaviors of such a nature as to warrant repeated corrective or punitive action (both verbal and non-verbal) by school officials. High average students are defined as those pupils who are functioning adequately within the regular classroom setting without the need of special external supports or interventions. Such students scored within the 65th and 85th percentile range on all subscales of a standardized intelligence test. Although somewhat arbitrary in nature, all of the cut-off scores used in the study were selected because of their current popularity as numeric identifiers of high average and gifted populations (Freeman, 1994; Shaughnessy, Stockard, Stanley, & Siegel, 1996; Stanley, Siegel, Cooper, & Marshall, 1995).

### Sample

There were a number of factors which determined the sample for this study. These included: 1) the sample size; 2) the representativeness of the sample; 3) the nature of the equipment used; 4) the results of a pilot study (Shaffer, 1994); and 5) the practical 'fit' between the goals of the study and the realities of the school system.

From the beginning, the researcher was interested in selecting a sample size which respected the established norms for a design or experiment (Stanley, 1991). After considerable deliberation and consultation with statisticians, it was decided that approximately 60 students

(20 high average students (at large) (HA), 20 gifted students (without perceived behavior problems) (G), and 20 gifted students with perceived behavior problems (GB) would be required to participate in the study. Given the unique nature of the research design which attempted to merge one of the elements found in gifted education (identification) with some of the technologies found in medical science (EEG and biofeedback equipment), the number seemed to be both statistically and practically appropriate. In the end, 66 students (20 HA, 26 G, and 20 GB) completed both of the paper and pencil screening tests and all of the laboratory activities as defined by the study.

Historically, it has been common practice to study the differences between average ability and gifted students (Keating & Bobbitt, 1978; Rogers, 1986; Scott, Deuel, Jean-Francois, & Urbano, 1996). The decision to expand the research base to include a third group (GB) was made because of the need for additional research which highlights the differences among various gifted subpopulations (Carr, Alexander, & Schwanenflugel, 1996; Lovecky, 1994; Rogers, 1996).

The final sample of 66 students, which included 38 males and 28 females, was drawn from children in Grades 5-7 who were 10-12 years of age. This age was selected because many school boards in Ontario identify gifted children after the age of eight (LaFrance, 1993).

Most of the students (54) were chosen from ten randomly selected urban schools in Eastern Ontario. The schools, which represented the cultural and socio-economic diversity of the region, were identified by school board personnel.

Once a verbal agreement to participate in the study had been received from all ten schools, the board supplied the investigator with ten computer printouts (one for each school).

The printouts contained the names of students (ages 10-12) who 1) had been identified as gifted (G) because they had scored at or above the 98th percentile on all subscales of the Canadian Cognitive Abilities Test (CCAT) in Grade 4, or 2) had been recognized as students with higher than average ability (HA) because they had scored within the 65th and the 85th percentile range on all subscales of the CCAT (Wright & Thorndike, 1988) in Grade 4.

With the assistance of each home school, all of the students received an information letter for parents/guardians about the study (see Appendix C). Unlike many 'first-contact' information letters which ask for an immediate fully-informed written consent decision to participate from parents/guardians, this letter did not ask for a statement of commitment. Instead, parents/guardians were asked to return the letter to the school with their signature and phone number only if they, along with their child, were interested in attending an hour-long information session at the home school to learn more about the study. Of the 205 information letters that were distributed by the schools, 73 (36%) were returned as expressions of interest in attending an information session.

Joint attendance on the part of parents/guardians and students at an information session was a mandatory pre-requisite to participation. The information session was included as an important component of the research design because its 'show-and-tell' format provided all potential stakeholders with an opportunity to 1) meet the investigator, 2) attempt some of the activities that would be done in the lab, 3) wear some of the equipment that would be worn in the lab, and 4) learn some of the fundamentals of neuropsychophysiology. In short, the information session was designed to increase the knowledge and the comfort levels of everyone who attended.

Fifteen group sessions and five individual sessions (for those families who were unable to attend a group session) were conducted by the investigator. At the end of each session a verbal invitation to participate was given. Those wishing to participate completed four steps before leaving:

- 1) each student and parent/guardian signed a consent form that summarized the most salient aspects of the information session and emphasized the option of withdrawal at any time without penalty (see Appendix D);
- 2) each parent/guardian selected a time to visit the lab within a three month time window;
- 3) each student and parent/guardian, in consultation with the investigator, agreed on a group placement for the student (i.e. high average, gifted, or gifted with perceived behavior problems) that was verified later by school personnel; and
- 4) each student completed two paper and pencil tests to be used as screening devices for incidents of psychopathology.

The screening devices used in the study were: 1) the Junior Eysenck Personality Inventory (Eysenck, 1963), a clinical measure to assess the psychological aspects of temperament (extroversion-introversion, neuroticism-stability; and 2) the Children's Personality Questionnaire Form A (Porter & Cattell, 1975), a psychometric test used to detect personality disorders. To participate in the study, subjects had to be judged as free of psychopathology by a registered psychologist.

Of the 73 students who originally expressed an interest in participating, 54 (74%) actually completed the four admittance steps. Thus, 54 students were recruited for the study in this manner from the ten randomly selected urban schools in Eastern Ontario.

The balance of the sample (12) was recruited in a similar way. These students, who represented three urban centres in Eastern and Southern Ontario and one rural centre in Northern Ontario, expressed an interest in participating in the project after attending a regional conference for the gifted where the study was showcased. After attending an information session, 12 of the 13 students who had originally expressed an interest in participating in the study actually completed the four admittance steps.

In the end, 54 (82%) students came from one of the largest school boards in Eastern Ontario and 12 (18%) students came from other school boards in the province. Regardless of their board affiliation, all of the students who participated in the project met the psychometric and clinical criteria for inclusion as defined by the terms of reference for the study.

The study was 'blind' in that the neuropsychophysicologist who administered the laboratory activities and later read the data had no prior knowledge regarding the various group assignments of the participants. Although some precautions were taken to minimize the effects of sample selection bias (e.g. random selection of the schools), the act of volunteerism may have affected randomness. Thus, a quasi-random selection process was used by the researcher to produce the sample shown in Table 3.1.

The proportion of males to females was fairly even for the high average group, slightly less balanced in favour of the females for the gifted group, and very imbalanced in favour of the males (19 to 1) for the gifted behavioral group. Although unplanned, these proportions agree with the literature which suggests that males are more likely to be identified as behavior problems because of their tendency to exhibit overt behaviors, both physical and verbal, which deviate from the accepted norms of traditional school environments (Dykman & Ackerman, 1991).

**Table 3.1**  
**Frequency Distribution of the Sample**

|                | <b>High Average (HA)</b> | <b>Gifted (G)</b> | <b>Gifted Behavioral (GB)</b> |
|----------------|--------------------------|-------------------|-------------------------------|
| <b>N</b>       | <b>20</b>                | <b>26</b>         | <b>20</b>                     |
| <b>Females</b> | <b>11 (55%)</b>          | <b>16 (62%)</b>   | <b>1 (5%)</b>                 |
| <b>Males</b>   | <b>9 (45%)</b>           | <b>10 (38%)</b>   | <b>19 (95%)</b>               |
| <b>Grade 5</b> | <b>5</b>                 | <b>10</b>         | <b>6</b>                      |
| <b>Grade 6</b> | <b>11</b>                | <b>11</b>         | <b>6</b>                      |
| <b>Grade 7</b> | <b>4</b>                 | <b>5</b>          | <b>8</b>                      |

## Measuring Instruments

Four measuring instruments were used in the study. These included the Junior Eysenck Personality Inventory (Junior E.P.I.) (Eysenck, 1963), the Children's Personality Questionnaire Form A (CPQ-Form A) (Porter & Cattell, 1975), the Grass Sixteen Channel Electroencephalograph (EEG) (Grass Instrument Co., 1977) with ECI Electro-Cap Electrode System (Electro-Cap International, Inc., 1983), and the Davicon Medac System/3 (NeuroDyne Medical Corp., 1994). Each instrument will be described in this section. Additional information about the Junior E.P.I., the CPQ-Form A, the Grass Sixteen Channel EEG, and the Davicon Medac System/3 is provided in Appendices E, F, G, and H respectively.

### The Junior Eysenck Personality Inventory (Junior E.P.I.)

The Junior Eysenck Personality Inventory (Junior E.P.I.) (Eysenck, 1963) is a 60 item YES-NO paper and pencil test that measures two of the most important personality dimensions in children (ages 7-16): extroversion-introversion and neuroticism-stability (Sweetland & Keyser, 1986). The test measures two subscales, extroversion (E) and neuroticism (N). In addition, it contains a lie scale (L) to determine the extent of faking (Wirt, 1972).

The Junior E.P.I. was standardized on 12,314 British children. Norms for both genders are provided in the test manual. Split half reliability coefficients obtained on 3,388 girls and 3,372 boys averaged between .7 and .85 for the E and the N scales, and test/retest reliability coefficients obtained on 1,056 boys and 1,074 girls over a one week period averaged between .7 and .8 for all three scales. Validity scores obtained on 229 children support Chazan's (1972) and

Wirt's (1972) recommendation that the instrument be used for the purposes of research and experimentation on a wide scale.

The test results for the E and the N scales remain stable when the instrument is administered to small groups of children (Sweetland & Keyser, 1986). The Junior E.P.I. was selected as a screening device to detect incidents of psychopathology for the study because it appeared to have merit as an instrument for measuring extroversion and neuroticism in children (ages 7-16) without probing deeply into their personalities (Chazan, 1972; Wirt, 1972).

#### The Children's Personality Questionnaire Form A (CPQ-Form A)

The Children's Personality Questionnaire Form A (CPQ-Form A) (Porter & Cattell, 1975) is one of four equivalent forms of the test that can be administered to children, ages 8 through 12. The CPQ-Form A is a paper and pencil test that contains 70 EITHER-OR and multiple choice items that measure 14 factorially independent personality factors (see Appendix F).

The Children's Personality Questionnaire (CPQ) was standardized on over 15,000 boys and girls in the United States representing three ethnic groups, two community types, and three socioeconomic conditions (Porter & Cattell, 1992). Norms for both genders, together and separately, are provided in the test manual.

Split half reliability coefficients obtained on 260 boys and girls in the United States for Forms A and B ranged from .30 to .65 with a median of .54 while test/retest coefficients obtained on the same population over a two week period ranged from .52 to .83 with a median of .70 (Anastasi, 1970; Layton, 1970). The CPQ-Form A was selected as a screening device for

incidents of psychopathology for the study because it appeared to be an educationally compatible instrument that would assess the personality development of children, 8 through 12 years of age (Sweetland & Keyser, 1986; Werner & Bachtold, 1969).

### The Grass Sixteen Channel Electroencephalograph (EEG) with ECI Electro-Cap Electrode System

Two important pieces of equipment, operating concurrently, were used to measure the individual neuropsychological reactivity patterns of each student. These were the Grass Sixteen Channel Electroencephalograph (Grass Instrument Co., 1977) and the ECI Electro-Cap Electrode System (Electro-Cap International Inc., 1983).

The ECI Electro-Cap Electrode System is an accurate, convenient, and non-invasive method of electrode placement that is used to monitor brain wave reactivity patterns in people of all ages in 4,000 research and clinical facilities in 75 countries around the world (Blom & Anneveldt, 1982; Polich & Lawson, 1985). One of the most important pieces of equipment in the system is the Electro-Cap (see Appendix G).

The Electro-Cap is an elastized hat which is placed securely on the head of the participant by a trained technician or professional. The hat contains a series of pure tin electrodes which monitor the “electrical potentials generated by nerve cells in the cerebral cortex” (Spehlmann, 1981, p. 3). The design of the cap insures the correct placement of the electrodes according to the Jasper International 10/20 System (Jasper, 1958). It eliminates the need to apply the electrodes directly to the scalp (Andreassi, 1995).

Six electrode sites were activated in the study. These included: 1) the two temporal sites (T5-T6) located at the sides of the head; 2) the two parietal sites (P1-P2) located in the middle anterior region of the cerebral cortex; and 3) the two occipital sites (O1-O2) located in the lower anterior region of the cerebral cortex. These sites were selected because they often provide researchers with distortion-free recordings of the alpha frequency band. Over the years, the alpha frequency band has been recognized for its role in cognition, learning, and mental performance (Anokhin & Vogel, 1996; Gruzelier, 1996; Zhuang et al., 1997).

The Grass Sixteen Channel Electroencephalograph (EEG) is one of several, 'brand-name' electroencephalographic machines used in medical and psychiatric facilities around the world to monitor and record brain wave reactivity patterns in people of all ages (Fox & Davidson, 1988; Grass Instrument Co., 1977). Like many of its competitors, the Grass Sixteen Channel EEG has been identified as a reliable and valid diagnostic instrument for electroencephalography by the American EEG Society because its technical design specifications satisfy the calibration and performance standards prescribed in *Guidelines in EEG* (Harner, 1980).

Since the researcher was interested in examining the reactivity patterns of the brain from a variety of perspectives during a simulated test sequence, a multiple-factor research design was selected for the neuropsychological aspects of the study. Four factors were monitored using EEG technology while the student was seated in a comfortable chair beside two members of the research team. These included: 1) amplitude; 2) frequency; 3) the presence of alpha waves; and 4) the presence of hemispheric symmetry (pp. 57-61). As a group, the factors represented three of the most prominent neuropsychological characteristics of neurocortical arousal:

1) neurocortical strength/power (Spehlmann, 1981); 2) neurocortical synchronicity (i.e. harmony) (Klimesch, 1996); and 3) neurocortical symmetry/coherence (i.e. balance, equilibrium) (Mulholland, 1995).

Sixty-six sets of data (i.e. electroencephalographs), one for each participant, were recorded during the study. Each set was carefully read and interpreted by a practising neuropsychophysiologicalist who did not know the group placements of the subjects.

### The Davicon Medac System/3

Two pieces of equipment, operating concurrently, were used to measure the individual psychophysiological reactivity patterns of each student. These included the Davicon Medac System/3 (NeuroDyne Medical Corp., 1994) and an IBM PC compatible computer system. The Davicon Medac System/3 is a non-invasive instrumentation and computer software package which has been used to monitor the psychophysiological reactivity patterns of patients in hospitals, universities, and rehabilitation centres around the world for over ten years (NeuroDyne Medical Corp., 1994) (see Appendix H).

In the study, three types of accurate and non-invasive sensors which had been temporarily attached to the upper body were used to monitor the psychophysiological reactivity patterns of each student. These included:

1) one photoplethysmography sensor which had been mounted on a velcro strip and attached to the medial phalanx of the third finger of the non-dominant hand to minimize the possibility of signal interference caused by excessive movement (Cunningham & Murphy, 1981);

2) two Beckman silver-silver chloride electrodes which had been attached with velcro straps to the medial phalanges of the first and second fingers of the non-dominant hand using 0.5% KCl in 2% agar-agar as the electrolyte (Hassett, 1978); and

3) two Active Electrodes which had been mounted on a three-piece dry disposable bandage called a Davicon Triple Stix which had been attached to the forehead and the forearm of the non-dominant hand (Carry, Bütter, Persinger, & Bialik, 1995).

The psychophysiological reactivity patterns that were detected by the sensors at the various placement sites (fingers/forearm of the non-dominant hand, forehead) were transformed electronically into mean scores. Each mean score was the average of all the values recorded for a particular factor during a specific condition. Generally, one mean score for each factor during each condition was recorded on the final database. The data consisted of a computer printout of all the mean scores that had been recorded by the Davicon Medac System/3 during the hour long testing period (approximate time). Sixty-six computer printout summaries (one for each student) were made during the study.

Since the researcher was interested in examining the reactivity patterns of “the whole child” during a simulated test sequence (Mehler & Sella, 1993b), a multiple-factor research design was also selected for the psychophysiological aspects of the study. Seven factors were monitored during the investigation. These included: 1) heart rate (HR); 2) skin conductance (SC); 3) electromyography of the arm (EMG-ARM); 4) electromyography of the forehead (EMG-HEAD); 5) skin temperature (TEMP); 6) inter-beat-interval (IBI); and 7) pulse height (PH) (pp. 62-67).

The importance of the cardiovascular system, represented by three factors (i.e. HR, IBI, PH), cannot be overstated. A cardiovascular system that is stable and dilated delivers adequate

supplies of oxygen and glucose to all parts of the body. Since the elements are the fuel used by all active cells, it is important that the body receive adequate supplies at all times (Fite, 1994). Interruptions in the flow of blood that carries these essential elements to the body usually hinders overall performance and systemic efficiency.

The Davicon Medac System/3 has been designed to respond to the earliest signs of oxygen/glucose deprivation. During moments of vasoconstriction, the graphic displays on the computer monitor arrest and the system records numeric values of 0.00 on the database for all factors. These electronic responses alert the attending medical research team to changes in cardiovascular performance that may be potentially problematic. After receiving such an alert, the attending medical personnel in the present study stopped the testing process. During the moments that followed, the testees were asked to close their eyes and relax. The testing process resumed when the Davicon Medac System/3, once again, recorded cardiovascular values of increasing strength.

It is not unusual to see values of 0.00 on the database of a student who is involved in a test-taking activity. Many students react strongly to the testing process (Andreassi, 1980). A number of 0.00 values were recorded by the Davicon Medac System/3 during this study. Databases which contained values of 0.00 were not included in the process of statistical analysis because the data was not available.

## The Factors

To review, in the study, the Grass Sixteen Channel Electroencephalograph (Grass Instrument Co., 1977) measured four neuropsychological factors and the Davicon Medac System/3 (NeuroDyne Medical Corp., 1994) measured seven psychophysiological factors. Brief descriptions of all 11 factors are presented in this section.

To facilitate understanding, essential information is provided in this chapter and highly technical details are presented in Appendix I. In addition, where possible, the constructs of attention, memory, and vigilance are highlighted because these constructs affect student performance and learning (Lyon & Krasnegor, 1996; Rumbaugh & Washburn, 1996). The following definitions have been selected for the study:

- 1) Attention is “a hypothetical process of an organism which facilitates the selection of relevant stimuli in the environment (internal or external) to the exclusion of other stimuli and results in a response to the relevant stimuli” (Tecce, 1972, p. 100).
- 2) Memory is “a diverse collection of ... capacities that are distributed across multiple, separate processing modules” (Lyon & Krasnegor, 1996, p. 186).
- 3) Vigilance is “the ability to maintain one’s focus across time” (Lyon & Krasnegor, 1996, p. 207).

Before beginning, it is important to emphasize two things. First, many of the numeric references in this section are equipment-specific, that is, they are based upon the technical specifications of the Davicon Medac System/3 (NeuroDyne Medical Corp., 1994). Second, although specific patterns of reactivity do exist in the field, all neuropsychophysiological data are

affected by, and the result of, the unique nature of the individual and the special environmental forces at work during the assessment process (Andreassi, 1995; Mehler, 1994). Thus, the numeric values cited in this chapter should be used as guiding principles rather than fixed points of reference.

### Neuropsychological Factors

#### *Amplitude*

Amplitude is a measure of neurocortical arousal, strength, and power that is expressed in microvolts ( $\mu\text{V}$ ) (Fite, 1994; Fox et al., 1995). Generally, lower amplitude values ( $20 \mu\text{V}$  or less) indicate an increase in neurocortical arousal with a decrease in neurocortical strength and power, and higher amplitude values ( $51+ \mu\text{V}$ ) indicate a decrease in neurocortical arousal with an increase in neurocortical strength and power (Cunningham & Murphy, 1981; Röder, Rösler, Hennighausen, & Näcker, 1996). From an educational perspective, students with higher amplitude values ( $51+ \mu\text{V}$ ) tend to perform in ways that support the learning process because values that exceed  $50 \mu\text{V}$  have been associated with increases in attention, memory, and vigilance (Anokhin & Vogel, 1996; Surwillo, 1971).

#### *Frequency*

Frequency is the number of times a particular wave shape is repeated in one second. It is a measure of neurocortical arousal and synchronicity which is expressed in Hertz (Hz) (Spehlmann, 1981). Usually, lower frequency values (0-7 Hz) indicate a decrease in neurocortical arousal, higher frequency values (16-31+ Hz) indicate an increase in neurocortical

arousal, and moderate frequency values (8-15 Hz) indicate levels of neurocortical arousal that fall somewhere between the two extremes (Hayes & Venables, 1970; Ota, Toyoshima, & Yamauchi, 1996).

There are several types of frequency waves. Each type is unique in appearance, and each type broadly signals the presence of a particular 'state' of the human condition. The types of waves are:

- 1) delta waves (3 Hz or less) which signal a state of sleep (Gruzelier, 1996);
- 2) theta waves (4-7 Hz) which signal states of sleepy inattentiveness or relaxed creativity (Mulholland, 1995);
- 3) alpha waves (8-12 Hz) which signal a state of semi-relaxed general attention accompanied by a large amount of synchronized neurocortical arousal (Crawford, 1996; Pfurtscheller, Stancák, & Neuper, 1996);
- 4) beta waves (13-30 Hz) which signal a state of focused attention on a moderately difficult task (Fernández et al., 1995; Harmony et al., 1996); and
- 5) gamma waves (31+ Hz) which signal a state of extreme focus on a very complex and challenging task that causes some frustration. Such waves lack synchronicity, harmony, and balance (Başar-Eroglu, Strüber, Kruse, Başar, & Stadler, 1996; Mattson, Sheer, & Fletcher, 1992).

Since the assessment protocols used in the study included both active and passive conditions in a simulated test sequence, the researcher expected to see theta, alpha, beta, and gamma waves in the EEG profiles of the sample. Since delta waves usually signal the presence of sleep, the research team did not anticipate seeing such waves in the profiles.

In terms of frequency, educators should expect most students with moderate frequency values (8-15 Hz) to behave in a manner that facilitates learning because alpha and very low beta wave activity enhances physical relaxation, attention, memory, clarity of thought, and vigilance

(Golubeva, 1980; Pfürtscheller, Stancák, & Neuper, 1996). In addition, educators should expect students with lower frequency values (0-7 Hz) to exhibit signs of inattentiveness and drowsiness (Mulholland, 1995), and students with higher values (16-31+ Hz) to experience moments of effortful focus accompanied by some frustration and destabilization of the perceptual system (Başar-Eroglu, Strüber, Schürmann, Stadler, and Başar, 1996).

### *The Presence of Alpha Waves*

As noted in the previous section, alpha waves are neurocortical rhythms with a frequency of about 8-12 Hz that occur during a state of relaxed wakefulness (Fite, 1994). Typically, the presence or absence of alpha wave activity in a specific condition indicates a decrease or increase in neurocortical arousal for that moment in time respectively (Ota, Toyoshima, & Yamauchi, 1996; Pfürtscheller, 1992).

Since alpha waves are synchronized, they tend to be very stable, efficient, and enduring in nature (Başar & Bullock, 1992). Thus, students who are functioning in the presence of alpha wave activity tend to perform in ways that enhance the learning process because the wave seems to be associated with increases in attention, memory, and vigilance (Golubeva, 1980; Zhuang et al., 1997).

### *The Presence of Hemispheric Symmetry*

Hemispheric symmetry describes a state of neurocortical arousal where the average amplitude strength of the right hemisphere (RH) corresponds to the average amplitude strength of the left hemisphere (LH) (Spehlmann, 1981). According to Rippon (1990), the presence of

hemispheric symmetry in a specific condition signals a time of arousal when the neurocortical workload of the moment is shared almost equally between the left and the right hemispheres. During these moments of 'shared equality' the LH and RH tend to process the verbal and non-verbal aspects of the moment respectively (Petsche, Etlinger, Schmidt-Henrich, & Filz 1994; Rothschild & Hyun, 1990). Roberts and Kraft (1989) refer to this process of LH/RH 'job-sharing' as hemispheric specialization.

In most cases, hemispheric symmetry increases neurocortical coherence. Petsche (1996) defines neurocortical coherence as "the functional cooperation between [the two hemispheres]" (p. 156). Neurocortical coherence describes a state of increased efficiency and flexibility where one part of the brain is allowed to 'rest' while the other part is active (Grafton, Woods, Mazziotta, & Phelps, 1991; Rao et al., 1993). Students who are functioning in the presence of hemispheric symmetry and neurocortical coherence often perform in a manner that facilitates learning because such patterns have been associated with increases in information processing speed, memory, and vigilance (Hughes, 1996; Martindale & Greenough, 1973; Zola-Morgan & Squire, 1993).

Thus, four neuropsychological factors were selected for the study: 1) amplitude, 2) frequency; 3) the presence of alpha waves; and 4) the presence of hemispheric symmetry.

Table 3.2 describes the factors from an educational perspective.

**Table 3.2**  
**Neuropsychological Factors - Educational Perspective**

| <b>Factor</b>                               | <b>Unit of Measure</b>                 | <b>Preferred Range of Values</b>         | <b>Classroom Behaviors Often Associated with Range</b> |
|---|--|--|--|
| <b>Amplitude</b>                            | <b>Microvolts (<math>\mu V</math>)</b> | <b>Higher<br/>51+ <math>\mu V</math></b> | <b>Improved Attention, Memory, and Vigilance</b>       |
| <b>Frequency</b>                            | <b>Hertz (Hz)</b>                      | <b>Moderate<br/>(8-15 Hz)</b>            | <b>Improved Attention, Memory, and Vigilance</b>       |
| <b>The Presence of Alpha Waves</b>          | <b>Presence of/<br/>Absence of</b>     | <b>Presence of Alpha Waves</b>           | <b>Improved Attention, Memory, and Vigilance</b>       |
| <b>The Presence of Hemispheric Symmetry</b> | <b>Presence of/<br/>Absence of</b>     | <b>Presence of Hemispheric Symmetry</b>  | <b>Improved Memory and Vigilance</b>                   |

## Psychophysiological Factors

### *Heart Rate*

Heart rate (HR) is a measure of the cardiac cycle. It is expressed in beats per minute (bpm). Generally, lower HR values (0-55 bpm) indicate a decrease in cardiovascular arousal, higher HR values (111-165 bpm) indicate an increase in cardiovascular arousal, and moderate HR values (56-110 bpm) indicate levels of cardiovascular arousal between the two extremes (Coles, 1984; Turner, 1994). From an educational perspective, students with moderate heart rate values (56-110 bpm) tend to perform in ways that support the learning process because values that fall within this range have been associated with increases in attention and task engagement (Andreassi, 1995; Raskin, Kotses, & Bever, 1969).

### *Skin Conductance*

Skin conductance (SC), which is expressed in micromhos ( $\mu\text{mhos}$ ), is a measure of electrodermal arousal (i.e. perspiration) (Fowles et al., 1981; Venables & Christie, 1973). According to the NeuroDyne Medical Corporation (1994), lower SC values (.45-5.31  $\mu\text{mhos}$ ) indicate a decrease in electrodermal arousal, higher SC values (10.64-16.35+  $\mu\text{mhos}$ ) indicate an increase in electrodermal arousal, and moderate SC values (5.32-10.63  $\mu\text{mhos}$ ) indicate levels of electrodermal arousal that fall somewhere between the two ranges at opposite ends of the continuum. Since moderate SC values have been associated with improved memory and learning, this is the preferred range of intensity for students who are involved in the learning process (Andreassi, 1966; Berry, 1962).

*Electromyography (Arm and Forehead)*

Electromyography (EMG) is a measure of skeletal-muscular arousal and tension that is expressed in microvolts ( $\mu\text{V}$ ) (Basmajian & DeLuca, 1989; Mehler & Sella, 1993a). Usually, lower EMG values (0-333  $\mu\text{V}$ ) indicate a decrease in skeletal-muscular arousal/tension, higher EMG values (667-1000+  $\mu\text{V}$ ) indicate an increase in skeletal-muscular arousal/tension, and moderate EMG values (334-666  $\mu\text{V}$ ) indicate levels of skeletal-muscular arousal/tension that fall between the two extremes (Hanegan, 1992).

EMG values of lower intensity (0-333  $\mu\text{V}$ ) often signal a state of neuromuscular stability that is surprisingly free of tension and physical discomfort. Students who are functioning within this range (0-333  $\mu\text{V}$ ) tend to behave in ways that support the learning process (Courts, 1939; Davicon Inc., 1989) because such values have been associated with increases in attention, vigilance, and task engagement (Chapman, 1974; Eason, 1963).

*Skin Temperature*

Skin temperature (TEMP), which is expressed in degrees Fahrenheit ( $^{\circ}\text{F}$ ) or degrees Celsius ( $^{\circ}\text{C}$ ), is a measure of overall body warmth (Hassett, 1978). Typically, lower TEMP values (59-73 $^{\circ}\text{F}$ ) indicate a decrease in body warmth, and higher TEMP values (89-100 $^{\circ}\text{F}$ ) indicate an increase in body warmth (NeuroDyne Medical Corp., 1994).

Most students with higher temperature values (89-100  $^{\circ}\text{F}$ ) behave in a manner that facilitates learning because higher TEMP values seem to increase synchronized neurocortical activity and improve memory (Schultz & Luthe, 1959). However, skin temperatures that exceed 100  $^{\circ}\text{F}$  may signal, for some students, the first stages of sleep and inattention (NeuroDyne

Medical Corp., 1994). In such situations, temperature values that are very high would not support the process of learning.

### *Inter-Beat-Interval*

Inter-beat-interval (IBI) is the time between two consecutive heart beats (Brown, 1972). Like heart rate (HR), IBI is a measure of the cardiac cycle. It is expressed in milliseconds (msec) (Turner, 1994).

Since the construct is extremely difficult to measure, numeric approximations of such relative terms as lower, moderate, and higher are not always possible. However, since there is a direct inverse relationship between heart rate (HR) and the inter-beat-interval (IBI), many of the conclusions related to changes in HR are also applicable to the IBI (Mehler, 1994).

Like heart rate, IBI values that are either too high or too low may be problematic. Since moderate IBI values have been associated with increases in attention and task engagement, this is the preferred level of intensity for students who are involved in the learning process (Andreassi, 1995).

### *Pulse Height*

Pulse height (PH) is a measure of changes in peripheral blood flow (Hassett, 1978). Since pulse height values have no absolute value, they are expressed in relative units (Mehler, 1994). Generally, higher PH values (68-100) signal a state of vasodilation, lower PH values (0-33) signal a state of vasoconstriction, and moderate PH values (34-67) are indicative of peripheral blood flow levels that fall somewhere between the two ranges at opposite ends of the

continuum (NeuroDyne Medical Corp., 1994; Obrist, 1981). Examples of lower, moderate, and higher blood flow levels are presented in Figure 3.1. The figure is an adaptation of p. 3.10 in the 1994 edition of the *Davicon Medac System/3 Instrumentation User's Guide* by NeuroDyne Medical Corporation. Since higher PH values (68-100) have been associated with increases in attention to novel stimuli and states of general systemic well-being, students who are functioning within that range often perform in ways that support the learning process (Miller, Smith, & Mehler, 1987).

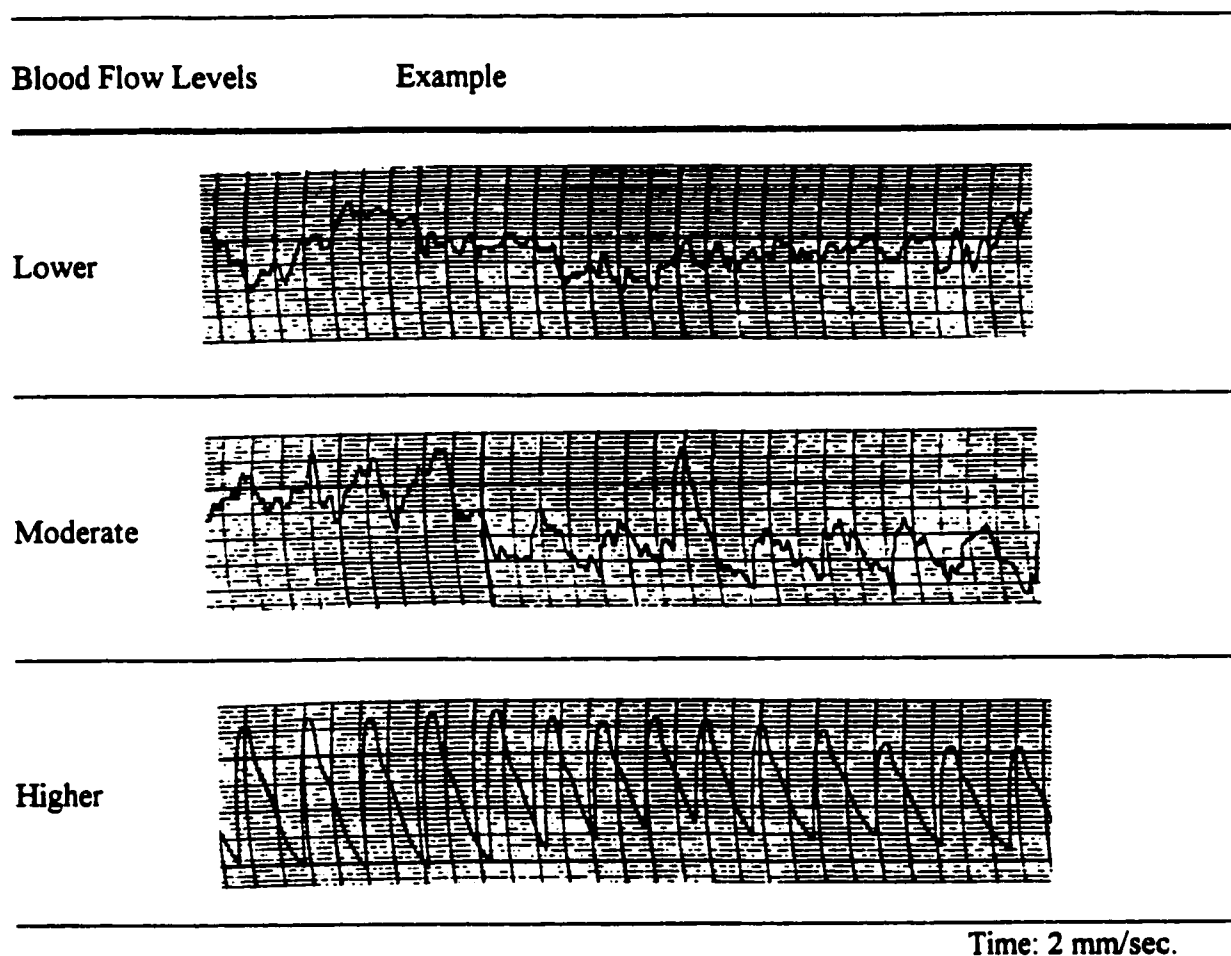
Thus, seven psychophysiological factors were selected for the study: 1) heart rate (HR); 2) skin conductance (SC); 3) electromyography of the arm (EMG-ARM); 4) electromyography of the forehead (EMG-HEAD); 5) skin temperature (TEMP); 6) inter-beat-interval (IBI); and 7) pulse height (PH). Table 3.3 describes the factors from an educational perspective.

In summary, a total of 11 neuropsychophysiological factors were selected for the study. These factors have been part of the 'common language' of the health care profession for over 60 years (Andreassi, 1995; Hassett, 1978).

### Procedures Used for Data Collection

All students were tested individually in a sound attenuated room at a medical facility in Hull, Quebec. Upon arrival at the facility, each participant was given a brief, informal orientation to the research site. During the orientation, the students and their parents/guardians were encouraged to review what they had learned during their information session (individual or

**Figure 3.1**  
**Examples of Lower, Moderate, and Higher Blood Flow Levels**



**Note:** From Davicon Medac System/3 Instrumentation User's Guide (p. 3.10) by NeuroDyne Medical Corporation, 1994, Newton, MA: Author. Copyright 1994 by NeuroDyne Medical Corporation. Adapted by permission.

**Table 3.3**  
**Psychophysiological Factors - Educational Perspective**

| <b>Factor</b>                                    | <b>Unit of Measure</b>                             | <b>Preferred Range of Values</b>                      | <b>Classroom Behaviors Often Associated with Range</b>           |
|--|--|---|--|
| <b>Heart Rate (HR)</b>                           | <b>Beats/Minute (bpm)</b>                          | <b>Moderate<br/>56-110 bpm</b>                        | <b>Increases in Attention and Task Engagement</b>                |
| <b>Skin Conductance (SC)</b>                     | <b>Micromhos (<math>\mu</math>mhos)</b>            | <b>Moderate<br/>(5.32-10.63 <math>\mu</math>mhos)</b> | <b>Improved Memory and Learning</b>                              |
| <b>Electromyography (EMG-ARM)<br/>(EMG-HEAD)</b> | <b>Microvolts (<math>\mu</math>V)</b>              | <b>Lower<br/>(0-333 <math>\mu</math>V)</b>            | <b>Increases in Attention, Vigilance, and Task Engagement</b>    |
| <b>Skin Temperature (TEMP)</b>                   | <b>Degrees Fahrenheit (<math>^{\circ}</math>F)</b> | <b>Higher<br/>(89-100 <math>^{\circ}</math>F)</b>     | <b>Synchronized Neurocortical Arousal and Improved Memory</b>    |
| <b>Inter-Beat-Interval (IBI)</b>                 | <b>Milliseconds (msec)</b>                         | <b>Moderate</b>                                       | <b>Increases in Attention, and Task Engagement</b>               |
| <b>Pulse Height (PH)</b>                         | <b>Relative Units</b>                              | <b>Higher<br/>(68-100)</b>                            | <b>Increases in Attention, and States of Systemic Well-Being</b> |

group) by examining the various pieces of equipment positioned around the room and asking any questions about the experimental procedures to follow.

After the orientation session, the student was seated in a comfortable chair facing an IBM PC compatible computer system. Sensors to measure the psychophysiological reactivity patterns of the student were carefully attached to the upper body, and an ECI Electro-Cap (Electro-Cap International, Inc., 1983) to measure the neuropsychological reactivity patterns of the student was placed securely on the head. Following the placement of all sensors and electrode sets, the Grass Sixteen Channel Electroencephalograph (Grass Instrument Co., 1977), the Davicon Medac System/3 (NeuroDyne Medical Corp., 1994), and the IBM PC computer system were checked for recording accuracy by the attending neuropsychophysiologicalist, and the slide projector was tested for visual clarity by other members of the research team. Once the team was satisfied with the technical performance of the equipment, the actual process of testing and data collection began.

There were two parts to the testing process, Phase 1 and Phase 2. Phase 1, containing three conditions (CO1A, CO2A, CO3A) measured by the Grass Sixteen Channel Electroencephalograph and three conditions (CO1B, CO2B, CO3B) measured by the Davicon Medac System/3, took approximately five minutes to complete. Phase 2, containing 11 relax-active-relax conditions (C1-11) measured simultaneously by both pieces of equipment took approximately 30 minutes to complete. As an advanced organizer, Table 3.4 describes the experimental conditions contained in both phases of the study.

**Table 3.4.**  
**Summary of Experimental Conditions - Phases 1 and 2**

---

**PHASE 1 (Approx. 5 Min.)**

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**Neuropsychological Factors**

Measured by the EEG

Condition Description

**Psychophysiological Factors**

Measured by the Davicon Medac System/3

Condition Description

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|             |                                    |             |                                    |
|-------------|------------------------------------|-------------|------------------------------------|
| <b>CO1A</b> | eyes opened (EO)                   | <b>XX</b>   |                                    |
| <b>CO2A</b> | eyes closed (EC)                   | <b>XX</b>   |                                    |
| <b>X</b>    |                                    | <b>CO1B</b> | relax (BPP) †                      |
| <b>CO3A</b> | active answering questions (BPP) † | <b>CO2B</b> | active answering questions (BPP) † |
| <b>X</b>    |                                    | <b>CO3B</b> | relax (BPP) †                      |

---

**PHASE 2 (Approx. 30 Min.)**

---

**Neuropsychophysiological Factors (Measured by both EEG and Davicon Medac System/3)**

Condition Description

---

|            |   |
|------------|---|
| <b>C1</b>  | Relaxation with eyes closed (C1-relax)  |
| <b>C2</b>  | Selecting from four options, the geometric shape that does not belong - 12 slides (C2-active shapes) (see Appendix J)                             |
| <b>C3</b>  | Relaxation with eyes closed (C3-relax)  |
| <b>C4</b>  | Verbal response to "cartoon" characters involved in a hypothetical situation involving conflict - 12 slides (C4-active cartoons) (see Appendix K) |
| <b>C5</b>  | Relaxation with eyes closed (C5-relax)  |
| <b>C6</b>  | Selecting from four options, the geometric shape that does not belong - 12 slides (C6-active shapes) (see Appendix J)                             |
| <b>C7</b>  | Relaxation with eyes closed (C7-relax)  |
| <b>C8</b>  | Verbal response to "cartoon" characters involved in a hypothetical situation involving conflict - 12 slides (C8-active cartoons) (see Appendix K) |
| <b>C9</b>  | Relaxation with eyes closed (C9-relax)  |
| <b>C10</b> | Visual-motor activity, paper and pencil drawing, student choice of content (C10-active drawing)   |
| <b>C11</b> | Relaxation with eyes closed (C11-relax)   |

---

**X - Data collected but not used in analysis**

**XX - No data collected**

**† - Timed condition**

### Phase 1

Phase 1 began with two brief, untimed, relaxation conditions that were monitored by the Grass Sixteen Channel Electroencephalograph (EEG) only. During the first relaxation condition (CO1A), the students were asked to sit comfortably with their eyes opened (EO) and during the second relaxation condition (CO2A), the students were asked to sit comfortably with their eyes closed (EC). The two conditions, eyes opened/eyes closed (EO/EC) were included in the study because there is evidence in the literature to suggest: 1) that brain wave reactivity patterns in the alpha frequency band (8-12 Hz) are affected by changes in visual stimuli (e.g. EO/EC) (Corning, Steffy, & Chaprin, 1982; Walker, 1980); and 2) that many participants need a 'warm-up' period to help them adjust to the general and specific sensory stimuli often found in a medical research laboratory (e.g. room temperature, white technician coats) (Mulholland, 1995; Wooding & Bingham, 1988).

Once the research team was satisfied that the student had adjusted reasonably well to the laboratory setting, the Davicon Medac System/3 and the IBM PC compatible computer system were activated so that the last three conditions of Phase 1 could be completed. To finish Phase 1 of the testing process, each student was required to complete The Brief Physiological Profile (Davicon, 1989).

The Brief Physiological Profile (BPP), a standardized software protocol designed to assess an individual's psychophysiological reactivity patterns to mild stress (Mehler, 1994), was delivered by the IBM PC compatible computer. It included three, timed conditions: 1) a two minute relaxation period where the students were asked to breathe deeply and relax (CO1B); 2) a 30 second simulated test sequence where the students were asked to read and verbally

answer three factual questions involving language, mathematical computation, and general knowledge (CO2B); and 3) a second two minute relaxation period where the students were asked, once again, to breathe deeply and relax (CO3B). The three questions that were asked in CO2B were: 1) Which is different? ball, worm, diamond, bat; 2) Solve the following problem:  $7 + 3 - 2 \times 3$ ; and 3) Spell the name of the capital city of England.

The Brief Physiological Profile (BPP) was selected for the study because it provided the research team with a “short standardized protocol for assessing physiological reactivity to a mild stress situation” (Mehler, 1994, p. 1), and it contained some of the rapid questioning techniques often used in a classroom environment (e.g. timed tests, pop quizzes, spelling bees). Since the BPP was not designed to test knowledge acquisition, no attempt was made in the study to record the number of correct/incorrect responses made by the student while completing the ‘active answering questions’ part of the profile.

In the study, two sets of data were printed after the student had completed the Brief Physiological Profile (BPP). The first set of data was a computer printout of the psychophysiological data that had been collected by the Davicon Medac System/3 for the three relax-active-relax conditions of the BPP (relax-CO1B, active answering questions-CO2B, relax-CO3B); and the second set of data was an EEG printout of the neuropsychological data collected by the Grass Sixteen Channel Electroencephalograph for the eyes opened condition (CO1A), the eyes closed condition (CO2A), and the three relax-active-relax conditions of the BPP (CO3A).

Since neuropsychological data had already been collected for two relaxation conditions (eyes opened-CO1A, eyes closed-CO2A) during the opening moments of Phase 1, the research

team decided to eliminate the neuropsychological data collected during the two relaxation conditions of the BPP (CO1B, CO3B) from the process of analysis. Thus, Phase 1 of the study contained three neuropsychological conditions - eyes opened (CO1A), eyes closed (CO2A), and active answering questions (CO3A), and three psychophysiological conditions - relax (CO1B), active answering questions (CO2B), and relax (CO3B).

## Phase 2

After the completion of Phase 1, the participant's chair was relocated so that the student was facing a slide projector, a white screen projection surface, and an electronic response machine. Since movement often affects sensor and electrode placement, the Grass Sixteen Channel Electroencephalograph (Grass Instrument Co., 1977) and the Davicon Medac System/3 (NeuroDyne Medical Corp., 1994) were checked, once again, for recording accuracy. Once the research team was satisfied with the technical performance of the equipment, Phase 2 of the testing process began.

Phase 2 contained 11 untimed conditions (C1-11) that had been placed in an alternating relax-active-relax pattern. The decision to sequence the 11 conditions in an alternating pattern was made because the pattern would help the researchers identify the beginning and the end of each condition, and help the students recover physically and neurologically from conditions of activity (Petsche, 1996; Pfurtscheller, 1992; Pfurtscheller, Stancák, & Neuper, 1996). The decision to include both timed and untimed conditions in the study was made because there is evidence in the literature to suggest that there are psychophysiological changes in the reactivity patterns of participants who are involved in tasks that are timed and untimed (Dykman,

Ackerman, & Oglesby, 1992). In addition, the research team wanted to limit the negative effects of data misinterpretation. Data misinterpretation often occurs when EEG fragments of insufficient length are analysed (Anokhin & Vogel, 1996).

The 24 slides that were used in conditions two and six (C2, C6) of the study came from the Halstead Category Test (Reitan, 1979); a timed, nonverbal test designed to measure the child's ability to solve problems, form concepts, and think abstractly (Incagnoli, Goldstein, & Golden, 1986; Jarvis & Barth, 1984). In its original form, the Halstead Category Test (HCT) asks the students to select, from a set of four possible options, the geometric shape that does not belong and record their answers on an automatic response machine by pressing one of four option buttons. The machine is designed to 1) ring a bell when a correct response is made, and 2) sound a buzzer when an incorrect response is made. An automatic response machine, with sound, was used in the study. Before starting the HCT the students were taught how to record their answers on the machine.

A modified version of the Halstead Category Test (HCT) was used in the study because unmodified versions of the test have been used by clinical neuropsychologists for a number of years (Bireley, Languis, & Williamson, 1992), and the multiple-choice testing format of the HCT was similar to the testing protocols often used in classroom settings. In addition, the HCT provided the students with a novel and complex thinking challenge. Complex thinking challenges tend to affect the neuropsychophysiological reactivity patterns of an individual more than tasks of simple rote and repetition (Dujardin, Bourriez, & Guieu, 1995; Shaw, 1996). Thus, they are often included in the research designs of clinicians and educators who want to generate a rich

and comprehensive database (Flynn, Deering, Goldstein, & Rahbar, 1992; Lubar, Mann, Gross, & Shively, 1992).

The 24 slides that were used in conditions four and eight (C4, C8) of the study came from the Rosenzweig Picture-Frustration Study (RPFS) (Rosenzweig, 1978), a test designed to measure “both constructive and hostile reactions to interpersonal frustration” (Viglione, 1985, p. 1295). In its original form, the RPFS asks the students to respond to a number of pictures of cartoon characters in conflict by recording their answers in written form. In the study, the students responded to the cartoon characters verbally while a member of the research team made a written record of their responses. Thus, the amount of sensor/electrode distortion caused by excessive movement was minimized (NeuroDyne Medical Corp., 1994).

A modified version of the Rosenzweig Picture-Frustration Study (RPFS) was used in the study because its cartoon-like format was familiar to most school-aged children. In addition, the RPFS gave the students an opportunity to respond emotionally to a hypothetical, non-threatening situation which involved mild conflict (Sweetland & Keyser, 1986). Activities that have been designed to elicit an emotional response tend to affect the neuropsychophysiological reactivity patterns of an individual (Davidson & Fox, 1988; Dawson, 1994). Thus, the RPFS was included in the study because the researcher was interested in examining these patterns in children who were 10-12 years of age.

The 48 slides of the Halstead Category Test and the Rosenzweig Picture-Frustration Study were delivered in four alternating sets of 12 (C2, C4, C6, C8) to minimize the effects of habituation. Habituation is “the reduction in the magnitude of response to a repeated stimulus event” (Fite, 1994, p. 8). In addition, the effects of habituation were minimized in the study by

1) changing the response format from tactile to verbal, 2) changing the response intensity from passive to active, and 3) changing the visual and auditory stimuli in the environment. By making such changes it was anticipated that the results would be more accurate (Andreassi, 1995; O’Gorman, 1973; Polich, 1987).

Finally, Torrance (1969) believes that the testing protocols used with children should include activities that will awaken their creative processes. Based upon some of the results of the pilot study conducted by Shaffer (1994), a drawing activity (C10) was included in the study. Specifically, during the pilot study, the psychophysiological recovery rate of one participant was unusually high during the drawing activity and the researcher was interested in examining this phenomenon more closely.

After completing all of the experimental conditions in Phase 1 and 2 of the study, each student was encouraged to remain seated and comfortable while the research team 1) removed the ECI Electro-Cap (Electro-Cap International, Inc., 1983), 2) disconnected the upper body sensors, 3) organized the volume of neuropsychological data collected by the EEG machine during Phase 2 of the testing process, and 3) organized the computer printout summary of the psychophysiological data collected by the Davicon Medac System/3 during Phase 2 of the testing process. After saying good-bye to the student and his/her parent/guardian, the researcher labelled all data sets with a numeric code that would be used as an anonymous identifier in the future.

The challenges of designing an experimental paradigm that approximates ‘the everyday life situations’ of its participants has been recognized by a number of authors (Carry, Bütter, Persinger, & Bialik, 1995; Petsche, 1996). Paradigms that reflect the everyday life situations of

its participants have ecological validity (Turner, 1994). The ecological validity of the current study, which attempted to examine the neuropsychophysiological reactivity patterns of students (10-12 years) during a mild stress test situation that simulated some of the testing practices currently found in classroom settings, was strengthened by 1) the familiar show-and-tell teaching strategies used by the investigator during the information sessions, 2) the multiple-choice and cartoon-like formats of the activities that were completed in the laboratory setting, and 3) the teacher/student rapport that was maintained throughout the delivery of the experimental design.

To screen for incidents of psychopathology, the data collected from the Junior Eysenck Personality Inventory (Eysenck, 1963) and the Children's Personality Questionnaire (Porter & Cattell, 1975) were read individually by a registered psychologist who did not know the group placements of the sample. Judgements about the psychological character of each participant were based upon this analysis.

To answer the two research questions posed by the investigator, the data collected by the Grass Sixteen Channel Electroencephalograph and the Davicon Medac System/3 were analysed in one of two ways. These included:

- 1) dichotomous data for two factors (the presence of alpha waves, the presence of hemispheric symmetry), were analysed using a Chi-Square Test (2 x 3 contingency table) to find if any association existed between the three groups (HA, G, GB) and each factor for each condition; and
- 2) continuous data for nine factors (amplitude, frequency, HR, SC, EMG-ARM, EMG-HEAD, TEMP, IBI, PH) were analysed using a Kruskal-Wallis Test, and, where the results were found to be significant, a Mann-Whitney U Test was used to test for paired comparisons (G-HA, G-GB, GB-HA) between the three groups for each condition.

This chapter reported on the research methodology by describing 1) the terms of reference, 2) the sample population, 3) the measuring instruments, 4) the factors, and 5) the procedures used for data collection. A glossary of terms that figured prominently in the chapter was included to facilitate understanding (Table 3.5). Chapters 4 and 5 present the results and interpretation of the data for the first and second research questions, respectively.

**Table 3.5**  
**Glossary of Terms - Chapter Three**

| <b>Term</b>                        | <b>Symbol</b>         | <b>Description/Explanation</b>  |
|------------------------------------|-----------------------|---|
| <b>Alpha Waves</b>                 | <b>None</b>           | <b>Neurocortical rhythms with a frequency of (8-12 Hz)</b>  |
| <b>Amplitude</b>                   | <b>None</b>           | <b>A measure of neurocortical strength and power</b>  |
| <b>Brief Physiological Profile</b> | <b>BPP</b>            | <b>A standardized software protocol designed to assess an individual's psychophysiological reactivity patterns to mild stress</b>                 |
| <b>Conditions 1-11</b>             | <b>C1-11</b>          | <b>Relax/active, untimed testing protocol used during Phase 2 (Measured by both the Grass Sixteen Channel EEG and the Davicon Medac System/3)</b> |
|                                    | <b>C1</b>             | <b>Relax</b>  |
|                                    | <b>C2</b>             | <b>Active - Halstead Category Test (geometric shape selection)</b>  |
|                                    | <b>C3</b>             | <b>Relax</b>  |
|                                    | <b>C4</b>             | <b>Active - Rosenzweig Picture Frustration Study (responding to cartoon figures in a hypothetical situation of frustration)</b>                   |
|                                    | <b>C5</b>             | <b>Relax</b>  |
|                                    | <b>C6</b>             | <b>Active - Halstead Category Test (geometric shape selection)</b>  |
|                                    | <b>C7</b>             | <b>Relax</b>  |
|                                    | <b>C8</b>             | <b>Active - Rosenzweig Picture Frustration Study (responding to cartoon figures in a hypothetical situation of frustration)</b>                   |
|                                    | <b>C9</b>             | <b>Relax</b>  |
|                                    | <b>C10</b>            | <b>Active - Student drawing</b>   |
|                                    | <b>C11</b>            | <b>Relax</b>  |
| <b>Conditions 1A-3A</b>            | <b>CO1A-<br/>CO3A</b> | <b>Relax/active, untimed/timed testing protocol used during Phase 1 and measured by the Grass Sixteen Channel EEG</b>                             |
|                                    | <b>CO1A</b>           | <b>Relax - Eyes opened</b>  |
|                                    | <b>CO2A</b>           | <b>Relax - Eyes closed</b>  |
|                                    | <b>CO3A</b>           | <b>Active- Answering three timed questions</b>  |

|                                      |               |  |
|--------------------------------------|---------------|--|
| Conditions 1B-3B                     | CO1B-<br>CO3B | Relax/active/relax, timed testing protocol used during Phase 1 and measured by the Davicon Medac System/3  |
|                                      | CO1B          | Relax  |
|                                      | CO2B<br>CO3B  | Active - Answering three timed questions<br>Relax  |
| Electromyography                     | EMG           | A measure of skeletal-muscular arousal and tension   |
|                                      | EMG-HEAD      | A measure of skeletal-muscular tension in the forehead   |
|                                      | EMG-ARM       | A measure of skeletal-muscular tension in the arm  |
| Frequency                            | None          | Number of times a particular wave shape is repeated in one second  |
| Halstead Category Test               | HCT           | A timed, nonverbal test designed to measure an individual's ability to solve problems, form concepts, and think abstractly - used as the testing protocol for C2 and C6. |
| Heart Rate                           | HR            | A measure of the cardiac cycle   |
| Hemispheric Symmetry                 | None          | A state of neurocortical arousal where the average amplitude strength of the right hemisphere corresponds to the average amplitude strength of the left hemisphere       |
| Inter-Beat-Interval                  | IBI           | Time between two consecutive heart beats   |
| Pulse Height                         | PH            | Measure of changes in peripheral blood flow  |
| Rosenzweig Picture Frustration Study | RPFS          | A test designed to measure both constructive and hostile reactions to interpersonal frustration - used as the testing protocol for C4 and C8.                            |
| Skin Conductance                     | SC            | A measure of electrodermal arousal (i.e. perspiration)   |
| Skin Temperature                     | TEMP          | A measure of overall body warmth   |

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## CHAPTER FOUR

### Results and Interpretation - Question 1

*“Neuropsychophysiology stems from a desire to know about behavior which is not discernible through mere observation.”*

*-J. Andreassi (1980, p. 4)*

The purpose of this chapter is to present the results of data analysis as they pertain to the first research question posed by the investigator:

- 1) What are the neuropsychophysiological patterns in individual assessments which differentiate students who are gifted from those of high average ability?

The chapter opens by 1) presenting the results of the procedures used to analyse the psychometric data collected by the Junior Eysenck Personality Inventory (Eysenck, 1963) and the Children’s Personality Questionnaire Form A (Porter & Cattell, 1975) during the information sessions, and 2) describing three non-parametric statistical tests used to analyse all of the neuropsychophysiological data collected during the investigation. Following this, the results of the procedures used to analyse the neuropsychological data collected by the Grass Sixteen Channel Electroencephalograph (Grass Instrument Co., 1977) and the psychophysiological data collected by the Davicon Medac System/3 (NeuroDyne Medical Corp., 1994) during Phases 1 and 2 of the testing period are presented.

Although the tables in this chapter contain information related to all three groups (i.e. HA, G, GB), the interpretations of the data related specifically to gifted behavioral students will be reserved for Chapter Five. Whereas, Chapter Five attempts to answer the second

research question which focuses on gifted students with perceived behavior problems, this chapter attempts to answer the first question by interpreting the data specifically related to gifted students.

### Psychometric Data

To review, the Junior Eysenck Personality Inventory (Junior E.P.I.) (Eysenck, 1963) and the Children's Personality Questionnaire Form A (CPQ-Form A) (Porter & Cadell, 1975) were used as screening devices to detect incidents of psychopathology in the sample. Towards this end, the Junior E.P.I. and the CPQ-Form A were scored manually according to the guidelines presented in the *Manual for the Junior Eysenck Personality Inventory* (Eysenck, 1963) and the *Children's Personality Questionnaire Handbook* (Porter & Cattell, 1992) respectively. The resulting values of both instruments were examined individually by a registered psychologist. The results of the examination suggest the absence of any incidents of psychopathology in the sample.

### Statistical Tests

Two types of neuropsychophysiological data were collected during the investigation. First, dichotomous data were collected for two factors (the presence of alpha waves, the presence of hemispheric symmetry). Second, continuous data were collected for nine factors - amplitude, frequency, heart rate (HR), skin conductance (SC), electromyography of the arm

(EMG-ARM), electromyography of the forehead (EMG-HEAD), skin temperature (TEMP), the inter-beat-interval (IBI), and pulse height (PH).

Three non-parametric statistical tests were used to analyse the data. First, a Chi-Square Test for proportions was used to analyse the dichotomous data. Second, a Kruskal-Wallis Test was used to analyse the continuous data, and third, where the analysis was found to be significant, a Mann-Whitney U Test was used to test for paired comparisons (G-HA, G-GB, GB-HA) between groups.

Table 4.1 presents the statistical tests used to analyse the various types of data collected during the study. The decision to use non-parametric statistical tests to analyse the neuropsychophysiological data collected during the study was made after it was determined that the values attained by the subjects were not normally distributed as tested by the Kolmogorov-Smirnov Goodness of Fit for Normality.

### Neuropsychological Data - Phase 1

#### Continuous Data - Amplitude and Frequency (Phase 1)

The data collected during the short, untimed/timed, relax/active, simulated test sequence of Phase 1 (approx. 5 min.) for the amplitude and frequency measures were analysed using a Kruskal-Wallis Test and, where the results were found to be significant, a Mann-Whitney U Test was used to test for paired comparisons (G-HA, G-GB, GB-HA) between groups. The analysis was performed on each of the three relax/active conditions (CO1A-relax eyes opened, CO2A-relax eyes closed, CO3A-active answering questions).

**Table 4.1**  
**Statistical Tests Used to Analyse the Data**

| <b>Test</b>  | <b>Type of Data</b> | <b>Factors Included</b>   |
|--|---------------------|---|
| <b>Chi-Square Test<br/>for Proportions</b>               | <b>Dichotomous</b>  | <b>Presence of Alpha Waves<br/>Presence of Hemispheric Symmetry</b>           |
| <b>Kruskal-Wallis Test<br/>&amp; Mann-Whitney U Test</b> | <b>Continuous</b>   | <b>Amplitude, Frequency, HR, SC,<br/>EMG-ARM, EMG-HEAD, TEMP,<br/>IBI, PH</b> |

Due to a technological malfunction in the Grass Sixteen Channel Electroencephalograph (Grass Instrument Co., 1977), the data of two subjects (gifted) had to be excluded from the process of analysis. Thus, the data of 64 students (66-2) were included in the analysis. Tables 4.2 and 4.3 present the results of the Kruskal-Wallis and Mann-Whitney U Tests for the amplitude and frequency measures respectively for Phase 1.

The results of the Kruskal-Wallis Test for the amplitude measure (Table 4.2) show that significant differences were observed for all three relax/active conditions during Phase 1 of the testing period. Specifically, differences at the  $p \leq 0.01$  and  $p \leq 0.05$  levels were observed for CO2A, and CO1A and CO3A respectively.

The interpretation of the results of the Mann-Whitney U Test for the amplitude measure (Table 4.2) ( $p \leq 0.05$ ) shows that the mean rank of amplitude values (MRAV) of the gifted students were significantly higher than those of the high average students ( $G > HA$ ) for all three relax/active conditions (CO1A, CO2A, CO3A). These results suggest that, compared to high average students, gifted students tend to have higher amplitude values during conditions of relaxation and activity. Since higher amplitude values differentiated G from HA during two untimed conditions of relaxation (CO1A, CO2A) and one timed condition of activity (CO3A), these results also suggest that the measure may have potential as an identifier of gifted students who are involved in a relatively short, untimed/timed, relax/active simulated test sequence.

The results of the Kruskal-Wallis Test for the frequency measure (Table 4.3) show that significant differences were observed for only one of the three relax/active conditions during Phase 1. Significant differences ( $p \leq 0.01$ ) were observed for CO3A and levels of significance higher than 0.05 were observed for CO1A and CO2A.

**Table 4.2**  
**Results of Kruskal-Wallis Test and Paired Comparisons Between Groups for Amplitude -**  
**Phase 1**

| Condition           | K-W<br>Chi-Square<br>(df = 2) | p        | Mean Ranks     |               |                | Paired Comparisons |          |          |
|---------------------|-------------------------------|----------|----------------|---------------|----------------|--------------------|----------|----------|
|                     |                               |          | HA<br>(n = 20) | G<br>(n = 24) | GB<br>(n = 20) | G > HA             | G > GB   | GB = HA  |
| CO1A<br>Eyes Opened | 8.61                          | p ≤ 0.05 | 25.63          | 40.83         | 29.38          | p = 0.05           | p = 0.04 | p = 0.56 |
| CO2A<br>Eyes Closed | 9.58                          | p ≤ 0.01 | 24.45          | 41.15         | 30.17          | p = 0.01           | p = 0.05 | p = 0.33 |
| CO3A<br>Questions   | 6.35                          | p ≤ 0.05 | 26.65          | 39.69         | 29.73          | p = 0.02           | p = 0.09 | p = 0.66 |

**Table 4.3**  
**Results of Kruskal-Wallis Test and Paired Comparisons Between Groups for Frequency - Phase 1**

| Condition           | K-W<br>Chi-Square<br>(df = 2) | p        | Mean Ranks     |               |                | Paired Comparisons |          |          |
|---------------------|-------------------------------|----------|----------------|---------------|----------------|--------------------|----------|----------|
|                     |                               |          | HA<br>(n = 20) | G<br>(n = 24) | GB<br>(n = 20) | G > HA             | G > GB   | GB = HA  |
| CO1A<br>Eyes Opened | 3.64                          | p > 0.05 | 38.85          | 28.50         | 30.95          | p = 0.06           | p = 0.81 | p = 0.27 |
| CO2A<br>Eyes Closed | .90                           | p > 0.05 | 35.65          | 31.65         | 30.38          | p = 0.47           | p = 0.82 | p = 0.36 |
| CO3A<br>Questions   | 9.26                          | p ≤ 0.01 | 42.40          | 30.46         | 25.05          | p = 0.03           | p = 0.31 | p = 0.01 |

The interpretation of the results of the Mann-Whitney U Test for the frequency measure (Table 4.3) ( $p \leq 0.05$ ) shows that the mean rank of frequency values (MRFV) of the high average students were significantly higher than those of gifted students (G > HA) for CO3A only. These results suggest that, compared to gifted students, high average students tend to have higher frequency values during conditions of activity but not relaxation. Since lower frequency values differentiated G from HA during one condition of activity (CO3A), these results also suggest that the measure may have potential as an identifier of gifted students who are involved in a relatively short, untimed/timed, relax/active, simulated test sequence.

#### Dichotomous Data - Presence of Alpha Waves and Presence of Hemispheric Symmetry

##### (Phase 1)

The data collected during the short, untimed/timed, relax/active, simulated test sequence of Phase 1 (approx. 5 min.) for the two dichotomous measures (the presence of alpha waves, the presence of hemispheric symmetry) were analysed using a Chi-Square Test with a 2 x 3 contingency table to find if any association existed between the three groups (HA, G, GB) and one of the dichotomous measures for each of the three relax/active conditions (CO1A-relax eyes opened, CO2A-relax eyes closed, CO3A-active answering questions). The data of 64 students were included in the analysis. As an example of the six two-by-three (2 x 3) contingency tables produced during the process of analysis, Table 4.4 presents the results of the Chi-Square Test for the presence of hemispheric symmetry measure for condition CO3A (active-answering questions) during Phase 1 of the testing period.

**Table 4.4**  
**Example - Results of Chi-Square Test for the Presence of Hemispheric Symmetry Measure for CO3A for HA, G, GB - Phase 1**

| Count<br>Row %<br>Column %<br>Total % | Presence                      | Absence                       | Total               |
|---------------------------------------|-------------------------------|-------------------------------|---------------------|
| High Average (n)                      | 14<br>70.0%<br>40.0%<br>21.9% | 6<br>30.0%<br>20.7%<br>9.4%   | 20<br><br><br>31.3% |
| Gifted (n)                            | 10<br>41.7%<br>28.6%<br>15.6% | 14<br>58.3%<br>48.3%<br>21.9% | 24<br><br><br>37.5% |
| Gifted Beh. (n)                       | 11<br>55.0%<br>31.4%<br>17.2% | 9<br>45.0%<br>31.0%<br>14.1%  | 20<br><br><br>31.3% |
| Chi-Square (2) =<br>Total (n)         | 3.535<br>35<br>54.7%          | p = 0.17<br>29<br>45.3%       | 64<br>100.0%        |

The results of the Chi Square Test for the presence of hemispheric symmetry measure show that the two variables (groups and the presence of hemispheric symmetry) for CO3A are not associated because the chi-square value ( $p=0.17$ ) was not significant at the 0.05 level. Similar results were observed for the five remaining contingency tables. Since, none of the 2 x 3 contingency tables produced during the analysis revealed significant chi-square values at the 0.05 level, these results suggest that the two dichotomous measures (the presence of alpha waves, the presence of hemispheric symmetry) may have little or no potential as identifiers of gifted students who are involved in a relatively short, untimed/timed, relax/active, simulated test sequence.

## Neuropsychological Data - Phase 2

### Continuous Data - Amplitude and Frequency (Phase 2)

To review, Phase 2 of the investigation was a relatively long simulated test sequence (approx. 30 min.) containing 11 untimed relax/active conditions (C1-C11). The procedures used to analyse the continuous data collected during Phases 1 and 2 of the study ( $n=64$ ) were identical (see p. 82). Table 4.5 presents the results of the Kruskal-Wallis and Mann-Whitney U Tests for the amplitude measure for Phase 2.

Generally, the results of the Kruskal-Wallis Test for the amplitude measure show:

1) Chi-Square values of 8.18-14.96; and 2) significant differences for all 11 relax/active conditions during Phase 2 of the testing period. Specifically, differences at the  $p \leq 0.01$  level were observed for six conditions (C1, C2, C4, C7, C8, C10), and differences at the  $p \leq 0.001$  and  $p \leq 0.05$  levels were observed for one (C3) and four conditions (C5, C6, C9, C11) respectively.

**Table 4.5**  
**Results of Kruskal-Wallis Test and Paired Comparisons Between Groups for Amplitude - Phase 2**

| Condition               | K-W<br>Chi-Square<br>(df = 2) | p                | Mean Ranks     |               |                | Paired Comparisons |                 |                 |
|-------------------------|-------------------------------|------------------|----------------|---------------|----------------|--------------------|-----------------|-----------------|
|                         |                               |                  | HA<br>(n = 20) | G<br>(n = 24) | GB<br>(n = 20) | G > HA             | G > GB          | GB=HA           |
| C1<br>Relax             | 10.03                         | <b>p ≤ 0.01</b>  | 25.08          | <b>41.60</b>  | 29.00          | <b>p = 0.01</b>    | <b>p = 0.02</b> | <b>p = 0.47</b> |
| C2<br>Shapes (Active)   | 9.34                          | <b>p ≤ 0.01</b>  | 24.85          | <b>40.65</b>  | 30.38          | <b>p = 0.01</b>    | <b>p = 0.06</b> | <b>p = 0.30</b> |
| C3<br>Relax             | 14.96                         | <b>p ≤ 0.001</b> | 22.65          | <b>43.43</b>  | 29.27          | <b>p = 0.001</b>   | <b>p = 0.01</b> | <b>p = 0.30</b> |
| C4<br>Cartoons (Active) | 8.18                          | <b>p ≤ 0.01</b>  | 23.27          | <b>37.85</b>  | 33.30          | <b>p = 0.01</b>    | <b>p = 0.63</b> | <b>p = 0.06</b> |
| C5<br>Relax             | 8.86                          | <b>p ≤ 0.05</b>  | 25.65          | <b>41.02</b>  | 29.13          | <b>p = 0.01</b>    | <b>p = 0.03</b> | <b>p = 0.53</b> |
| C6<br>Shapes (Active)   | 8.76                          | <b>p ≤ 0.05</b>  | 23.98          | <b>39.94</b>  | 32.10          | <b>p = 0.01</b>    | <b>p = 0.13</b> | <b>p = 0.13</b> |
| C7<br>Relax             | 10.54                         | <b>p ≤ 0.01</b>  | 24.10          | <b>41.60</b>  | 29.98          | <b>p = 0.01</b>    | <b>p = 0.03</b> | <b>p = 0.27</b> |
| C8<br>Cartoons (Active) | 9.52                          | <b>p ≤ 0.01</b>  | 24.13          | <b>40.67</b>  | 31.08          | <b>p = 0.01</b>    | <b>p = 0.08</b> | <b>p = 0.22</b> |
| C9<br>Relax             | 8.79                          | <b>p ≤ 0.05</b>  | 26.48          | <b>41.13</b>  | 28.17          | <b>p = 0.01</b>    | <b>p = 0.02</b> | <b>p = 0.78</b> |
| C10<br>Drawing (Active) | 11.26                         | <b>p ≤ 0.01</b>  | 25.02          | <b>41.83</b>  | 28.70          | <b>p = 0.01</b>    | <b>p = 0.02</b> | <b>p = 0.56</b> |
| C11<br>Relax            | 8.40                          | <b>p ≤ 0.05</b>  | 25.27          | <b>40.67</b>  | 29.92          | <b>p = 0.01</b>    | <b>p = 0.06</b> | <b>p = 0.47</b> |

The interpretation of the results of the Mann-Whitney U Test for the amplitude measure ( $p \leq 0.05$ ) shows that the mean rank of amplitude values (MRAV) of the gifted students was significantly higher than those of the high average students ( $G > HA$ ) for all 11 relax/active conditions (C1-C11). Like Phase 1, these results suggest that, compared to high average students, gifted students tend to have higher amplitude values during conditions of relaxation and activity. Since higher amplitude values differentiated G from HA during 11 relax/active conditions (C1-C11), the results also suggest that the measure may have potential as an identifier of gifted students who are involved in a relatively long, untimed, relax/active simulated test sequence.

The results of the Kruskal-Wallis Test for the frequency measure revealed that levels of significance higher than 0.05 were obtained for all 11 relax/active conditions (C1-C11) during Phase 2. Since there were no significant differences ( $p \leq 0.05$ ) for any of the conditions during the phase, these results suggest that the measure may have little or no potential as an identifier of G who are involved in simulated test sequences similar to those described above. Significant differences ( $p \leq 0.05$ ), however, were observed for the frequency measure during Phase 1 of the testing period.

### Dichotomous Data - Presence of Alpha Waves and Presence of Hemispheric Symmetry

#### (Phase 2)

The procedures used to analyse the dichotomous data collected during Phases 1 and 2 of the study ( $n=64$ ) were identical (see p. 87). Of the 22 two-by-three ( $2 \times 3$ ) contingency tables produced during the process of analysis during Phase 2, only one was found to be significant

( $p \leq 0.05$ ) - the presence of alpha waves measure for C3 (relax). Table 4.6 presents the results of the Chi-Square Test for the presence of alpha waves measure for C3 during Phase 2 of the testing period.

The results of the Chi Square Test for the presence of alpha waves measure show that the two variables (groups and the presence of alpha waves) for C3 are associated because the chi-square value ( $p=0.02$ ) was significant at the 0.05 level. The results also show: 1) that alpha waves were present for 95.8% of the gifted students; 2) that alpha waves were present for 70.0% of the gifted behavioral students; and 3) that alpha waves were present for 65.0 % of the high average students. These results suggest that, compared to students of high average ability, gifted students tend to have more alpha waves during some conditions of relaxation (C3).

Since higher amounts of alpha waves differentiated G from HA during one condition of relaxation, these results also suggest that the presence of alpha waves measure may have potential as an identifier of gifted students who are involved in a relatively long, untimed, relax/active simulated test sequence. Conversely, since there were no significant differences ( $p \leq 0.05$ ) observed for any of the conditions (C1-C11) for the presence of hemispheric symmetry measure, these results suggest that the measure may have little or no potential as an identifier of gifted students who are involved in simulated test sequences similar to those described above. Overall, these results are similar to those obtained for Phase 1.

**Table 4.6**  
**Results of Chi-Square Test for the Presence of Alpha Waves Measure for C3 for HA, G, GB - Phase 2**

| Count<br>Row %<br>Column %<br>Total % | Presence                      | Absence                      | Total               |
|---------------------------------------|-------------------------------|------------------------------|---------------------|
| High Average (n)                      | 13<br>65.0%<br>26.0%<br>20.3% | 7<br>35.0%<br>50.0%<br>10.9% | 20<br><br><br>31.3% |
| Gifted (n)                            | 23<br>95.8%<br>46.0%<br>35.9% | 1<br>4.2%<br>7.1%<br>1.6%    | 24<br><br><br>37.5% |
| Gifted Beh. (n)                       | 14<br>70.0%<br>28.0%<br>21.9% | 6<br>30.0%<br>42.9%<br>9.4%  | 20<br><br><br>31.3% |
| Chi-Square (2) =<br>Total (n)         | 7.192<br>50<br>78.1%          | p = 0.02<br>14<br>21.9%      | 64<br>100.0         |

## Psychophysiological Data - Phase 1

### Continuous Data - Seven Psychophysiological Measures (Phase 1)

The Davicon Medac System/3 (NeuroDyne Medical Corp., 1994) performed two data management functions during Phase 1 of the testing period. First, the system collected continuous data for seven psychophysiological measures (HR, SC, EMG-ARM, EMG-HEAD, TEMP, IBI, PH) for three conditions (CO1B, CO2B, CO3B), and second, the system electronically reduced the continuous data to seven values (%) which represented the percentage of recovery obtained for each measure after the three conditions had been completed by the students. When grouped together, the three conditions formed a relatively short, timed, relax-active-relax simulated test sequence called the Brief Physiological Profile (BPP) (NeuroDyne Medical Corp., 1994). The BPP was developed to assess an individual's psychophysiological reactivity patterns to a situation involving mild stress.

Although continuous data were collected for seven psychophysiological measures for each of the conditions of the BPP during Phase 1 of the testing period, only the percentage of recovery values that were calculated electronically by the Davicon Medac System/3 (NeuroDyne Medical Corp., 1994) for each measure after the completion of the BPP were analysed. The decision to analyse the percentage of recovery data instead of the continuous data was based upon the technical capabilities of the Davicon Medac System/3. Generally, biological systems which recover quickly from mild to moderate stress-enhancing situations tend to be associated with states of psychophysiological flexibility and stability (Lanzetta, Cartwright-Smith, & Kleck,

1976). Conversely, systems which recover slowly from such situations tend to be associated with states of psychophysiological instability and stimulus-rejection (Shagass, 1977).

In the study, the percentage of recovery values calculated for each of the measures were analysed using a Kruskal-Wallis Test. Where the analysis was found to be significant, a Mann-Whitney U Test was used to compare the groups by pairs (G-HA, G-GB, GB-HA).

Due to the electronic medical alert capabilities of the Davicon Medac System/3 (NeuroDyne Medical Corp., 1994), the data of 27 students (13 HA, 11 G, three GB) had to be excluded from the process of analysis. As previously noted in Chapter Three, the Davicon Medac System/3 has been designed to respond to the earliest signs of oxygen/glucose deprivation. During moments of vasoconstriction (i.e. decreasing PH values indicating a decrease in blood flow throughout the cardiovascular system), the graphic displays on the computer's monitor arrest and numeric values of 0.00 are recorded on the database for all measures. Since numeric values of 0.00 for all seven psychophysiological measures were recorded on the databases of 27 subjects during Phase 1 of the testing period, the data of these subjects were excluded from the process of analysis. The number (27) represented a 41% (27÷66) loss in useable data. Thus, the data of only 39 students (66-27) were included in the analysis. Table 4.7 presents the results of the Kruskal-Wallis and Mann-Whitney U Tests for the percentage of recovery values for the seven psychophysiological measures for Phase 1.

Generally, the results of the Kruskal-Wallis Test for the percentage of recovery values for the seven psychophysiological measures show: 1) Chi-Square values of .19-11.40; and 2) significant differences for two of the measures. Specifically, differences at the  $p \leq 0.01$  level

**Table 4.7**  
**Results of Kruskal-Wallis and Paired Comparisons Between Groups for the Percentage of Recovery Values for Seven Psychophysiological Measures - Phase 1**

| Condition                  | K-W<br>Chi-Square<br>(df = 2) | p        | Mean Ranks    |               |                | Paired Comparisons |                 |                 |
|----------------------------|-------------------------------|----------|---------------|---------------|----------------|--------------------|-----------------|-----------------|
|                            |                               |          | HA<br>(n = 7) | G<br>(n = 15) | GB<br>(n = 17) | G > HA             | G > GB          | GB=HA           |
| Heart Rate<br>(HR)         | 5.60                          | p > 0.05 | 14.25         | 18.43         | 25.26          | p = 0.33           | p = 0.82        | p = 0.60        |
| Skin Conduct.<br>(SC)      | .19                           | p > 0.05 | 21.25         | 19.47         | 21.06          | p = 0.72           | p = 0.71        | p = 0.98        |
| Electro-Arm<br>(EMG-ARM)   | 1.71                          | p > 0.05 | 21.88         | 17.40         | 22.59          | p = 0.27           | p = 0.28        | p = 0.75        |
| Electro-Head<br>(EMG-HEAD) | 6.99                          | p ≤ 0.01 | 20.29         | <b>25.60</b>  | 14.94          | p = 0.36           | <b>p = 0.01</b> | p = 0.35        |
| Temperature<br>(TEMP)      | 4.27                          | p > 0.05 | 31.61         | 21.87         | 30.86          | p = 0.06           | p = 0.11        | p = 0.96        |
| Inter-Beat-Int.<br>(IBI)   | 11.40                         | p ≤ 0.01 | <b>32.88</b>  | 18.33         | 16.59          | <b>p = 0.01</b>    | p = 0.53        | <b>p = 0.01</b> |
| Pulse Height<br>(PH)       | 4.33                          | p > 0.05 | 15.81         | 25.30         | 18.47          | p = 0.06           | p = 0.13        | p = 0.71        |

were observed for EMG-HEAD and IBI. In addition, levels of significance higher than 0.05 were observed for the remaining five variables (HR, SC, EMG-ARM, TEMP, PH).

The interpretation of the results of the Mann-Whitney U Test for the IBI measure ( $p \leq 0.01$ ) shows that the mean rank of the percentage of recovery values of the high average students were significantly higher than those of gifted students ( $G \succ HA$ ). These results suggest that, compared to gifted students, high average students tend to recover more quickly and completely from changes in the inter-beat-interval.

Since lower IBI percentage of recovery values differentiated G from HA, these results also suggest that the measure may have potential as an identifier of gifted students who are involved in a relatively short, timed, relax-active-relax simulated test sequence. Conversely, since there were no significant differences ( $p \leq 0.05$ ) observed for the percentage of recovery values for HR, SC, EMG-ARM, TEMP, PH, the results suggest that these measures may have little or no potential as identifiers of gifted students who are involved in simulated test sequences similar to those described above.

Although the analysis revealed levels of significance ( $p \leq 0.01$ ) for two measures (EMG-HEAD, IBI), all of the results presented here should be considered as tentative because the data of 27 students (41% of the sample) had to be excluded from the process of analysis. For instance, since the data of only seven high average students were included in the analysis, the interpretations associated with the mean rank of the percentage of recovery values for the IBI measure may be in question.

To obtain a more accurate picture of the systemic recovery potential of high average students, perhaps it would be wise to review the number of students who had to be excluded

from the analysis because their systems were unable to recover from the testing experience in the time allotted. Since the system-wide recovery rates of 65% (13÷20) of the high average group were at the 0.00% level, this data suggest that, compared to gifted students, high average students may not be able to recover quickly from changes in the inter-beat-interval. Since the Davicon Medac System/3 recorded 0.00 values on the databases of 27 students, it is unclear whether the results of the high average students were due to the design of the equipment or the physiological nature of the students. Additional research will be required to clarify these apparent discrepancies in interpretation.

### Psychophysiological Data - Phase 2

#### Continuous Data - Seven Psychophysiological Measures (Phase 2)

The procedures used to analyse the continuous data collected during the long, untimed, relax/active, simulated test sequence of Phase 2 (approx. 30 min.) for the seven psychophysiological measures (HR, SC, EMG-ARM, EMG-HEAD, TEMP, IBI, PH) were identical to those used to analyse the continuous neuropsychological data in Phase 1 (see p. 82). Due to a technological malfunction in the IBM PC compatible computer system, the data of three students (one HA, one G, one GB) had to be excluded from the process of analysis, and due to the electronic medical alert capabilities of the Davicon Medac System/3 (NeuroDyne Medical Corp., 1994), the data of five more students (four G, one GB) also had to be excluded. Thus, the data of 58 students (66-8) were included in the analysis.

The results of the Kruskal-Wallis Test for the seven psychophysiological measures revealed no significant differences ( $p < 0.05$ ) for any of the relax/active conditions (C1-C11) during Phase 2. These results suggest that HR, SC, EMG-ARM, EMG-HEAD, TEMP, IBI, PH may have little or no potential as identifiers of gifted students who are involved in a relatively long, untimed, relax-active simulated test sequence.

#### Summary: Question 1 Answered

**Question 1:** What are the neuropsychophysiological patterns in individual assessments which differentiate students who are gifted from those of high average ability?

The results of the analysis of the neuropsychophysiological data collected during the investigation suggest that, within specific testing parameters, three neuropsychological and one psychophysiological measure may have potential as identifiers of gifted students. Table 4.8 summarizes the neuropsychophysiological measures that differentiated gifted students from those of high average ability.

The summary suggests that there are a number of neuropsychophysiological differences between gifted and high average ability students who are involved in a simulated test sequence. The most robust difference between the two groups is in the amplitude measure which differentiated the two groups during both untimed and timed conditions of relaxation and activity. Since amplitude is a measure of neurocortical power and strength, this finding suggests

**Table 4.8**  
**Summary of Neuropsychophysiological Measures that Differentiated G and HA - Phases 1 and 2**

| Measure                 | n  | Strength of Value     | Groups Differentiated | Testing Parameters          |                             |
|-------------------------|----|-----------------------|-----------------------|-----------------------------|-----------------------------|
|                         |    |                       |                       | Conditions                  | Duration of Test Sequence   |
| Amplitude               | 64 | Higher                | G from HA             | Relax and Active            | Short (5 Min.)† and Long †† |
| Frequency               | 64 | Lower                 | G from HA             | Active                      | Short (5 Min.)†             |
| Presence of Alpha Waves | 64 | Higher Amounts        | G from HA             | Relax                       | Long ††                     |
| Inter-Beat Interval     | 39 | Smaller % of Recovery | G from HA             | Relax/Active/Relax Sequence | Short (5 Min.)†             |

† Timed simulated test sequence

†† Untimed simulated test sequence

that gifted students bring more “thinking power” to situations involving rest and performance than those of high average ability.

The summary also highlights the importance of including both untimed/timed and relax/active conditions in the identification procedures. For instance, whereas the frequency measure emerged as an identifier of gifted students during one timed condition of activity; the presence of alpha waves measure became an identifier of the population during one untimed condition of relaxation.

Since lower frequency values and higher amounts of alpha waves tend to signal the presence of neurocortical endurance and flexibility, these findings also suggest that the thinking patterns of gifted students are more stable and adaptable than those of high average ability during conditions of relaxation and performance. However, further investigation will be required to substantiate this finding since the smaller IBI percentage of recovery rate obtained for the gifted students contradicts this interpretation (HA n=7, G n=15). Overall, the results of this study suggest that gifted and high average ability students can be differentiated using a neuropsychophysiological paradigm.

The purpose of this chapter was to present the results of data analysis as they pertained to the first research question posed by the investigator. Specifically, the results of the procedures used to analyse the psychometric data collected during the information sessions, and the neuropsychophysiological data collected during Phases 1 and 2 of the testing period, were discussed. The following chapter focuses on Question 2 of the study.

## CHAPTER FIVE

### Results and Interpretation - Question 2

*"The goal of research should not be the creation of a new stereotype, rather it should lead to broader, more equitable guidelines for recognizing giftedness among diverse populations."*

*-J. Rogers & A. Neilson (1993, p. 264)*

This chapter answers the second research question:

2) What criteria can be drawn that will be helpful in the identification of students who are gifted with perceived behavior problems?

To do this, the results of the analysis of the neuropsychophysiological data presented in Chapter Four will be revisited, and, where the analysis relates specifically to gifted students with perceived behavior problems, the interpretations will be presented here. To facilitate understanding, many of the headings used in Chapter Four will be repeated in Chapter Five.

### Neuropsychological Data - Phase 1

#### Continuous Data - Amplitude and Frequency (Phase 1)

The interpretation of the results of the Mann-Whitney U Test for the amplitude measure (Table 4.2) ( $p \leq 0.05$ ) shows that the mean rank of amplitude values (MRAV) of the gifted students were significantly higher than those of gifted behavioral students ( $G > GB$ ) for conditions of relaxation (CO1A, CO2A) but not activity (CO3A). The interpretation also shows that there

were no significant differences in the MRAV of gifted behavioral and high average students (GB=HA) during Phase 1.

These results ( $p \leq 0.05$ ) suggest that, compared to gifted behavioral students, gifted students tend to have higher amplitude values during conditions of relaxation but not activity. Since lower amplitude values differentiated GB from G during two untimed conditions of relaxation (CO1A, CO2A), these results also suggest that the measure may have potential as an identifier of gifted students with perceived behavior problems who are involved in a relatively short, untimed/timed, relax/active simulated test sequence.

In addition, the descriptive statistics listed in the Kruskal-Wallis Test for this measure show that the ranges of the mean rank of amplitude values for the high average (HA), gifted behavioral (GB), and gifted (G) students were 24.45 - 26.65, 29.38 - 30.17, and 39.69 - 41.15 respectively. These results suggest that there is a tendency for the mean rank of amplitude values (MRAV) of the gifted behavioral students to be mutually exclusive of the MRAV of the other two groups during untimed/timed conditions of relaxation and activity (CO1A-CO3A).

The results suggest the presence of three distinct groups - HA, G, and GB. To date, the existence of a subgroup of gifted students with perceived behavior problems has not been completely substantiated by the literature.

The interpretation of the results of the Mann-Whitney U Test for the frequency measure (Table 4.3) ( $p \leq 0.05$ ) shows 1) that the mean rank of frequency values (MRFV) of the high average students were significantly higher than those of the gifted behavioral students for CO3A (active-answering questions), and 2) that there were no significant differences in the MRFV of gifted and gifted behavioral groups during the phase. These results suggest that, compared to

gifted behavioral students, high average students tend to have higher frequency values during conditions of activity but not relaxation. Since lower frequency values differentiated GB from HA during one condition of activity (CO3A), these results also suggest that the measure may have potential as an identifier of gifted students with perceived behavior problems who are involved in a relatively short, untimed/timed, relax/active, simulated test sequence.

### Dichotomous Data - Presence of Alpha Waves and Presence of Hemispheric Symmetry

#### (Phase 1)

To review, six 2 x 3 contingency tables were produced during the analysis (i.e. Chi-Square Test). Since none of the tables revealed significant chi-square values at the 0.05 level (Table 4.4), these results suggest that the two dichotomous measures (the presence of alpha waves, the presence of hemispheric symmetry) may have little or no potential as identifiers of gifted students with perceived behavior problems who are involved in a relatively short, untimed/timed, relax/active, simulated test sequence.

### Neuropsychological Data - Phase 2

#### Continuous Data - Amplitude and Frequency (Phase 2)

The interpretation of the results of the Mann-Whitney U Test for the amplitude measure (Table 4.5) ( $p \leq 0.05$ ) shows that the mean rank of amplitude values (MRAV) of the gifted students were significantly higher than those of gifted behavioral students ( $G > GB$ ) for five of the six relax conditions (C1, C3, C5, C7, C9) and one of the five active conditions (C10). The

interpretation also shows that there were no significant differences in the MRV of gifted behavioral and high average students (GB=HA) during the phase.

Like Phase 1, these results ( $p \leq 0.05$ ) suggest that, compared to gifted behavioral students, gifted students tend to have higher amplitude values during conditions of relaxation instead of activity. Since lower amplitude values differentiated GB from G during one active condition (C10) and five relax conditions (C1, C3, C5, C7, C9), these results suggest that the measure may have potential as an identifier of gifted students with perceived behavior problems who are involved in a relatively long, untimed, relax/active, simulated test sequence.

In addition, the descriptive statistics listed in the Kruskal-Wallis Test for this measure show that the ranges of mean rank of amplitude values for the high average (HA), gifted behavioral (GB), and gifted (G) students were 22.65 - 26.48, 28.17 - 33.30, and 37.85 - 43.43 respectively. These results suggest that there is a tendency for the mean rank of amplitude values (MRV) of the gifted behavioral students to be mutually exclusive of the MRV of the other two groups during untimed conditions of relaxation and activity (C1-C11). Once again, these results suggest the presence of three distinct groups - HA, G, and GB.

The results of the Kruskal-Wallis Test for the frequency measure revealed no significant differences ( $p \leq 0.05$ ) for any of the relax/active conditions (C1-C11) during Phase 2. These results suggest that the measure may have little or no potential as an identifier of gifted students with perceived behavior problems who are involved in a relatively long, untimed, relax/active, simulated test sequence. Significant differences ( $p \leq 0.05$ ) were observed for the frequency measure during Phase 1 of the testing period.

**Dichotomous Data - Presence of Alpha Waves and Presence of Hemispheric Symmetry****(Phase 2)**

The results of the Chi-Square Test for the presence of alpha waves measure (Table 4.6) show that the two variables (groups and the presence of alpha waves) for C3 are dependent because the chi-square value ( $p=0.02$ ) was significant at the 0.05 level. The results also show that alpha waves were present for 65.0% of the high average (HA), 70.0% of the gifted behavioral (GB), and 95.8% of the gifted (G) students. These results suggest, that GB tend to have more alpha waves than HA but less than G during some conditions of relaxation (C3).

Since lower amounts of alpha waves differentiated GB from G, and higher amounts of the wave differentiated GB from HA for one relax condition (C3), these results suggest that the presence of alpha waves measure may have potential as an identifier of gifted students with perceived behavior problems who are involved in a relatively long, untimed, relax/active, simulated test sequence. Conversely, since there were no significant differences ( $p \leq 0.05$ ) observed for any of the conditions (C1-C11) for the presence of hemispheric symmetry measure, these results suggest that the measure may have little or no potential as an identifier of GB who are involved in simulated test sequences similar to those described above. Overall, these results are similar to those obtained for Phase 1.

## Psychophysiological Data - Phase 1

Continuous Data - Seven Psychophysiological Measures (Phase 1)

The interpretation of the results of the Mann-Whitney U Test for the EMG-HEAD measure (Table 4.7) ( $p \leq 0.01$ ) shows that the mean rank of the percentage of recovery values of the gifted students were significantly higher than those of the gifted behavioral students ( $G > GB$ ). These results suggest that, compared to gifted behavioral students, gifted students tend to recover more quickly and completely from electromyographic (muscle tension) changes in the forehead.

The interpretation of the results of the Mann-Whitney U Test for the IBI measure (Table 4.7) ( $p \leq 0.01$ ) shows that the mean rank of the percentage of recovery values of the high average students were significantly higher than those of the gifted behavioral students ( $GB \neq HA$ ). These results suggest that, compared to gifted behavioral students, high average students tend to recover more quickly and completely from changes in the inter-beat-interval.

Since lower EMG-HEAD percentage of recovery values differentiated GB from G, and lower IBI percentage of recovery values differentiated GB from HA, these results also suggest that the two measures may have potential as identifiers of gifted students with perceived behavior problems who are involved in a relatively short, timed, relax-active-relax simulated test sequence. Conversely, since there were no significant differences ( $p \leq 0.05$ ) observed for the percentage of recovery values for HR, SC, EMG-ARM, TEMP, PH, the results suggest that these measures may have little or no potential as identifiers of GB who are involved in simulated test sequences similar to those described above. Although the analysis revealed levels of significance ( $p \leq 0.01$ )

for two measures (EMG-HEAD, IBI), all of the results presented here should be considered as tentative because the data of 27 students (41% of the sample) had to be excluded from the process of analysis (see p.95).

### Psychophysiological Data - Phase 2

#### Continuous Data - Seven Psychophysiological Measures (Phase 2)

The results of the Kruskal-Wallis Test for the seven psychophysiological measures revealed no significant differences ( $p \leq 0.05$ ) for any of the relax/active conditions (C1-C11) during Phase 2. These results suggest that HR, SC, EMG-ARM, EMG-HEAD, TEMP, IBI, PH may have little or no potential as identifiers of gifted students with perceived behavior problems who are involved in a relatively long, untimed, relax-active simulated test sequence.

#### Summary: Question 2 Answered

**Question 2:** What criteria can be drawn that will be helpful in the identification of students who are gifted with perceived behavior problems?

The results of the analysis of the neuropsychophysiological data collected during the investigation suggest that, within specific testing parameters, three neuropsychological and two psychophysiological measures may have potential as identifiers of gifted students with perceived behavior problems. Table 5.1 summarizes the neuropsychophysiological measures that differentiated gifted behavioral students from those of gifted and high average ability.

**Table 5.1**  
**Summary of Neuropsychophysiological Measures that Differentiated GB from G and HA -**  
**Phases 1 and 2**

| Measure                      | n  | Strength of Value     | Groups Differentiated | Testing Parameters          |                              |
|------------------------------|----|-----------------------|-----------------------|-----------------------------|------------------------------|
|                              |    |                       |                       | Conditions                  | Duration of Test Sequence    |
| Amplitude                    | 64 | Lower                 | GB from G             | Relax                       | Short (5 Min.)†† and Long †† |
| Frequency                    | 64 | Lower                 | GB from HA            | Active                      | Short (5 Min.)†              |
| Presence of Alpha Waves      | 64 | Lower Amounts         | GB from G             | Relax                       | Long ††                      |
|                              |    | Higher Amounts        | GB from HA            | Relax                       | Long ††                      |
| Inter-Beat Interval (IBI)    | 39 | Smaller % of Recovery | GB from HA            | Relax/Active/Relax Sequence | Short (5 Min.)†              |
| Electromyog. Head (EMG-HEAD) | 39 | Smaller % of Recovery | GB from G             | Relax/Active/Relax Sequence | Short (5 Min.)†              |

† Timed simulated test sequence  
 †† Untimed simulated test sequence

According to Table 5.1, there are three significant neuropsychophysiological differences between GB and G students who are involved in a simulated test sequence:

- 1) during untimed conditions of relaxation, gifted behavioral students have lower amplitude values than those who are gifted;
- 2) during a timed, relax-active-relax test sequence, the percentage of recovery rate for muscle tension in the forehead is significantly smaller for gifted students with perceived behavior problems; and
- 3) compared to gifted pupils, gifted behavioral students have less alpha wave activity during untimed conditions of relaxation.

Since lower amplitude values, smaller rates of electromyographic recovery, and smaller amounts of alpha wave activity usually signal the presence of neuropsychophysiological destabilization, these results suggest that compared to gifted pupils, gifted students with perceived behavior problems bring less neurocortical and psychophysiological stability, efficiency, and endurance to situations of relaxation and performance.

However, when comparing the results of gifted behavioral and high average students, the conclusions appear to be somewhat different. According to Table 5.1:

- 1) during timed conditions of activity, gifted behavioral students have lower frequency values than those of high average ability,
- 2) during a timed, relax-active-relax test sequence, the percentage of recovery rate for the inter-beat-interval is significantly smaller for gifted behavioral students, and
- 3) compared to the high average, gifted behavioral students have more alpha wave activity during untimed conditions of relaxation.

Whereas, lower frequency values and higher amounts of alpha wave activity tend to signal the presence of neuropsychophysiological stability, efficiency, and endurance, smaller rates of IBI recovery do not. Since the data related to GB and HA students seem inconsistent, any conclusions drawn from these results must remain tentative. However, as noted earlier, changes in sample size (i.e.  $n=64$  to  $n=39$ ) may have affected the results.

Overall, the results of this study suggest that gifted students with perceived behavior problems can be differentiated from gifted and high average ability students using a neuropsychophysiological paradigm. Specifically, the results of the investigation suggest that the neuropsychophysiological characteristics of gifted behavioral students are less stable, efficient, and enduring than those of the gifted, but moreso than those of high average ability. In addition, implicit in the findings and new to the field, is the conclusion that gifted students with perceived behavior problems do exist as a subgroup of the larger population.

## CHAPTER SIX

### Conclusions and Summary

*“What has been tackled here is the tip of the iceberg and much more needs to be done”.*

*-D. Smith (1995, p. 29)*

The identification of gifted children has been examined from a number of perspectives over the past half century. This study adds to the literature by presenting a new assessment paradigm comprised of 14 untimed/timed relaxation and performance conditions to identify three groups of children - high average, gifted, and gifted students with perceived behavior problems, from a neuropsychophysiological perspective. The current chapter discusses the conclusions, limitations, and areas in need of further research that are related to the investigation.

### Conclusions and Educational Implications

Education is comprised of the interplay of four major components - the student, the teacher, the content, and the milieu. Since knowledge of one construct affects the other three, the following sections reflect the interactive nature of these elements by discussing the most important contributions and educational implications of the study.

#### Contribution One

This study enhances our understanding of the nature of the gifted child, ages 10-12 years. By using the significant neuropsychophysiological data collected during the investigation as a

guide, new typologies of gifted and gifted behavioral students are possible. A typology is a symbolic meaning or representation (McKechnie, 1958). When viewed from a neuropsychophysiological perspective, typological descriptive snapshots which emerge from this study are presented below.

### *Typology - Gifted Students*

Gifted students possess considerable neurocortical power and strength. During moments of relaxation and task-engagement, amplitude values of 50-125+  $\mu\text{V}$  and 25-75  $\mu\text{V}$ , respectively, are not uncommon. Gifted students also possess neurocortical arousal and synchronicity patterns that allow them to focus for extended periods of time. During moments of relaxation and task-engagement, these patterns tend to be dominated by alpha (8-12 Hz) and alpha/beta (8-30 Hz) brain wave activity patterns respectively. In addition, these students seem to be able to recover quickly from muscle tension in the forehead after periods of intense, effort, concentration, and focus.

### *Typology - Gifted Students with Perceived Behavior Problems*

Gifted students with perceived behavior problems possess considerable neurocortical power during moments of task-engagement when amplitude values of 25-75  $\mu\text{V}$  are not uncommon. During moments of relaxation, the strength of their neurocortical activity tends to range between 25-100  $\mu\text{V}$ . Thus, neurocortical patterns of gifted behavioral students are similar to those of gifted students during moments of task-engagement but lower than those of the gifted during periods of relaxation. The EEG profiles of gifted students with perceived behavior

problems tend to be dominated by combinations of alpha/beta (8-30 Hz) and beta/gamma (31+ Hz) brain wave activity during moments of relaxation and task-engagement respectively. Thus, unlike the gifted, these students often have difficulty relaxing or sustaining controlled focus for extended periods of time. In addition, compared to the gifted, gifted students with perceived behavior problems are less likely to recover quickly from muscle tension in the forehead after periods of intense effort, concentration, or focus.

Although far from comprehensive, these descriptive passages contribute to the field in a number of ways. First, although not definitions per se, the typologies add to the literature related to the conceptualizations and definitions of giftedness by highlighting some of the neuropsychological and psychophysiological tendencies of pre-adolescent gifted students. Since these typologies probably represent two of the first attempts to describe gifted learners from a neuropsychophysiological perspective, they may be the foundation upon which future definitions are built. Potentially, such definitions would contain information about the cognitive, emotional, and physical inclinations of gifted students. Thus, they could be used to guide the efforts of educators who were interested in meeting the needs of the whole child within the educational milieu (Gagné, 1991; Roeper, 1982). In addition, such definitions could be valuable points of reference for educational theorists and practitioners who are trying to answer some of the most pressing questions in the field today - "What is giftedness and how should it be defined?" (Margolin, 1996; Morelock, 1996).

Second, in addition to providing educators with new information about the nature of giftedness, the typologies could be used to confirm specific longstanding notions about the

construct. For instance, as cited in the descriptions, elevated levels of neurocortical strength and power (i.e. amplitude) for both groups during moments of task-engagement seem to support Terman's (1926) and Sternberg's (1985) beliefs about the advanced intellectual aptitude and the unique thinking patterns of gifted children respectively. However, whereas Sternberg (1991) stressed the importance of the intellectual construct by recognizing several types of cognition (i.e. analytical, synthetic, practical), this study emphasizes the importance of the construct by suggesting that gifted students may have sufficient neurocortical power to engage successfully all types of thinking.

Also, as cited in the descriptions, moderate frequency values of 8-30 Hz and rapid recovery rates from muscle tension in the forehead suggest that the overall psychophysiological stability of gifted pupils may be superior to that of their peers. Such stability enhances their ability to remain flexible and controlled during times of stress. The conclusions, which mirror those of Bütter (1988), Shaffer (1994), and Carry, Bütter, Persinger, and Bialik (1995), suggest that, although gifted students are subjected to the usual complement of stresses and strains endured by the rest of the population (Shawn & Lovett, 1994), their ability to adapt to and recover from its effects are more efficient. Thus, based upon the results of this study, it appears that gifted students excel in at least two domains - the intellectual and the psychophysiological.

Third, since the typologies are descriptive summaries of some of the neuropsychophysiological characteristics that differentiated gifted (G) from gifted behavioral students, their mere existence challenges the myth of gifted homogeneity (Kirschenbaum, 1998a; Roedell, 1986; Winner, 1996). At the present time there is no conceptual framework for gifted students with perceived behavior problems. This apparent lack of theory does not negate their

presence as a legitimate subpopulation of the larger group (G). As outlined below and based on the results of this study, educators may find it useful to make some subtle but important instructional modifications to their practice

As evidenced by their elevated amplitude values, gifted students with perceived behavior problems have considerable neurocortical power and strength during moments of task-engagement. This may be utilized by increasing the complexity of the curricula and the pace of its delivery to meet the natural intellectual and cognitive rhythms of these students (Baum, Olenchak, & Owen, 1998; Reis, Westberg, Kulikowick, & Purcell, 1998).

As evidenced by their increased beta and gamma brain wave activity patterns, the neuropsychophysiological well-being of gifted students with perceived behavior problems tends to destabilize during periods of sustained focus. Hence, their learning may become more successful when moments of concentration are alternated with guided sessions of relaxation (e.g. yoga, progressive relaxation techniques).

As evidenced by their decreased electromyographic recovery rates, gifted students with perceived behavior problems tend to retain tension in their skeletal-muscular system during and after periods of intense focus and concentration. Thus, educators may expect to see signs of physical discomfort such as restlessness and large motor activity from gifted behavioral students. Members of the educational community, such as teachers, counsellors, and principals should

- 1) remember that these movement patterns may be physically rather than behaviorally motivated,
- 2) use a variety of instructional techniques that engage students actively as well as passively, and
- 3) be aware of the importance of structured learning opportunities that involve large motor activity (e.g. recess, physical education classes). By providing a balance of active and passive

activity in the classroom, it is anticipated that the psychophysiological tensions of gifted students with perceived behavior problems will be moderated. In turn, it is expected that their ability to focus for sustained periods of time will improve.

Since many of the recommendations presented above have been included in 'best-practice' lists for a number of years, their importance to the field has already been established in the literature. From this study, a neuropsychophysiological rationale provides strong reinforcement for their serious and consistent use in schools.

Finally, besides adding a new subpopulation to the gifted family, the study helps educators refine their knowledge about gifted learners whose behavior patterns do not always conform to the learning process in a classroom environment (e.g. those pupils who exhibit immature, atypical, or deviant behavior). Specifically, by eliminating the possibility of incidents of psychopathology in the sample, the investigation has been able to highlight the important distinction between students with 'real'- trait behavior problems (i.e. those related to incidents of psychopathology), and 'perceived'- state behavior problems (i.e. those related to aspects of the learning environment). Thus, the research provides a better understanding about subgroups of the gifted population.

From a psychobehavioral perspective, only one to three percent of the population at large are affected by incidents of psychopathology. Thus, it is reasonable to assume that most of the unacceptable behavior patterns in schools are related to temporary or long term incompatibility in the learning environment (i.e. state behaviors) rather than permanent or chronic psychophysiological deficiencies in the student (i.e. trait behaviors). The results of this study tend to support this assumption.

With the understanding that most behaviors are environmentally motivated, and the use of a new label that reinforces this reality, 1) the self-esteem of students with perceived behavior problems will be elevated, 2) the concerns of parents about the innate personality of their child will be tempered, and 3) the efforts of teachers to look for program modifications that will eventually affect a positive change in the academic and behavioral performance of their pupils will be increased (Manor-Bullock, Look, & Dixon, 1995). For gifted students with perceived behavior problems, such modifications may include the maintenance of academic environments that are less restrictive and regimented in design, and the inclusion of learning opportunities that encourage pupils to seek challenge and experiment with the unknown (Freeman, 1994; May, 1994; McVey & Snow, 1988; Soriano de Alencar, 1995).

Jung (1939) once said, "If there is anything that we wish to change in the child, we should first examine it and see whether it is not something that could better be changed in ourselves" (p. 285). Based upon the results of this study, it is hoped that educators will begin to modify their perceptions of gifted students who exhibit patterns of behavior that do not always harmonize with the expectations of an academic setting.

### Contribution Two

This study adds to our repertoire of assessment strategies currently used to identify gifted learners by presenting a new paradigm that differentiates high average, gifted, and gifted behavioral students from a neuropsychophysiological perspective. Unique to the design and new to the field of gifted studies is the paradigm's ability to generate:

- 1) two types of data (i.e. neuropsychological, psychophysiological), that represent
- 2) two domains (i.e. intellectual, psychophysiological), across
- 3) two oppositional conditions of performance (i.e. relaxation, task-engagement), that can be
- 4) analysed quantitatively and interpreted globally.

By generating two types of data (i.e. neuropsychological, psychophysiological), the paradigm supports the efforts of those who are interested in assessing student populations holistically (Treffinger & Feldhusen, 1996). By generating data that represents two domain areas (i.e. intellectual, psychophysiological), the paradigm respects the philosophical beliefs of multidimensionalists who maintain that intellectual and non-intellectual constructs should be considered as equal partners in the identification process (Wright & Borland, 1993). By generating quantitative data that can be interpreted locally and globally, concerns of psychometric standardization and cultural test bias from psychometricians and special needs interest groups respectively are addressed (Burger & Burger, 1994; Maker, 1996).

By collecting data during conditions of relaxation and task-engagement (particularly during test sequences), determinations about the effects of stress on performance can be made (Andreassi, 1980). Finally, since the paradigm tends to focus on the innate, internal characteristics of its subjects rather than on their contrived or learned external behavior patterns, the assessment design is less susceptible to the faking techniques of gifted students who want to camouflage their ability (Comer, 1990; Hebert, 1991), or the perceptual biases of teachers who may be involved in the identification protocols established by their school boards (Roldan, 1996).

Since no assessment design is complete, it is hoped that this paradigm will be used in conjunction with others. By comparing the data generated by several different paradigms (e.g. single-criterion, multidimensional, neuropsychophysiological), more complete and accurate profiles of gifted students may be possible (Coleman & Gallager, 1995). With this information, educators may be able to improve their ability to advise parents about the identification and placement options available to gifted learners. In addition, with the profiles as a guide, program modifications and potential learning opportunities that may enrich the educational experiences of gifted students can be explored.

“Complex people is an excellent term to describe the human condition” (Smith, 1995, p. 28). When the neuropsychophysiological paradigm described in this investigation is used concurrently with other forms of assessment, it is expected that some of the complexities related to the nature of gifted students will be revealed, and some of the errors made in the identification of these students, to date, will be corrected. It remains for the education community to take up this challenge.

### Assumptions and Limitations

The importance of recognizing the basic assumptions underlying a study cannot be overstated. For, as LaFrance (1993) has observed, assumptions often impose limitations on a research investigation.

There are several assumptions which may have affected the current study. The first assumption was that the school boards had accurately identified the students as either high

average (HA) or gifted (G). Related to the first assumption, is the second - that the combined opinions of the student, parent/guardian, researcher, and home school accurately differentiated gifted students with perceived behavior problems (GB) from the larger group (G).

In the study, decisions of group placement for HA and G, and GB students were based upon standardized test protocols and small group consensus respectively. Since two different procedures were used to identify the sample (i.e. quantitative, qualitative), the effects of procedural bias must be recognized as a potential limitation.

However, it may be possible that this limitation may not be problematic. By confirming the presence of three distinct groups from a neuropsychophysiological perspective, this study tends to support most of the identification and placement decisions made during the process of sample selection. Further research will be needed to determine if this approach is a limitation or a new model for selecting populations of little known origin.

The third assumption was that each student performed as well as possible during the 14 experimental conditions. Related to the third assumption, is the fourth - that the individual reactivity patterns recorded during the simulated test sequences were accurate representations of the student's neuropsychophysiological response to mild/moderate stress-enhancing situations in general.

Although efforts were made throughout the investigation to minimize apprehension and maximize ecological validity, the potential effects of a technologically-rich, white-coat environment cannot be ignored. To determine the effects of this limitation on the study, longitudinal research projects that establish baseline reactivity profiles for each student would be useful. By comparing the neuropsychophysiological data collected during this study with such

profiles, determinations about the typicality of the responses made by the sample could be ascertained. With a more proactive vision on the part of educators and the rapid advances in technology, it is possible that the ecological validity of research designs in the future will be improved.

Until then, confidence in the typicality and generalizability of the data must depend upon the expertise of the neuropsychophysiologicalist who monitored the reactivity patterns of the students throughout the testing sequence. Based upon on-site observations of the participants and the equipment in the laboratory, the attending physician concluded: 1) that the students were very interested and actively engaged during the assessment process; and 2) that the neuropsychophysiological reactivity patterns of all but four participants (i.e. one HA, three G) were probably accurate representations of their response to stress-enhancing situations in a classroom environment (e.g. tests, exams). These conclusions were verified later during the examination of the neuropsychological and psychophysiological profiles generated by the EEG and biofeedback equipment respectively. Thus, according to the attending neuropsychophysiologicalist, most of the students performed as well as possible during the 14 experimental conditions, and the effects of the white-coat phenomenon, in general, were not profound.

Surprisingly this discussion, intended to focus on the assumptions and limitations of the study, highlights a potential strength of the paradigm - its ability to assess qualitatively and quantitatively the psychosocial construct of task-engagement. In addition, the paradigm provides the researcher with a statistical snapshot of each student's emotional state as he/she proceeds through the experimental process.

It is difficult to imagine a research project devoid of limitations. The results of this study, which were triangulated by medical personnel who did not know the group placements of the students, suggest that the effects of the limitations cited here may have been minimal.

### Further Research and Questions

One of the most important points that can be made as a result of this study is that high average and gifted students can be differentiated using a neuropsychophysiological paradigm. Since the paradigm is relatively new to the field, further research will be needed to confirm the neuropsychological and psychophysiological reactivity patterns that emerged as a result of the investigation. Specifically, it will be important to reinforce the existence of gifted students with perceived behavior problems as a legitimate subpopulation of the larger group through repeated examinations of their neuropsychophysiological characteristics. Parallel to this, are opportunities to study other variables in the larger group (e.g. female members of this subpopulation). Are the neuropsychophysiological characteristics of females different from those of males? If so, should the two genders be identified differently?

In addition, it would be worthwhile to explore the advantages of using this paradigm of identification in tandem with others. Are some combinations more effective and accurate than others? Would specific multi-paradigmatic approaches to assessment improve our ability to recognize subtle differences among mild, moderate, and profoundly capable students, or help us to identify various subpopulations within the larger group? For example, it is interesting to note that all three gifted Asian students who participated in the study had extremely high

electromyographic (muscle tension) values in the forehead (i.e. 800+  $\mu\text{V}$ ). Is there a relationship between psychophysiological patterning and specific cultures? Without further investigation, the answer to this question remains speculative.

Foremost in the conclusions cited in the study is the suggestion that gifted students may excel in at least two domain areas - the intellectual and the psychophysiological. Since psychophysiological destabilization caused by stress (real or perceived) severely impedes neurocortical functioning and overall performance, it is essential that further research be initiated to investigate both domain areas - singularly and in combination. Why do some gifted students, apparently, perform to their potential in spite of environmental circumstances while others do not? Could the answer to these differences in performance lie in the psychophysiological rather than the intellectual make-up of pupils who are able to systemically remain flexible and stable during times of mild/moderate stress? Could it be that giftedness depends more upon the symbiotic relationship between the two domains, rather than the individual strength of just one? The results of this study suggest that, in fact, this may be the case.

### Summary

The purpose of this research study was to develop a neuropsychophysiological paradigm which differentiated high average, gifted, and gifted students with perceived behavior problems. It is anticipated that the investigation, which revealed evidence of difference in the neuropsychophysiological reactivity patterns of the three groups, will make a valuable contribution to the field by providing educators with a more comprehensive identification strategy that will recognize strength in at least two domain areas - the intellectual and the

psychophysiological. Secondly, it will help the parents of gifted students with perceived behavior problems understand the unique cognitive and physical needs of their children. Lastly, it will guide teachers in their efforts to design educational experiences that will meet the needs of the whole child.

The degree to which the assessment strategies presented in this study will be used by educators to identify gifted learners in the future will depend upon the number of replicated research investigations attempted and the willingness of educators to look for new, innovative ways to answer their questions about identification. As Kuhn (1970) has observed:

“Characteristics of responses that inaugurate paradigm shifts include expressions of discontent over existing practices, a loosening of stereotypes associated with past practices, the articulation and emergence of plans that accommodate new world views, and a willingness to try new techniques and methods”  
(p. 71).

This study has attempted to address current discontent in the field of gifted education by presenting a new identification paradigm. What remains is a willingness on the part of educators to be vigilant in their efforts to develop more accurate, inclusive, and comprehensive identification protocols that embrace both innovation and tradition.

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**APPENDIX A**

**Teacher's Perceptions of Student Behaviors/Characteristics**

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**Examples of Behaviors/Characteristics that Signal Giftedness - Teacher Perceptions**

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- |  |  |
|--|--|
| 1. Academic success (i.e. good grades)   | Tallent-Runnels et al., 1994.          |
| 2. Model behavior  | Clinkenbeard, 1991.                    |
| 3. High levels of motivation   | Porath, 1996.                          |
| 4. Superior metacognitive ability  | Cheng, 1993.                           |
| 5. Performs well on standardized tests   | Rhodes, 1992.                          |
| 6. Learns easily and quickly   | Gagné, 1995.                           |
| 7. Socially popular with peers and teachers  | McCallister, Nash, & Meckstroth, 1996. |
| 8. Parental/guardian support for the school  | May, 1994.                             |
| 9. Creative production - presents information in novel ways                                  | Torrance, 1962.                        |
| 10. Unusual memory capacity  | Gross, 1998.                           |
| 11. Ability to formulate categories, use metaphors, think abstractly, and formulate problems | Morelock, 1996.                        |
| 12. Ability to organize and lead others  | Rudnitski, 1996.                       |

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**Examples of Behaviors/Characteristics that Signal Immaturity/Nonconformity - Teacher Perceptions**

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- |   |                                     |
|---|-------------------------------------|
| 1. Uneven development - cognitive, emotional, or social                     | Lovecky, 1994.                      |
| 2. Exceptional responsiveness or overexcitability to the environment        | Miller, Silverman, & Falk, 1994.    |
| 3. Difficulty understanding or interacting successfully with peers          | Jones & Day, 1996.                  |
| 4. Verbal assertiveness (i.e. outspoken, challenges authority)              | Sowa, McIntire, May, & Bland, 1994. |
| 5. Mild/moderate resistance to authority (verbal, body language)            | Griffin, 1992.                      |
| 6. Overt moral concern and sensitivity                                      | Merrell & Gill, 1994.               |
| 7. Having own mental agendas apart from school                              | Tolan, 1992.                        |
| 8. Difficulty answering "simple questions" or completing school assignments | Lovecky, 1992.                      |
| 9. Stubbornness, independence, and determination                            | MacRae & Lupart, 1991.              |
| 10. Classroom "clowns"  | Fern, 1991.                         |
| 11. Indifference  | Clasen & Clasen, 1995.              |
| 12. Continued attention-seeking behavior                                    | Whybra, 1992.                       |

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**Examples of Behaviors/Characteristics that Signal Deviance - Teacher Perceptions**

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- |  |                               |
|--|-------------------------------|
| 1. Repeated procrastination or laziness              | Fehrenbach, 1993.             |
| 2. Lack of control                                   | Kay & Subotnik, 1994.         |
| 3. Restlessness, lack of concentration               | Whybra, 1992.                 |
| 4. Overactive, disrupts/distracts others             | Purcell, 1996.                |
| 5. Aggressiveness                                    | Rohrer, 1995.                 |
| 6. Breaks rules repeatedly, overt nonconformity      | Ford, 1993.                   |
| 7. Anti-social behavior (ex. vandalism, petty crime) | Roldan, 1996.                 |
| 8. Lack of interest in improving oneself             | Shaughnessy & Fickling, 1993. |

**APPENDIX B**

**Wechsler Intelligence Scale for Children - Revised - Subtests**

| <b>Subtest</b>             | <b>Measures</b>  | <b>Areas of Focus</b>   |
|----------------------------|--|---|
| <b>Information</b>         | The kind of knowledge that average children with average opportunity should be able to acquire for themselves. | Memory.   |
| <b>Similarities</b>        | Verbal concept formation, the ability to place objects and events together in meaningful ways.                 | Memory/performance that may be related to opportunity and interest.             |
| <b>Arithmetic</b>          | Numerical reasoning ability.   | Concentration and attention.  |
| <b>Vocabulary</b>          | Language development, learning ability, and general information.   | Same.   |
| <b>Comprehension</b>       | Social judgement, the ability to draw on past experiences when finding solutions to a variety of situations.   | The ability to use facts in meaningful, and emotionally appropriate ways.       |
| <b>Digit Span</b>          | Short-term memory and attention.   | Auditory sequencing .   |
| <b>Picture Completion</b>  | The ability to differentiate between essential and nonessential details.                                       | Concentration, visual memory, reasoning, and alertness.                         |
| <b>Picture Arrangement</b> | Nonverbal reasoning ability.   | Ability to comprehend and size up a total situation.                            |
| <b>Block Design</b>        | Visual-motor coordination and perceptual organization.   | Perception, analysis, and synthesis - parts and wholes.                         |
| <b>Object Assembly</b>     | Perceptual organization.   | Synthesis.  |
| <b>Coding</b>              | Visual-motor coordination, speed of mental operation, and memory.  | Short term memory, and the ability to make associations quickly and accurately. |
| <b>Mazes</b>               | Planning ability and perceptual organization.  | Visual-motor control, speed, and accuracy.                                      |

**APPENDIX C**

**Dear Parent or Guardian,**

A research project comparing the thinking patterns of students has been approved by the University of Ottawa, the \_\_\_\_\_ Board of Education Research Advisory Committee and the principal of your school. The results from this research will help educators recognize and understand the unique thinking abilities of average ability students and of gifted students.

The information on the unique thinking patterns of students will come, with your signed permission only, from the following:

- two paper and pencil tests to assess the personality and character of the pupil
- three short problem-solving activities and one creative task to be completed while the student is monitored by EEG and computer technology (the equipment will record the brain waves and the physical responses of each participant)

If you choose to participate in this study your child will attend two activity sessions. First, your child will meet with the researcher at your school to complete two paper and pencil tests. Second, your child will visit the research site in Hull, Quebec where he/she will be asked to complete three short problem-solving tests and one creative task while being monitored by EEG and computer technology. Each session will be approximately 1 ½ hours in length and you will be expected to arrange for the transportation of your son/daughter. Visits to the research site will be scheduled between December 13 and December 31, 1995. The pupils will be provided with all of the materials needed to complete the various activities and all of the recorded data will be destroyed when analysis is complete.

Most students find the research process interesting and novel. Participation is voluntary and you or your son or daughter may withdraw at any time. Results will respect the confidentiality of each participant. If you choose to have your child involved, you will be fully informed of all aspects of the study either at a group meeting of interested parents or on an individual basis.

Please check one of the options below and return this letter to the school by Friday, November 24, 1995. Thank you for your attention to this matter.

Sincerely yours,

Dianna Shaffer  
Tel: (613) 562-5800 Ext. 4159

\_\_\_\_\_ I am interested in hearing more about this project. Please call me at \_\_\_\_\_ so that I might learn more about the study before deciding to participate.

\_\_\_\_\_ I am not interested in participating in the study at this time.

Name of Child (Please Print) \_\_\_\_\_  
Name of Parent/Guardian (Please Print) \_\_\_\_\_

**APPENDIX D**

**Title of Project:** Identification of Gifted and Talented Children Using a Neuropsychophysiological Paradigm: An Exploratory Study  
**Researcher:** Dianna Shaffer, Faculty of Education, University of Ottawa, 145 Jean-Jacques Lussier, Ottawa, Ont. K1N 6N5 (613) 562-5800 Ext. 4159  
**Major Advisor:** Dr. Janice A. Leroux, University of Ottawa

When a research project involving individuals is undertaken by researchers at the University of Ottawa, the Ethics committee of the University and the \_\_\_\_\_ Board of Education requires the written consent of the participants and, in the case of a minor, the written consent of the parent or legal guardian. This does not imply that the project is risky in any way; the intention is simply to assure the respect and confidentiality of the individuals concerned. The purpose of this research project is to compare the unique thinking patterns of average ability and gifted students.

If you decide to participate in this study, your child will be asked to attend two 90 minute testing sessions. During the first session your son/daughter will be asked to complete two paper and pencil tests (Children's Personality Questionnaire Form A, Junior Eysenck) at your school. These tests will tell the researcher something about your child's personality and temperament. It is anticipated that the amount of anxiety associated with these tests will be minimal since there are no right or wrong answers. During the second session your son/daughter will be asked to complete three short problem solving activities and one creative task (Brief Physiological Stress Profile, Halstead Category Test, Rosenweig Picture Frustration Study, drawing of choice) at a research laboratory in Hull, Quebec. Transportation to and from the research site will be provided by parents/guardians. It is anticipated that the amount of anxiety associated with these activities will be moderate (similar to what a pupil might experience in school during a test or when he/she has been asked to make a presentation in front of the class) since there are right and wrong answers to the questions. During the second session your son/daughter will also be asked to wear a variety of sensors which will be attached to the fingers, forearm and forehead. These sensors will be attached to the upper body by Velcro strips and special bandages which will be removed at the end of the session. Some minor discomfort may be experienced during the removal of the bandages. In addition, your son/daughter will be asked to wear an electrode-cap. The electrode-cap, which is similar to a bathing cap, will fit snugly on the head. It has a number of holes in it. These holes will be filled with a sticky gel which must be washed out of the hair after the electrode-cap has been removed. Thus, some inconvenience may be experienced during the removal of this gel. You or your son or daughter can stop the testing sessions at any time. If you decide not to participate for any reason, your son/daughter will not be penalized in any way for your decision.

Confidentiality of the students who serve as subjects in this study will be maintained through the numbering of all test and survey data. The numbering code to all identifying information will be available only to the investigator. All results will be reported in group format. Specific data will only be shared with the participants' family to which it applies. Upon analysis, all recorded data will be destroyed. The identity of the subjects will only be known to the investigator. All information is confidential and is protected under the Freedom of

Information and Protection of Privacy Act, 1989 (Bill 49).

Upon completion of the study, each participant will receive an executive summary of the results. In addition, the researcher will share the results of the tests for each participant personally and privately with the family to which they apply.

This research has been approved by the \_\_\_\_\_ Research Advisory Committee, the principal of the school, and the Faculty of Education Human Research Ethics Committee (EDHREC). Enquiries or any questions dealing with ethical conduct of this research can be addressed to the Chairperson of the EDHREC: Dr. Penny Gurney, EDHREC Chairperson, Faculty of Education, University of Ottawa, 145 Jean-Jacques Lussier, Ottawa, Ont. K1N 6N5.

I, \_\_\_\_\_, hereby consent to allow my son/daughter to participate in the above named study. I understand that my son's/daughter's participation is voluntary, and that participation has no effect on his/her school marks. Any results reported publicly will be presented in group format only and will be used solely for research purposes. I understand that access to my data will be limited to my family and to the investigator.

I understand that my son/daughter will attend two 90 minute testing sessions. The first session will be at my son's/daughter's school and the second session will be at a research laboratory in Hull, Quebec. During these sessions I understand that my son/daughter will complete a total of six research activities which include: two paper and pencil tests, three short problem-solving activities, and one creative task. I also understand that he/she will be monitored by EEG and biofeedback technology during the problem-solving tests and the creative task.

I understand that my son/daughter may experience a moderate amount of anxiety during some of the tests. In addition, I understand that he/she may experience minor discomfort during the removal of two sensor bandages and that he/she may experience some inconvenience when washing the electrolyte gel out of his/her hair.

I understand that the confidentiality of data will be assured through the numbering of all test and survey data, and that this numbering code will be available only to the investigator. Further, I understand that, although my son's/daughter's name will be known to the investigator, it will not be publicly associated with this project in any way. Upon analysis, all recorded data will be destroyed. Further, I understand that all information is confidential and is protected under the Freedom of Information and Protection of Privacy Act, 1989 (Bill 49).

I understand that I may withdraw my participation in the study at any time without penalty to my son/daughter. I have been given an opportunity to ask any questions regarding the research and these questions have been answered to my satisfaction.

\_\_\_\_\_  
Signature of Participant

\_\_\_\_\_  
Age

\_\_\_\_\_  
Date

\_\_\_\_\_  
Signature of Parent/ Legal Guardian

\_\_\_\_\_  
Date

\_\_\_\_\_  
Signature of Researcher

\_\_\_\_\_  
Date

**If you have any questions or concerns, please do not hesitate to call Dianna Shaffer at (613) 562-5800 Ext. 4159.**

**APPENDIX E****The Junior Eysenck Personality Inventory (Junior E.P.I.)**

The Junior Eysenck Personality Inventory (Eysenck, 1963) is a 60 item YES-NO pencil and paper test that measures extroversion-introversion and neuroticism-stability (Lingoes, 1970). Eysenck's work suggests that extroversion is characterized by social, active, optimistic, outgoing, and impulsive behavior, and introversion is characterized by unsociable, passive, quiet, thoughtful, and reserved behavior. Similarly, neuroticism is characterized by moody, touchy, unusually restless, and rigid behavior, and stability is characterized by calm, carefree, easy-going, and reliable behavior (Eysenck 1947, 1967).

The Junior Eysenck Personality Inventory (Junior E.P.I.) is a downward extension of the Maudsley Personality Inventory (Eysenck, 1962) and the Eysenck Personality Inventory (Eysenck & Eysenck, 1963) for adults. Like its predecessors, the Junior E.P.I. measures extroversion (E) and neuroticism (N). In addition, it contains a lie scale (L) to determine the extent of faking (Wirt, 1972). The Junior E.P.I. was standardized on 12,314 British children. There were 9,537 children (4,859 girls and 4,678 boys) involved in the standardization process for the E and the N scales, and 2,777 children (1,471 girls and 1,306 boys) involved in the standardization process for the L scale.

The test takes approximately 20 minutes to complete. It can be administered successfully by psychologists or paraprofessionals who have received little or no formal training. Those who have administered the Junior E.P.I. are often impressed by the instrument's age-appropriate vocabulary and uncomplicated format (Chazan, 1972).

**APPENDIX F****The Children's Personality Questionnaire Form A (CPQ-Form A)**

Like its three equivalent forms (B, C, and D), Form A of the CPQ is a paper and pencil test that has been divided into two equal sections (A1 and A2) for scheduling convenience. Each section contains 70 EITHER-OR and multiple choice items that measure 14 factorially independent personality factors (Cattell, 1950, 1959). The personality factors are often described in three ways: 1) by their symbolic, alphabet letter name (Cattell, Eber, & Tatsuoka, 1970); 2) by their traditionally-accepted technical term (French, 1953); and 3) by their "popular" behavioral characteristics (Laird & Laird, 1951) (see following page).

The Children's Personality Questionnaire is the second personality questionnaire in a series of four. It is a downward extension of the High School Personality Questionnaire for ages 12 through 17 (Cattell & Cattell, 1969) and the Sixteen Personality Factor Questionnaire for adults (Cattell, Eber, and Tatsuoka, 1970), and it is an upward extension of the Early School Personality Questionnaire for ages 6 through 8 (Coan & Cattell, 1966). All of the questionnaires measure the 14 personality factors which define and describe a person's character over time (Knoff, 1985)

The Children's Personality Questionnaire Form A (CPQ-Form A) takes approximately 50 minutes to complete. It can be administered by professionals or paraprofessionals who have received little or no formal training. The test is clearly printed and the questions are within the response capacity of most 10-12 year olds (Gough, 1978). The CPQ - Form A can be administered successfully to individuals and to small groups of children.

Factors Measured by the Children's Personality Questionnaire Form A

| Factor | Low Score Descriptors  | High Score Descriptors   |
|--------|--|--|
| A      | Reserved, Detached, Critical, Cool, Aloof                                | Warmhearted, Outgoing, Easygoing, Participating                |
| B      | Dull, Low Intelligence   | Bright, High Intelligence                                      |
| C      | Affected by Feelings, Emotionally Less Stable, Easily Upset              | Emotionally Stable, Faces Reality, Calm, Mature                |
| D      | Phlegmatic, Undemonstrative, Deliberate, Inactive, Stodgy                | Excitable, Impatient, Demanding, Overactive, Unrestrained      |
| E      | Obedient, Mild, Easily Led, Accommodating                                | Dominant, Assertive, Competitive, Aggressive, Stubborn         |
| F      | Sober, Prudent, Serious, Taciturn  | Enthusiastic, Happy-go-lucky, Heedless                         |
| G      | Expedient, Disregards Rules  | Conscientious, Persevering, Staid, Rule-bound                  |
| H      | Shy, Threat-sensitive, Timid, Diffident                                  | Venturesome, Socially Bold, Uninhibited                        |
| I      | Tough-minded, Self-Reliant, Realistic, No-nonsense                       | Tender-minded, Sensitive, Over-protected                       |
| J      | Zestful, Likes Group Action, Vigorous                                    | Circumspect Individualism, Reflective, Internally Restrained   |
| N      | Forthright, Natural, Artless, Sentimental                                | Shrewd, Calculating, Artful                                    |
| O      | Self-assured, Confident, Secure, Complacent                              | Guilt-prone, Apprehensive, Insecure, Worrying, Troubled        |
| Q3     | Undisciplined Self-conflict, Follows Own Urges, Careless of Social Rules | Controlled, Socially Precise, Following Self-image, Compulsive |
| Q4     | Relaxed, Tranquil, Torpid, Composed, Unfrustrated                        | Tense, Frustrated, Driven, Fretful, Overwrought, Fretful       |

**APPENDIX G****The Grass Sixteen Channel Electroencephalograph (EEG)  
with ECI Electro-Cap Electrode System**

The number of electrodes which have been sewn into an Electro-Cap varies. Caps which have been designed to monitor the brain wave reactivity patterns of infants, for instance, may contain as few as nine electrode sites. Conversely, caps which have been designed to monitor brain wave reactivity patterns of adults who are exhibiting complex or unusual symptomology may contain as many as 135 electrode sites (Electro-Cap International Inc., 1983). The ECI-M Electro-Cap (p. 167), containing 20 electrode sites, was used in the study because it was the appropriate size and comfort level for the target population.

The number of electrode sites which are actually used or 'turned on' during an individual testing session also varies. Sometimes it is appropriate to activate the entire complement of electrode sites, and just as often, it is appropriate to activate only a small portion of the total number. The decision to activate or eliminate specific sites during a particular testing session is usually made by the attending neurologist/neuropsychophysicologist who 1) has assessed the individual needs of the participant/client, and 2) has identified the goals and intent of the individual testing session (Hassett, 1978).

Although the ECI Electro-Cap is an excellent piece of equipment for monitoring the electrical potentials generated by the nerve cells in the cerebral cortex, its usefulness as a clinical assessment device is very limited until it is attached to an electroencephalograph. An electroencephalograph is a sophisticated machine which transforms the electrical potentials generated by the brain into a series of graphic representations which can be read and interpreted

by trained medical personnel. In the study, the ECI Electro-Cap was attached to a Grass Sixteen Channel Electroencephalograph (EEG) (Grass Instrument Co., 1977).

Specific to the study, the Grass Sixteen Channel EEG was calibrated with a time constant of 2 and a high filter set at 75. A high filter setting was selected for the study because it minimizes the effects of electrical interference from environmental sources such as hydro lines. The data, which appear as six uneven horizontal blue ink lines (called tracings) were recorded on large sheets of computer paper which moved across the horizontal surface of the machine at a rate of 30 mm/sec.

The sum total of tracings recorded on computer paper for an individual over a designated period of time is called an electroencephalogram. Sixty-six electroencephalograms were created during the study. Each was a graphic representation of the brain wave reactivity patterns for one student for 60 minutes (approximate time). Since the electroencephalogram is a highly-individualistic and comprehensive record of brain wave activity, it must be read and interpreted by qualified medical personnel.

ECI Electro-Cap



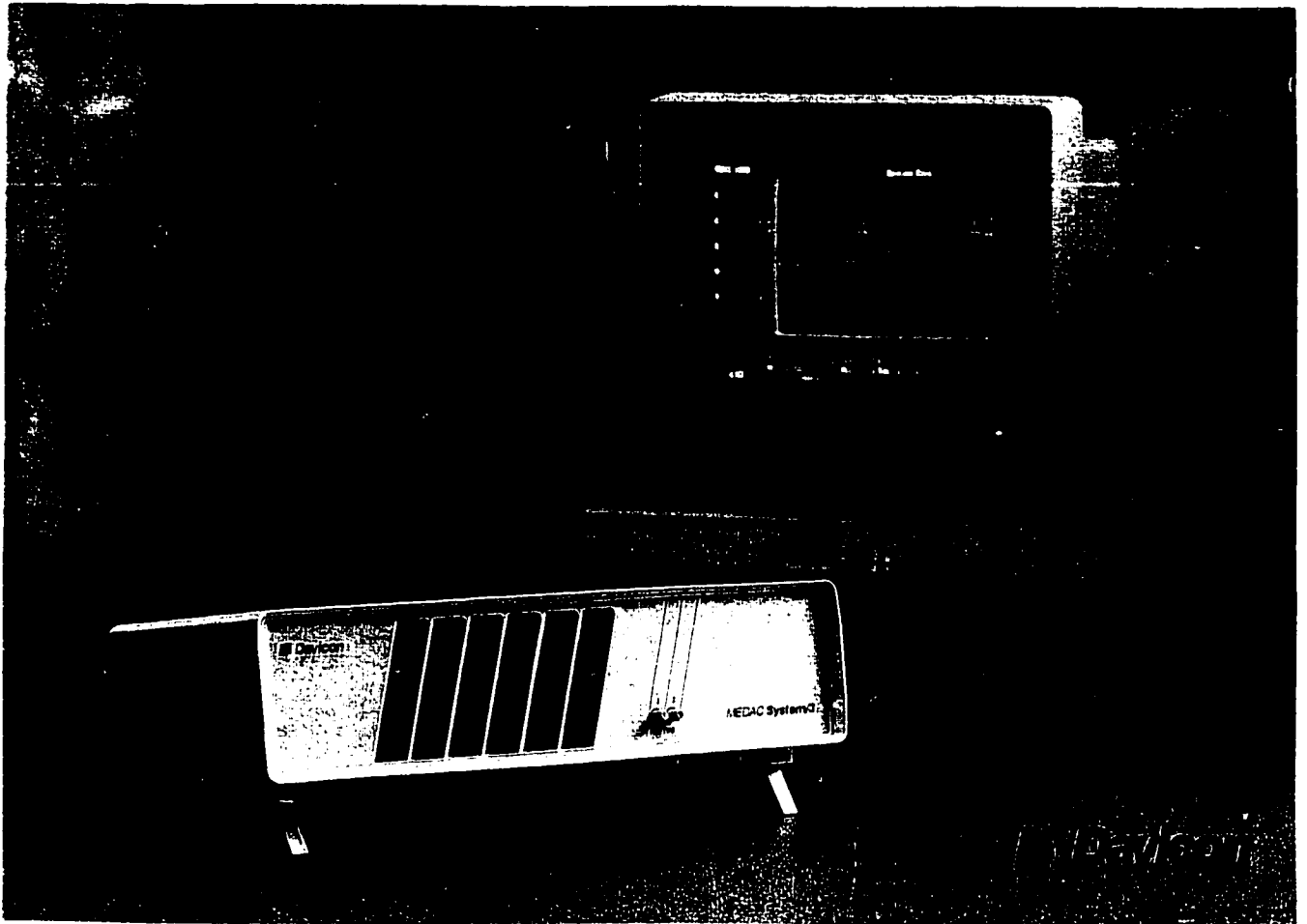
Note: From Electro-Cap Electrode System Assures Superior Quality EEG Data (p.2)  
by Electro-Cap International, Inc., 1995, Eaton, OH: Author. Copyright 1995 by Electro-Cap  
International, Inc. Reprinted by permission.

**APPENDIX H**

**The Davicon Medac System/3**

The Davicon Medac System/3 (NeuroDyne Medical Corp., 1994) is comprised of four essential components: 1) a number of sensors; 2) an instrumentation/isolation console; 3) a computer interface card; and 4) an assortment of computer software programs to assist the users in their efforts to manage records, generate reports, and print graphic screen displays (see following page). To be fully operational, the Davicon Medac System/3 must be attached to an IBM PC compatible computer system which has 640k RAM, a hard disk drive, an ISA standard card slot, and an EGA or VGA high resolution colour monitor with video card. Since the data recorded by the Davicon Medac System/3 is highly individualistic and complex, it must be read and interpreted by qualified medical personnel.

The Davicon Medac System/3



Note: From The Medac System/3: Enhanced Physiological Monitoring for Stress Management and Rehabilitation Applications (p. 1) by NeuroDyne Medical Corporation, 1994, Newton, MA: Author. Copyright 1994 by NeuroDyne Medical Corporation. Reprinted by permission.

## APPENDIX I

### Neuropsychophysiological Factors - Technical Descriptions

#### Neuropsychological Factors

##### *Amplitude*

To calculate the amplitude of an EEG wave a trained professional measures the vertical distance of the wave and compares it to the height of a calibration signal which has been recorded at the same time. Spehlmann (1981) suggests that 1) EEG waves which have amplitude values of  $20 \mu\text{V}$  or less (low intensity waves) have limited neurocortical strength and power, 2) EEG waves which have amplitude values of  $21\text{-}50 \mu\text{V}$  (moderate intensity waves) have moderate neurocortical strength and power, and 3) EEG waves which have amplitude values of  $51+ \mu\text{V}$  (high intensity waves) have considerable neurocortical strength and power.

From a medical perspective, health care professionals tend to favor amplitude values of higher intensity ( $51+ \mu\text{V}$ ) because they usually signal the presence of synchronized neurocortical arousal patterns of considerable strength and power (Mulholland, 1995; Pfurtscheller, Stancák, & Neuper, 1996). Moderate ( $21\text{-}50 \mu\text{V}$ ) or lower ( $0\text{-}20 \mu\text{V}$ ) amplitude values have been associated with physical movement, reading disabilities, effortful but inefficient processing, and decreases in vigilance (Bireley, Languis, & Williamson, 1992; Roland, Lassen, Larsen, & Skinhoj, 1980).

##### *Frequency*

To calculate the frequency of an EEG wave pattern a trained professional 1) selects a portion of a distortion-free tracing (one second in length) which he/she feels is exemplary of the larger EEG profile, and 2) counts the number of repetitive waves which recur in one second.

The total number of waves counted in this manner is the frequency of the wave pattern. A wave count of nine cycles per second, for instance, has a frequency of 9 Hz.

Synchronized neurocortical arousal, found in theta, alpha, and very low beta waves (4-15 Hz) describes a state of relatively high-amplitude neurocortical arousal that is rhythmic and efficient. Such states tend to be associated with moments of decreased frustration and tension because they require minimal amounts of systemic energy to maintain (Klimesch, 1996).

Desynchronized neurocortical arousal, found in high beta and gamma waves (16+ Hz), describes a state of relatively low-amplitude neurocortical arousal that is arrhythmic and less efficient. These states tend to be associated with moments of increased frustration and tension because they require large amounts of systemic energy to maintain (Başar-Eroglu, Strüber, Kruse, Başar, & Stadler, 1996). For the most part, the medical profession favors frequency values of moderate intensity (8-15 Hz) because they usually signal the presence of synchronized neurocortical arousal patterns that are rhythmic and efficient (Mulholland, 1995).

### *The Presence of Alpha Waves*

To determine the presence of alpha waves trained professionals 1) select an interval of tracing which they feel is representative of a particular test condition within the context of the larger EEG profile, and 2) examine the tracings for evidence of alpha wave activity (8-12 Hz). Alpha waves are considered 'present' when a particular condition contains one or more 'bursts' of alpha wave activity. Conversely, they are considered 'absent' when there is no evidence of alpha wave activity within the condition.

Alpha waves are best seen when the eyes are closed or during times of physical relaxation or cortical rest (Pfurtscheller, 1992). The waves are blocked or minimized by complex, difficult

stimuli because the cortical structure must work more energetically to process the information. Thus, alpha waves usually decrease as focus and mental activity increase (Dujardin, Bourriez, & Guieu, 1995; Niedermeyer, 1987). Medical practitioners tend to favor the presence of alpha wave activity in an EEG profile because alpha waves usually signal the presence of neurocortical rhythmicity, efficiency, and balance (Anokin & Vogel, 1996; Başar & Bullock, 1992).

### *Presence of Hemispheric Symmetry*

To determine the presence of hemispheric symmetry a trained professional 1) selects an interval of tracing which he/she feels is representative of a particular test condition within the context of the larger EEG profile, and 2) compares the average amplitude strength of the wave patterns that were manufactured in the right hemisphere (RH) with the average amplitude strength of the wave patterns that were manufactured in the left hemisphere (LH). Hemispheric symmetry is considered 'present' when the average amplitude strength of the wave patterns that were manufactured in the right and left hemispheres are almost equal. A state of hemispheric asymmetry occurs when the average amplitude strengths of the wave patterns from the two hemispheres (RH, LH) are noticeably unequal.

The appearance of hemispheric asymmetry in a specific condition signals a time of arousal when the neurocortical workload of the moment is not shared equally between the left and right hemispheres. One of the many types of hemispheric asymmetry is hemispheric inflexibility. Hemispheric inflexibility describes a state of limited/nil variance (change) in arousal during activities of verbal and/or non-verbal manipulation (Spehlmann, 1981).

Indicators of hemispheric inflexibility often appear in the EEG profiles of children with attention deficit disorder syndromes or learning disabilities (Bireley, Languis, & Williamson,

1992). Hemispheric inflexibility, which occurs in a state of neurocortical asymmetry, also has been associated with decreases in information processing speed (Toomin & Toomin, 1972; Viljoen, 1993). From a medical perspective, health care professionals tend to favor EEG profiles that are wanting in inappropriate patterns of hemispheric symmetry and inflexibility because such patterns often signal the presence of delayed neurocortical development, clinical depression, negative affect, and neurological pathology (Fox & Davidson, 1988; Fox et al., 1995; Spehlmann, 1981).

### Psychophysiological Factors

#### *Heart Rate (HR)*

From a medical perspective, health care professionals tend to favor heart rate values of moderate intensity (56-110 bpm), or slightly lower (40-55 bpm), because they usually signal the presence of a stable cardiovascular system (Miller, Smith, & Mehler, 1987; Obrist, 1981). Higher (111-165 bpm) or lower (0-40 bpm) HR values have been associated with decreases in attention and vigilance (Lacey & Lacey, 1970; O'Hanlon & Kelley, 1977).

#### *Skin Conductance (SC)*

Since skin conductance values of .8-2.0  $\mu$ mhos in adults usually signal the presence of a stable limbic system, this is the preferred range for most health care professionals (NeuroDyne Medical Corp., 1994). To date, SC norms for children have not been established. Based upon their clinical experience, some practitioners believe that the SC norms for children may be quite different from those of adults (i.e. much higher).

*Electromyography (EMG-ARM, EMG-HEAD)*

The Davicon Medac System/3 is calibrated to record electromyographic values of .01-1000 microvolts ( $\mu\text{V}$ ). Although the system has the capacity to detect EMG values of .01-1000  $\mu\text{V}$ , such readings are 'normal', but rare, because both surface and subdural (i.e. deep) muscle fibres must be aroused at the same time to generate such extreme levels of reactivity (Mehler & Sella, 1993b). The expected frequency range of most surface-electrode systems is 0-100  $\mu\text{V}$  (NeuroDyne Medical Corp., 1994). From a medical perspective, health care professionals tend to favor electromyographic values of lower intensity (0-333  $\mu\text{V}$ ) because they usually signal a state of neuromuscular stability that is surprisingly free of tension and physical discomfort (Davicon, 1989).

*Skin Temperature (TEMP)*

Since the Davicon Medac System/3 was developed in the United States, it is calibrated in degrees Fahrenheit ( $^{\circ}\text{F}$ ). The system records skin temperature values of 59-100 $^{\circ}\text{F}$ . Medical practitioners tend to favor skin temperature values of higher intensity (80-100 $^{\circ}\text{F}$ ) because they usually signal a state of cardiovascular efficiency (NeuroDyne Medical Corp., 1994).

*Inter-Beat-Interval (IBI)*

Before the advent of digitized computer technology, it was almost impossible to obtain precise measurements of the inter-beat-interval. Thus, until very recently, it was common practice to examine the measure (IBI) by an accurate, but somewhat indirect manner. Since there is a direct inverse relationship between HR and IBI that can be calculated mathematically [ $\text{HR}=1/\text{mean IBI}$ ] (NeuroDyne Medical Corp., 1994), researchers/clinicians often made conclusions about the inter-beat-interval based upon the heart rates of their subjects/clients. That

is, conclusions which were associated with higher HR values, were also (by inference) associated with lower IBI values. From a medical perspective, health care professionals tend to favor inter-beat-interval values that parallel HR values of moderate intensity (56-110 bpm), because they usually signal the presence of a stable cardiovascular system (Miller, Smith, & Mehler, 1987).

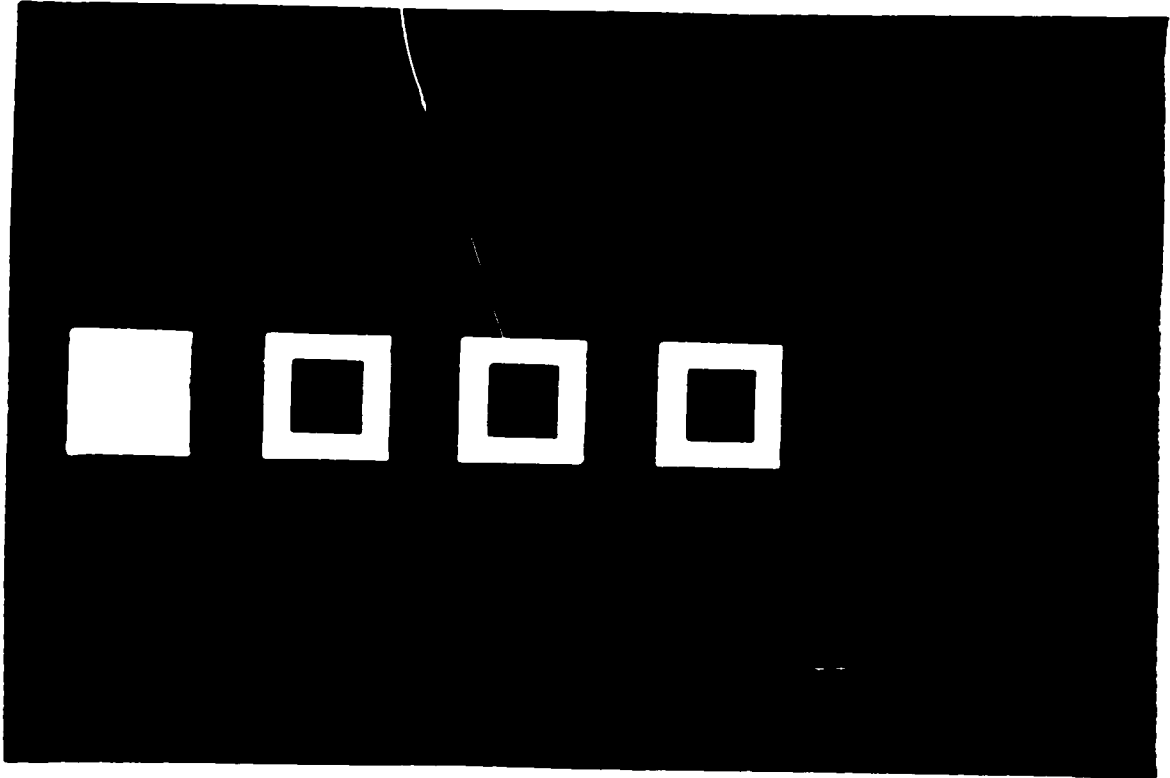
### *Pulse Height (PH)*

Medical practitioners prefer PH values of higher intensity (68-100) because they usually signal a state of cardiovascular stability and efficiency (Miller, Smith, & Mehler, 1987). As noted in Chapter Three, the importance of a stable cardiovascular system cannot be overstated.

Since the brain does not store oxygen or glucose, it is particularly important that these elements be delivered to the cerebral cortex at regular intervals by an efficient, stable, and dilated cardiovascular system. Without adequate supplies of oxygen and glucose, the delicate balance of oxygen/glucose uptake and hydrogen/carbon dioxide elimination is interrupted, the cerebral cortex ceases to function, and the overall systemic well-being of the individual is negatively affected (Mulholland, 1995). Individuals who are affected by the earliest stages of oxygen/glucose deprivation 1) have difficulty concentrating, 2) feel weak, and 3) show signs of disorientation and frustration (Cohen, Bondurant, & Silverman, 1960). Such feelings and behaviors are symptomatic of a cardiovascular system that has become 'closed' and restrictive. Advanced stages of oxygen/glucose deprivation are characterized by a comatose state.

APPENDIX J

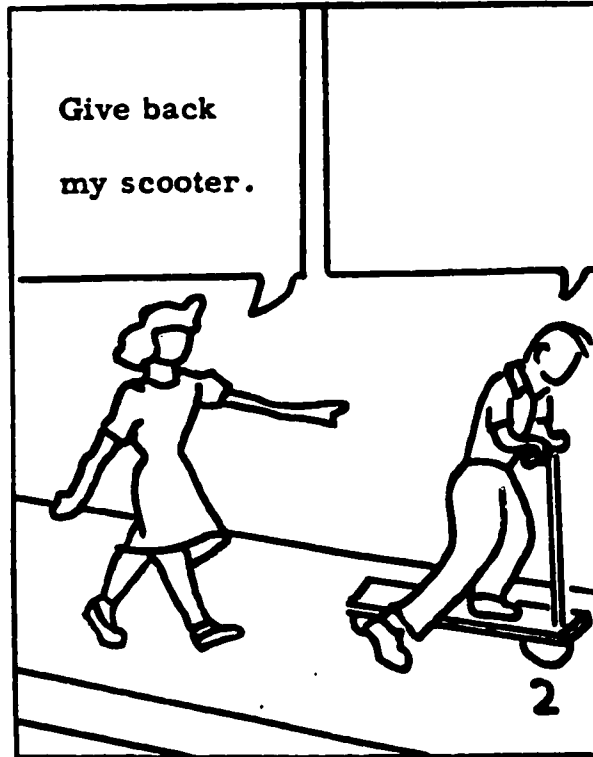
Example of a Slide - Halstead Category Test



Note: From The Halstead Category Test (slide 1) by R.M. Reitan, 1979, Tuscon, AZ: Reitan Neuropsychology Laboratory. Copyright 1978 by R.M. Reitan. Reprinted by permission.

**APPENDIX K**

**Example of a Slide - Rosenzweig Picture Frustration Study**



**Note:** From Rosenzweig P-F Study (Form for Children) (p. 1) by S. Rosenzweig, 1948, Odessa, FL: Psychological Assessment Resources, Inc. Copyright 1948, renewed 1975, by S. Rosenzweig. Reprinted by permission.

APPENDIX L

Letters - Permission to Reproduce



**Electro-Cap International, Inc.**

February 17, 1995

Dianna Shaffer  
University of Ottawa  
Faculty of Education  
145 Jean-Jacques Lussier  
Ottawa, ON K1N 6N5  
Canada

Dear Ms. Shaffer:

Please feel free to reproduce pictures from our literature for the purpose of presenting your thesis proposal.

I am enclosing some of our current literature, including an Instruction Manual, for your use.

If we may be of further service, please let us know.

Sincerely,

A handwritten signature in cursive script that reads 'Amy Swallows'.

Amy Swallows  
Director of Marketing

## **NeuroDyne Medical Corporation**

**Corporate Offices:**

51 Winchester Street  
Newton, MA 02161-1704  
(617) 558-5300  
(617) 558-2897 (fax)

February 14, 1995

Dianna Shaffer  
Ph.D. Student, Faculty of Education  
University of Ottawa  
145 Jean-Jacques Lussier  
Ottawa, Ontario K1N 6N5  
CANADA

Dear Ms. Shaffer,

I am pleased to hear of your plan to use the MEDAC System/3 as part of your doctoral dissertation project. I appreciate your asking for permission to reproduce material from our manuals in your proposal. You should feel free to reproduce any material from the manuals that you wish to use as long as you attribute the source (i.e. *MEDAC Instrumentation User's Guide*, NeuroDyne Medical Corporation, Newton MA, USA, or simply NeuroDyne Medical Corporation, Newton MA, USA, etc.).

My own background training is in psychophysiology and I would be interested in hearing for about your dissertation plans. Please feel free to contact me if I can be of any assistance in terms of background information, use of the system for developing research protocols, etc. Please keep me posted on the progress of your project.

Sincerely,



Bruce L. Mehier  
Director Clinical Applications

AL\_0213a

**Manufacture and Sale of Davicon and other quality instrumentation for the non-invasive measurement of Surface EMG, Skin Temperature, Respiration, Electrodermal Activity, Heart Rate, and Peripheral Blood Flow.**

To: Dr. Ralph Reitan,  
P.O. Box 66080,  
Tuscon, Arizona.  
85728

Dear Dr. Reitan,

May 30, 1999.

I am a Ph.D student at the University of Ottawa in Canada. Currently, I am writing my thesis. Since I used the The Halstead Category Test in my research, I would like permission to reproduce one slide of the test to be included in the appendix of the thesis as an example. In no way will the reproduction of this slide result in an exchange of monies or personal gain.

Thank you for your attention to this matter. If you agree to give me authorization, please forward such authorization to:

Dianna Shaffer,  
149 MacLaren Street,  
Apt. 1,  
Ottawa, Ontario.  
K2P 0K8

Should you have any questions please contact me at: 1-613-565-9212

Sincerely yours,

*Dianna Shaffer*

Dianna Shaffer  
Ph.D Student  
University of Ottawa  
Canada

*June 8, 1999*

*Dear Ms. Shaffer:*

*As you may know, we have an obligation to be sure that neuropsychological tests do not fall into the hands of unqualified persons (prospective testees, etc). However, reproduction of one item could hardly cause a problem. Identification of principles used in the test, or any information that might help a testee obtain a "better" score, would violate APA ethical standards of conduct.*

*Good luck with your dissertation.*

*Sincerely,  
Ralph Reitan*



Department of Psychology

June 16, 1999

Ms. Dianna Shaffer  
149 MacLaren Street, Apt. 1  
Ottawa, Ontario  
K2p OK8

Dear Ms. Shaffer:

In response to your letter sent to the Psychological Assessment Resources, Inc., requesting permission to reproduce a copy of the Children's Form of the Rosenzweig Picture Frustration Study as an appendix in your Ph.D. dissertation, we are glad to grant this request as copyright owners of the P-F Study.

Please acknowledge this permission in your dissertation, as a footnote to your reproduction.

Most sincerely,



Saul Rosenzweig  
Professor Emeritus

Washington University  
Campus Box 1125  
One Brookings Drive  
St. Louis, Missouri 63130-1125  
(314) 935-6565  
Fax (314) 935-7588