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Executive Functions in Asperger's Disorder: An Empirical Investigation of Verbal and Nonverbal Skills

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Abstract

Researchers have investigated the specific strengths and weaknesses of individuals with Asperger's Disorder (AD). One construct used in this effort is Executive Functioning (EF). Whereas research has shown that this population performs more poorly than typically-developing matched controls on many EF tasks, there is a lack of consistency in these results. This is likely due to the use of inconsistent diagnostic criteria leading to incomparable studies. The present study investigated EF in AD using a bottom-up method whereby several EF tasks were administered to 33 adolescents with AD and 33 age- and gender-matched controls. Two-step cluster analysis was then used to derive subgroups. Diagnostic composition of these subgroups was examined to provide empirical evidence of a performance bias towards verbal EF for the AD group. Based on research demonstrating differential performance of modality on measures of cognitive intelligence and executive functioning, it was expected that a subgroup demonstrating high verbal and low non-verbal EF performance would be derived and that the majority of participants with AD would fall within this group. Results indicated that a two cluster solution best fit the data with 73% of the AD participants being classified into one cluster and 64% of the control participants classified into another. Investigation of the performance characteristics of the participants in cluster 1 indicated that assignment into this cluster was based primarily upon poor performance on the four visual EF tasks whereas assignment into cluster 2 was based primarily upon good performance on the four visual EF tasks and one verbal EF task. Further analysis of the data indicated that only two EF tasks demonstrated significant specificity, leading to the conclusion that these EF tasks are not adequate for diagnostic assessment of AD by

themselves although they can provide insight into the current EF abilities of individuals with AD.

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Dedication

This dissertation is dedicated to the important people in my life:

To my mother, Christine Elliott. Thank you for years of support and encouragement. Your dedication and perseverance has shown me that hard work brings large rewards. I hope I continue to make your sacrifices worthwhile.

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List of Abbreviations

AD	Asperger's Disorder
D-KEFS	Delis-Kaplan Executive Functioning System
DSM-IV-TR	Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revised
EF	Executive functions
EFA	Exploratory factor analysis
FSIQ	Full Scale Intelligence Quotient
HFA	High functioning autism
ICD-10	International Classification of Diseases - Tenth Edition
IQ	Intelligence Quotient (a measure of cognitive intelligence)
NLD	Nonverbal Learning Disability
PIQ	Performance (nonverbal) Intelligence Quotient
PDD	Pervasive Developmental Disorder
PDD-NOS	Pervasive Developmental Disorder - Not Otherwise Specified
ROC	Receiver operating characteristics
VIQ	Verbal Intelligence Quotient

Executive Functions in Asperger's Disorder: An Empirical Investigation of Verbal and Nonverbal Skills

Many theories have been put forth to explain the primary deficits seen in individuals diagnosed with a Pervasive Developmental Disorder (PDD). Specific efforts have been directed towards description and characterization of one disorder within this clinical category, namely Asperger's Disorder (AD). The Executive Functioning (EF) (Ozonoff, Pennington, & Rogers, 1991) theory has been researched extensively in these efforts. The primary focus of these efforts has been to understand and describe EF deficits in this population and link those deficits to the primary impairments demonstrated by individuals with AD. Despite considerable research documenting EF deficits in individuals with AD and related PDDs, such as Autism and Pervasive Developmental Disorder - Not Otherwise Specified (PDD-NOS), the use of EF as a method of taxonomical validation of the PDD clinical category remains a controversial issue. Specifically, no consistent evidence describing the abilities of individuals with AD in regards to EF exists, nor is there consistent evidence providing empirical validity of these PDD disorders as distinct diagnostic categories. A general consensus is emerging in the research literature that AD and the other PDDs differ only in terms of severity of symptoms (Ehlers et al., 1997; Klin & Volkmar, 2003; Manjiviona & Prior, 1999; Miller & Ozonoff, 2000; Ozonoff, South, & Miller, 2000; Prior et al., 1998; Verte, Guerts, Roeyers, Oosterlaan, & Sergeant, 2006). However, this consensus may be unwarranted as research in the area of taxonomic validation of these disorders has consistently used a problematic research design potentially leading to confounded and unrepresentative results. Specifically, many clinicians fail to use a standardized set of diagnostic criteria

when conducting assessments for AD resulting in a potentially heterogeneous clinical population. Researchers investigating this population via quasi-experimental comparative studies (e.g., where individuals with AD are directly compared against a second group of individuals) thereby run the risk of inconsistent and unreplicable results arising from diagnostic heterogeneity. The purpose of this study was to investigate EF abilities in individuals with AD via a true experimental design to better understand the specific EF strengths and weaknesses of individuals in this population. To better understand this disorder and the abilities of affected individuals, a discussion of the historical background and current diagnostic criteria for AD is warranted.

History of Asperger's Disorder

Autistic Disorder was originally introduced to the scientific literature by Leo Kanner (1943) who described eleven children with "early infantile autism." These children were characterized as relating better to objects than people and showing severe social and communication abnormalities, as well as narrow and restricted interests. One year later, Hans Asperger, a Viennese physician, separately published a work characterizing children with "autistic psychopathology" (Asperger, 1944/1991). These children were described as being verbally fluent with peculiar language use and abnormal prosody. They also were socially isolated and demonstrated repetitive behaviours, a desire for sameness, a propensity towards rote memorization of facts, interest in unusual topics, and motor clumsiness. Although Kanner's work became well known in the English speaking world, it wasn't until Lorna Wing's (1981) seminal work that Asperger's Syndrome was introduced. Although several similarities exist between these accounts (e.g., difficulties with social interaction and communication and circumscribed

and idiosyncratic patterns of interest), Asperger's description differed in several areas. Speech was less commonly delayed, motor deficits were more common, onset of symptoms was later, and all of his initial cases were male.

Both the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision* (DSM-IV-TR; American Psychiatric Association, 2000) and *International Classification of Diseases, Tenth Edition* (ICD-10; World Health Organization, 1994) clinical classification systems currently recognize AD as a separate and distinct diagnostic disorder within the PDD category, defined using behavioural criteria. That is, this disorder is diagnosed through the exhibition of specific patterns of behaviour outlined in both clinical diagnostic classification systems. Currently, highly similar diagnostic requirements are specified for all clinical conditions described within the PDD category reflecting similarities in symptomology between these disorders, with the primary distinction being intact language and cognitive intelligence in the case of AD.

Asperger's Disorder: Diagnostic Criteria

AD is described in the DSM-IV-TR (American Psychiatric Association, 2000) and ICD-10 (World Health Organization, 1994) as a PDD defined by impairments in social interaction and repetitive and stereotyped behavioural patterns. In contrast to the other clinical disorders within the PDD category (e.g., Autistic Disorder), a diagnosis of AD requires that no significant delay in language exists as evidenced by appropriate single word use by the age of two and communicative phrases by the age of three, as well as no significant delay in cognitive and adaptive development (e.g., performance in the Average range, or above a standard score of 85, on standardized cognitive and adaptive measures). Additionally, the criteria for another PDD cannot be met for a diagnosis of

AD. The prevalence rate of AD is conservatively reported to be 2.5 (Fombonne, 2003) to 2.6 (Fombonne, 2005) per 10,000 children.

The addition of AD in the DSM-IV (American Psychiatric Association, 1994) was guided by an attempt to bring this condition to the attention of nosologic researchers to determine differences between it and the other PDD disorders (Klin & Volkmar, 2003). Prior to its addition, the diagnostic criteria for the disorder often differed from one clinician or researcher to another resulting in a heterogeneous clinical group. That is, many clinicians used different diagnostic criteria during assessments for AD resulting in inconsistencies in the diagnostic composition and characteristics of individuals provided with an AD diagnosis.

Subsequent to its inclusion in the DSM-IV and ICD-10 classification systems as a PDD, researchers investigated the nosology in an effort to empirically validate the distinction between AD, Autism, and PDD-NOS. Despite "gold standard" classification systems such as the DSM-IV-TR, nosological research efforts have yielded variable results, likely due to differential criteria used in clinical practice when diagnosing individuals with AD (Klin, Pauls, Schultz, & Volkmar, 2005). This variability is likely due to the lack of standardized operational definitions of the behaviours described in the classification systems, allowing for individual clinical judgment when conducting a diagnostic evaluation.

Diagnostic Validity of AD and the PDDs

Controversy currently exists in the research literature regarding the nosology of AD and the other clinical disorders within the PDD category, specifically Autism and PDD-NOS. Although both current major classification systems (DSM-IV-TR and ICD-

10) regard these disorders as distinct, consistent empirical evidence supporting such a differentiation is lacking (see Miller & Ozonoff, 2000; Szatmari, Archer, Fisman, Streiner, & Wilson, 1995). As per the DSM-IV-TR diagnostic requirements for AD and Autism, these two groups are clinically differentiated only by the presence or absence of intact verbal abilities and associated developmental milestones (American Psychiatric Association, 2000). Additionally, individuals with AD tend to be less severely affected in terms of symptom presentation than the typical presentation of Autism. These criteria are described in Table 1 on page 62. The problem of effective and appropriate differentiation becomes compounded when attempting to differentiate individuals with AD and "high-functioning autism" (HFA), a term often used in reference to individuals diagnosed with Autism who demonstrate overall intelligence in the Average to Above Average ranges in addition to intact language (Mayes, Calhoun, & Crites, 2001; Miller & Ozonoff, 2000; Schopler, 1998; Wing, 1991). In essence, AD and HFA can each be seen as falling within the high-functioning end of the PDDs; however, they are clinically differentiated by the presence of a significant delay in communicative skills in the case of individuals with HFA who should be more correctly clinically diagnosed with Autistic Disorder. This issue of differential diagnosis based upon language development has led many researchers to either combine individuals with AD, HFA, and PDD-NOS into one unitary "high functioning PDD" group or to improperly classify individuals with HFA or PDD-NOS as having AD based upon functioning level at the time of assessment or research participation. As a result, the research literature on the specific abilities of individuals with AD is abound with conflicting or inconsistent results.

Despite this methodological problem, many researchers have attempted to define and describe the specific pattern of abilities of individuals with AD. A review of the literature regarding neuropsychological functioning of individuals with AD is relevant to the present study.

Neuropsychological Functioning

Cognitive intelligence (IQ) is difficult to define as it is utilized in numerous contexts. In general, it refers to "the aggregate or global capacity of the individual to act purposefully, to think rationally, and to deal effectively with his environment" (Wechsler, 1944). This construct is most often used in reference to standardized testing by which an individual can be compared to age-related peers to determine if specific areas of cognitive strength or weakness are apparent.

In the area of cognitive ability, Asperger's original accounts (Asperger 1944/1991) described his cases as possessing normal cognitive intelligence and being capable of gainful employment. Researchers have investigated the intellectual profiles of individuals with AD to ascertain if a specific profile exists that may provide validity for differential diagnosis specifically from Autism/HFA and PDD-NOS. Results have been mixed. Many researchers have found evidence for a differentiation between Verbal IQ (VIQ) and Performance IQ (PIQ) within individuals with AD. The majority of research findings suggest that such individuals demonstrate higher VIQ and lower PIQ (Allen, Lincoln, & Kaufman, 1991; Ehlers et al., 1997; Ghaziuddin & Mountain-Kimchi, 2004; Klin & Volkmar, 2003; Klin, Volkmar, Sparrow, Cicchetti, & Rourke, 1995; Lincoln, Courchesne, Allen, Hanson, & Ene, 1998; Lincoln, Allen, & Killman, 1995; Miller & Ozonoff, 2000; Ozonoff, Rogers, & Pennington, 1991; Rourke, 1989; Volkmar et al.,

1994). However, these findings are not universal and some results show no modality differences (Ambery, Russell, Perry, Morris, & Murphy, 2006; Manjiviona & Prior, 1999; Ozonoff, 2000; Ozonoff et al., 2000; Szatmari, Tuff, Finlayson, & Bartolucci, 1990; Szatmari et al., 1995; Verte et al., 2006). Additionally, in some research, the opposite profile (higher PIQ compared to VIQ) has also been found (Ameli, Courchesne, Lincoln, Kaufman, & Grillon, 1998; Asarnow, Tanguay, Bott, & Freeman, 1987). Although no effective explanation for these contradictory findings has been put forth, one plausible reason is the use of inconsistent diagnostic criteria used to define participants as belonging to the AD samples.

Researchers have also investigated the differences in IQ subtest profiles of individuals with AD. Although the performance of these individuals on many cognitive tasks falls within the Average range (e.g., above a standard score of 85), findings suggest relative strengths in the verbally-mediated cognitive subtests of the Wechsler series of cognitive tests (e.g., Information, Vocabulary, Comprehension, Similarities, and Arithmetic) (Ehlers et al., 1997; Ghaziuddin & Mountain-Kimchi, 2004; Ozonoff et al., 2000; Ozonoff, Rogers, et al., 1991; Szatmari et al., 1990) and relative weaknesses in perceptually-mediated subtests (e.g., Block Design, Object Assembly, Coding) (Ehlers et al., 1997). This evidence provides further support for a verbally-mediated strength in AD as individuals in this population perform better on verbally-mediated subtests (Information, Vocabulary, Comprehension, Similarities, and Arithmetic) than visually-mediated subtests (Block Design, Object Assembly, Coding).

Additionally, a theory relating the cognitive profiles of AD and Nonverbal Learning Disability (NLD) has been put forth (Klin et al., 1995). NLD is characterized

by strengths in verbally mediated skills (e.g., vocabulary, rote knowledge, verbal memory, and verbal output) and a resulting right hemisphere dysfunction, a pattern shared by individuals with AD (Klin et al., 2005; Klin et al., 1995). Klin and colleagues (1995) compared individuals diagnosed with AD and HFA on measures of cognitive assets and deficits associated with NLD. They reported a high concordance rate between the profiles of individuals diagnosed with AD and NLD while individuals with HFA did not display this profile. Specifically, they reported that individuals with AD and NLD share a profile of higher VIQ and lower PIQ performance, as well as deficits in fine and gross motor skills, visual-motor and visual-spatial abilities, visual memory, and nonverbal concept formation. On this basis, the researchers concluded that, "... the NLD profile was indeed an adequate model of neuropsychological assets and deficits encountered in individuals with Asperger's Syndrome" (pg. 1133). Several additional studies have reported similar findings (e.g., Ehlers et al., 1991; Ghaziuddin & Mountain-Kimchi, 2004; Lincoln et al., 1998; Rourke, 1989). However, this finding is not universal, as some researchers have failed to replicate these findings (e.g., Ozonoff, 2000; Szatmari et al., 1995).

Although the finding of a distinct IQ profile of AD (especially in light of the concordance with NLD) is compelling evidence of a taxonomical distinction between AD and other clinical disorders within the PDD category, this line of evidence cannot be used to describe AD, or differentiate it from the other PDDs, due to the diagnostic criteria for these disorders. Specifically, the criteria for AD require that normal language developmental milestones be met. It is therefore not surprising that AD may be differentiated from HFA on the basis of verbal intelligence or ability. Moreover, the

criteria for a diagnosis of AD specify that no clinically significant delay in cognitive development or in the development of age-appropriate self-help skills, adaptive behaviour other than social interaction, and curiosity about the environment in childhood be present. Thus, all individuals with AD should by necessity demonstrate Full Scale Intelligence Quotients above 85 thereby restricting the range of scores and likely influencing the reported results. Research investigating external validity of the nosology must focus on aspects other than a differentiation in functioning related to verbal intellectual ability. Essentially, the diagnostic criteria specify that intact intelligence is a defining characteristic of AD as opposed to other PDDs, therefore it is inappropriate to use this criterion in nosological research efforts.

Researchers investigating these populations have focused upon external validity of the nosology, or determinants outside of the diagnostic criteria, to empirically prove or disprove the distinction of these disorders. Several theories have been proposed in an effort to provide the required criteria for appropriate external validation of the nosology. Each offers a potential method of differentiation between subgroups of individuals with a PDD while attempting to provide an account of the core symptoms of such disorders. One of the leading theories of differentiation is Executive Functioning.

Executive Functioning

Executive Functioning (EF) is a broad term used to refer to higher cognitive processes that allow one to mediate their behaviour in response to an ever-changing environment. It has been defined as "the ability to maintain an appropriate problem-solving set for attainment of a future goal" (Ozonoff, Pennington, et al., 1991). It is an umbrella term used to describe higher mental processes such as selective attention,

impulse control, planning, problem solving, inhibition of pre-potent (or automatic) responses, flexibility of thinking, concept formation, working memory, and abstract thinking. The term "Executive Functions" was introduced in relation to the work of Luria (1966) who proposed a cognitive system in charge of intentionality and formulation of thoughts and actions, the identification of goal-appropriate cognitive routines, and evaluation of outcomes. This area of mental functioning has been shown to be primarily regulated by the prefrontal cortex through imaging and neuropsychological studies, though it is not solely responsible for these cognitive processes (Elliott, 2003; Godefroy, 2003; Goldman-Rakic, 1987; Rubia, Smith, Brammer, & Taylor, 2003; Rubia et al., 2001). As such, this area of the brain is now thought to act primarily as a "control center" to mediate these higher-level cognitive functions (Miller & Cohen, 2001).

Developmentally, self control appears as early as 12 to 18 months of age (Kochanska, Coy, & Murray, 2001; Kopp, 1982), when children become capable of complying with caregivers' simple requests (e.g., "sit down"). As children near two years of age, they begin to acquire a more sophisticated ability to self-control where, for example, they are able to respond to a request to "wait" for something. By three years, more complex inhibitory control begins to emerge with children slowly increasing their ability to self-regulate. Children at this age demonstrate control through, for example, turn-taking, sharing, and asking permission. Inhibitory control has been found to increase significantly throughout the preschool years with a large improvement occurring between the ages of 3 and 6 years (Carlson & Moses, 2001; Gerstadt, Hong, & Diamond, 1994; Kochanska, Murray, Jacques, Koenig, & Vandergeest, 1996; Reed, Pien, & Rothbart, 1984). General inhibitory control abilities have been found to be related to a

variety of cognitive abilities, including those of social perspective taking or "theory of mind" (e.g., Carlson & Moses, 2001; Hala, Hug, & Henderson, 2003) and social competencies (e.g., Kochanska et al., 2001; Kopp, 1982).

The EF theory is a leading topic of research in the area of PDDs (Ozonoff, Pennington, et al., 1991; Pennington, 2002). Indeed, executive dysfunction has been proposed to potentially explain restricted interests and repetitive behaviours commonly displayed by individuals diagnosed with a PDD (Lopez, Lincoln, Ozonoff, & Lai, 2005; Pennington, 2002; Turner, 1997, 1999). Such individuals often display restricted and stereotyped patterns of behaviour that are hypothesized to result from a deficit in mental flexibility and related EF abilities. As EF is a realm independent of the diagnostic criteria for AD, as opposed to cognitive intelligence, examining EF abilities offers an externally valid means to identify and differentiate PDD subgroups and could potentially be a useful construct in the diagnostic process.

Executive Functioning and IQ

As has been noted frequently in the research literature, although EF and IQ may be related, they are different cognitive constructs (Pennington & Ozonoff, 1996; Kolb & Winshaw, 1990). A common misperception is apparent in clinical practice and the research literature regarding the relationship between EF and IQ. A high degree of overlap is often cited in the research literature, stemming primarily from the work of Sternberg (Sternberg, 1985; Sternberg & Gardner, 1982). This line of research has proposed that *g*, or general intelligence, represents an individual's overall cognitive intellectual functioning and that individual differences in EF can be explained by differences in *g*.

Corollaries of this hypothesis have been explored and challenged (Crinella and Yu, 2000). Three lines of evidence have been put forward to challenge this notion of EF/IQ interdependence. First, if such a direct relationship exists, then tasks with a higher *g* loading will necessarily draw more upon EF than tasks with low *g* loadings. Researchers investigating this relationship between IQ and EF have shown that, although a positive correlation may exist between EF and IQ measures, the correlations are quite low (Ardila, Pineda, & Rosselli, 2000, Arffa, 2007, Welsh, Pennington, & Grossier, 1991). Moreover, this relationship appears to be most related to one aspect of *g*, fluid intelligence, rather than crystallized intelligence. Several researchers have reported that individuals affected by some childhood disorders, such as Learning Disorders, Autism, phenylketonuria, and Attention-Deficit/Hyperactivity Disorder, demonstrate poor performance on measures of fluid intelligence and EF, but relatively intact overall and crystallized intelligence (Barkley, 1997; Berlin, 2003; Diamond, Prevor, Callendar, & Druin, 1997; McLean & Hitch, 1999; Pennington & Ozonoff, 1996; Stanovich, Siegel, & Gottardo, 1997; Swanson, 1999).

Second, if such a direct relationship between EF and IQ exists, then individuals with a deficit in one area should necessarily demonstrate a deficit in the other. There is ample research evidence that many individuals, such as those with Attention-Deficit/Hyperactivity Disorder (ADHD), demonstrate consistent EF deficits (Barkley, 1995, 1997; Pennington, Grossier, & Welsh, 1993). However, despite this well-documented EF deficit, the mean Full Scale IQ scores of individuals with ADHD do not reflect this deficit. Although individuals with ADHD do often displays areas of deficit on common measures of intelligence such as the Wechsler Intelligence Scale for Children –

Fourth Edition (WISC-IV; Wechsler, 2003), the effect size of this difference is not large nor is it commensurate with their demonstrated EF deficits (Schwean & Saklofske, 2005, Schwean & McCrimmon, 2008, Mayes & Calhoun, 2006). Thus, although individuals may demonstrate an EF deficit, they do not necessarily demonstrate an equivalent IQ deficit (Schwean, Saklofske, Yackulic, & Quinn, 1993; Swanson et al., 1997).

Third, there is research evidence to show that the frontal lobes of the brain are clearly responsible for EF (Cummings & Benson, 1990, Luria, 1966). However, minor insult to sections of the frontal lobes of the brain frequently results in deficits to EF but not IQ (Hebb, 1945, 1949, Teuber, 1959; Stuss & Benson, 1984). Thus, individuals with intact IQ are capable of demonstrating deficits in EF, providing evidence for their differentiation in terms of skills and abilities.

In general, a positive relationship exists between EF and IQ in that tasks of EF typically require a base level of cognitive ability in order to succeed and vice-versa. Indeed, common sense dictates that problems cannot be solved without EF. However, the relationship between these two constructs is far from direct. EF is but one information processing component necessary for problem solving. Correlations between IQ and EF measures tend to be small to moderate, suggesting that many factors other than EF influence an individual's IQ. Many individuals who demonstrate an EF deficit do not demonstrate a comparable IQ deficit. Similarly, insult to the regions of the brain associated with EF does not always impair *g*. Indeed, as succinctly pointed out by Duncan, Burgess, and Emslie (1995, p. 262), "frontal patients have impaired 'planning', 'problem solving', etc. but preserved 'intelligence'".

Executive Functioning in Asperger's Disorder

Many studies have investigated EF in individuals with AD (Miller & Ozonoff, 2000; Manjiviona & Prior, 1999; Ozonoff, Pennington, et al., 1991; Ozonoff, Rogers, et al., 1991). The common approach has been quasi-experimental, investigating this construct across individuals with differing clinical diagnoses and matched control groups to determine if differential performance exists. Pennington (1997) has identified a number of variables commonly investigated in EF research: mental flexibility/set shifting and planning, working memory, and inhibition.

Mental flexibility, or set shifting, is defined as the ability to perceive things in a different manner, respond in unique ways and/or to make necessary cognitive adjustments to assist goal attainment, whereas planning is defined as the ability to form a strategy for goal attainment and see it through regardless of the number of required steps (Calhoun, 2005). Several studies have reported that individuals with AD perform significantly below typically-developing matched controls on common EF measures of mental flexibility and planning such as the Wisconsin Card Sorting Task (Ozonoff, 1997; Ozonoff, Pennington, et al., 1991; Ozonoff, Rogers, et al., 1991; Verte et al., 2006), Tower of Hanoi (Ozonoff, Rogers, et al., 1991), Tower of London (Manjiviona & Prior, 1999; Verte et al., 2006), the Intradimensional-Extradimensional Set-Shift (ID/ED shift) task of the CANTAB (Hughes, Russell, & Robbins, 1994), and a local-global shifting task (Rinehart, Bradshaw, Moss, Brereton, & Tonge, 2001). It has been suggested that this pattern of reduced mental flexibility and planning could be more commonly displayed as an inability to disengage from an object and shift from an external to an internal point of reference resulting in difficulties relating to people in a social manner

and engaging in conversation where the topic of discussion often changes over time (Hughes & Russell, 1993; Russel, Mauthner, Sharpe, & Tidswell, 1991).

In contrast, working memory is the ability to hold information in storage (in a system of short-term memory) while manipulating it and comparing it with information possessed in long-term storage (Calhoun, 2006). Several researchers have found evidence for impaired spatial working memory in individuals with AD (Bennetto, Pennington & Rogers, 1996; Morris et al., 1999; Ozonoff and Jensen, 1999; Ozonoff, Pennington et al., 1991; Williams, Goldstein, Carpenter, & Minshew, 2005; Williams, Goldstein, & Minshew, 2006). However, these findings are not consistent, as other studies have failed to find evidence for impairment (Griffith, Pennington, Wehner, & Rogers, 1999; Ozonoff & Strayer, 2001; Russell, Jarrold, & Henry, 1996). Again, the use of inconsistent diagnostic criteria is a likely explanation for these inconsistent results.

Finally, inhibition is the ability to control a response that will not support goal attainment and instead activate an appropriate alternative (Calhoun, 2006). Researchers using the Stroop task, a classic measure of inhibition where participants are asked to say the color of ink a word is printed in rather than read the word (e.g., saying "blue" when the word 'green' is written in blue ink), have reported no differences in performance between individuals with AD and typically-developing controls. This lack of difference in the realm of inhibition has also been demonstrated on a task of negative priming (Ozonoff & Strayer, 1997), a Go/No-Go task, and the Color-Word Interference Task (Ozonoff, Strayer, McMahon, & Filloux, 1994), a modification of the classic Stroop task with an added inhibition/switching task that increases task difficulty. It therefore appears that individuals with AD possess intact inhibition skills.

The forgoing literature has shown there to be inconsistent evidence in favour of an EF deficit in mental flexibility/set shifting, planning, and working memory in individuals diagnosed with AD as compared to typically-developing controls. Whereas some researchers have found a difference in performance between individuals with AD and typically-developing controls on common EF tasks (Ozonoff, Rogers, et al., 1991; Rinehart et al., 2001; Verte et al., 2006), others have reported no difference (Manjiviona & Prior, 1999; Miller & Ozonoff, 2000). Nonetheless, some researchers have continued to investigate EF in these populations in an effort to clarify the research findings regarding the current clinical nosology.

Kleinhans, Akshoomoff, and Delis (2005) investigated EF in individuals with AD and Autism using four subtests of the Delis-Kaplan Executive Functioning System (D-KEFS), a comprehensive EF battery comprised of nine measures of EF ability. Their sample was a combined group comprised of individuals with AD and individuals with Autism within the high-functioning range (HFA). These researchers found that this combined participant group performed significantly below typically-matched controls on a composite EF measure despite Average IQ, although this discrepancy was generally mild. In addition, performance in the individual subtests was examined. The combined participant group performed in the Below Average range on letter fluency and switching fluency, two aspects of the Verbal Fluency subtest. This finding, in combination with the finding that participants' performance was within the Average range on design fluency (a non-verbal EF task) and the general understanding in the research literature that individuals with AD tend to have a relative strength in visuospatial processing (Joseph, Tager-Flusberg, & Lord, 2002; Lincoln, Courchesne, Kilman, Elmasian, & Allen, 1988;

O'Riordan, Plaisted, Driver, & Baron-Cohen, 2001), led these researchers to suggest that individuals within these two clinical populations may be associated with a modality-specific EF deficit, specifically a verbal EF deficit. However, the results of this study are potentially unrepresentative of individuals with AD as a mixed sample was utilized. Specifically, given that individuals with AD and HFA are clinically differentiated based upon the presence of a language delay in early childhood (before the age of three) in the case of HFA, this could result in further difficulties in language processing later in life. In turn, this delay could be represented by reduced performance on verbally-mediated EF measures. The combination of individuals with HFA and AD into the same participant group may have resulted in erroneous conclusions regarding a potential verbal EF deficit in individuals with AD. Moreover, these researchers utilized a very small sample size consisting of six participants with AD and six with HFA resulting in potentially unrepresentative conclusions of the skills and abilities of the participants with AD.

The notion of a modality-specific deficit in EF ability in individuals with AD was also investigated by Manjiviona and Prior (1999). These researchers used a sample of 56 children with an average age of 10.8 years (range of 6-17 years) who were separated into AD or HFA groups. Measures purported to be left- or right-hemisphere mediated (verbal and non-verbal respectively) were selected to investigate differential performance on these tasks. Left hemisphere tasks included the Similarities, Vocabulary, and Comprehension subtests of the Wechsler Intelligence Scale for Children-Revised (WISC-R; Wechsler, 1974) and the Verbal Problem-Solving, Problem Situations, and Verbal Absurdities subtests of the Stanford-Binet Intelligence Scale, Third Revision (Terman & Merrill, 1960). Right hemisphere tasks included the Block Design and Object Assembly

subtests of the WISC-R and the Rey-Osterrieth Complex Figure Test (Osterrieth, 1944). EF measures used were the Tower of London (Shallice, 1982) and the Controlled Oral Word Association Test (Benton, 1969), as they were age-appropriate tasks. The results showed that, although the AD group had a significantly greater Full-Scale IQ ($M = 102.6$) than the individuals classified as having HFA ($M = 88.6$), there was no difference in performance on the EF measures. On the basis of these results, the researchers concluded that these two groups cannot be distinguished on the basis of EF ability or, when IQ is in the normal range, on the basis of intellectual modality. However, this study employed a potentially problematic methodology that may have confounded their results. Specifically, a quasi-experimental research design was used. Research investigating AD utilizing a quasi-experimental design that separates participants into specified groupings prior to the research process may encounter the problematic issue of heterogeneous participant grouping. As non-standard criteria are often used in clinical diagnosis of individuals with AD, participants placed in this category based upon previous diagnosis may be classified differently if appropriate criteria are used.

Summary and Critique

Researchers have investigated specific skills and abilities in individuals with AD. A theorized deficit in EF has driven many of these efforts. Although it has been shown that individuals in this population exhibit a deficit in various aspects of EF ability, conflicting results have been reported in the research literature. There are several reasons as to why this may be so. As described previously, the criteria used in classifying participants as either AD or Autism/HFA often differs from clinician to clinician, from researcher to researcher, and from project to project. This inconsistency has expanded

beyond research into clinical work as evidenced by Mayes, et al. (2001) where it was reported that the DSM-IV definition and specific criteria of AD is often ignored in place of personal clinical judgment. This issue has been highlighted by Klin and colleagues (2005) who examined differential diagnosis through the use of three classification criteria. The "DSM-IV" approach utilized the triad of symptom clusters criteria outlined in the DSM-IV and DSM-IV-TR (American Psychiatric Association, 1994; 2000). The "Speech Delays" approach utilized criteria of intact speech milestones in early development to differentiate the groups. The "New System" approach included those unique aspects of AD included in the narrative text of the DSM-IV-TR (American Psychiatric Association, 2000) and ICD-10 (World Health Organization, 1992), such as seeking of social contact in an insensitive manner and precocious speech. Although the results showed no difference in FSIQ, VIQ or PIQ of individuals classified as having either AD or Autism by the three classification schemes, both the DSM-IV and New System approaches yielded differences in the VIQ-PIQ differential between the AD and Autism groups. Specifically, the DSM-IV system resulted in an average VIQ-PIQ differential of 23 points in favour of VIQ for the AD participants (compared to a similar split of only 7.5 points for individuals classified as having Autism) whereas the New System scheme yielded an average split of 17.4 points in favour of VIQ for the individuals classified as AD (compared to 5.0 for those classified as having Autism). Additionally, agreement between the three systems in terms of classification of individuals was only 44%, meaning that 56% of the individuals received two different diagnoses depending upon the diagnostic scheme. On this basis the researchers reported

that "comparison across studies using different diagnostic systems for AD is virtually impossible" (Klin et al., 2005, pg. 230).

This inconsistency in diagnostic criteria for individuals with AD poses a critical issue for research in that findings among research projects cannot be directly compared. This issue is further compounded in that research in this domain, as outlined in this review, has primarily used a quasi-experimental research paradigm whereby individuals are classified *a priori* as having AD followed by examination of potential differential performance on specific tasks. This research method, coupled with inconsistent classification criteria, has likely lead to the contradictory findings that abound in the research literature on this topic.

Present Study

The present study was designed to investigate the theorized modality-specific deficit in EF in individuals with AD proposed by Kleinhans and colleagues (2005). A true experimental research paradigm was utilized, rather than a quasi-experimental approach as is typically used in research efforts, to provide empirically-based evidence of a modality-specific EF deficit in adolescents and young adults in this population. This approach allows for *a posteriori* empirical judgement of group categorization rather than *a priori* group membership which has resulted in inconsistencies in the research literature.

To achieve this goal, performance on seven subtests of the Delis-Kaplan Executive Functioning System (D-KEFS) was examined through the use of cluster analysis to empirically derive subgroups of participants. Three of these subtests are purported to measure verbally-mediated EF ability (Verbal Fluency, Word Context, and

Proverb), whereas four are visually-mediated (Trail Making, Design Fluency, Color-Word Interference, and Tower; Delis, Kaplan & Kramer, 2001). The composition of these empirically derived subgroups was then examined in terms of diagnostic characteristics and specific EF performance of the represented individuals.

Finally, to determine the effectiveness of the D-KEFS as a diagnostic tool for AD, the seven administered subtests were examined via receiver operating characteristics (ROC) analysis. Specifically, the sensitivity and specificity of each subtest was examined to determine which subtests could potentially be clinically useful for diagnostic purposes.

Based upon research evidence showing an overall EF deficit in individuals with AD, it was hypothesized that subgroups of participants would be derived based upon performance on the EF subtests. Specifically, it was hypothesized that one cluster of participants would be comprised primarily of individuals with AD and a second cluster would be comprised primarily of typically-developing matched control participants. Further, it was hypothesized that the clusters would be differentiated by performance on verbally-mediated versus visually-mediated EF tasks. That is, cluster 1, comprised primarily of individuals with AD, would demonstrate better performance on verbally-mediated EF tasks than the individuals in cluster 2. Additionally, cluster 2, comprised primarily of typically-developing control participants, would demonstrate better performance on visually-mediated EF tasks than the individuals in cluster 1. Finally, based upon the diagnostic requirements and well-documented research findings of intact language and communication skills in individuals with AD, it was hypothesized that the results of the ROC analysis would indicate that the four visually-mediated subtests of the

DKEFS possess significant sensitivity and specificity in identifying individuals with AD from typically-developing individuals. That is, the individuals with AD would demonstrate poor performance on the visually-mediated EF tasks, and this performance can be used to clinically differentiate them from the typically-developing control participants. As such, the four visually-mediated D-KEFS tasks may be clinically useful in a comprehensive diagnostic assessment for AD.

This study will potentially provide a significant contribution to the current research literature on EF in individuals with AD in that it overcomes the present methodological issue of *a priori* group designation. Specifically, the empirical process whereby groups are empirically derived on the basis of performance does not fall prey to the quasi-experimental confound of *a priori* designation of groups that has often been the practice in research with clinical populations such as AD. This practice typically results in inconsistent results when, as is the case with AD, the diagnostic criteria used to clinically define specific groups of participants differs from one research study to the next. The results of this study will potentially provide an empirically sound foundation from which external validation of the nosology on the basis of EF can be examined.

Methods

Participants

41 participants with a PDD initially participated in the study. Eight of these were removed for 1 of 2 reasons: six participants were removed due to a confirmed clinical diagnosis of Autistic Disorder (HFA) and two participants were removed due to failure to meet the IQ inclusion criteria described below. Therefore, the final clinical sample included 33 adolescents or young adults diagnosed with AD (M = 18.83 years, range 16-

21 years, 78.8% male) and 33 age- and gender-matched typically-developing controls (M = 18.86 years, range 16-21 years, 78.8% male). All participants were required to demonstrate verbal (VIQ), nonverbal (PIQ), and full scale intelligence (FSIQ) in the Average or higher ranges (Full Scale IQ scores of 85 or greater) on the Wechsler Abbreviated Scales of Intelligence (WASI; Wechsler, 1999). These inclusionary criteria were necessary to ensure both the integrity of the clinical diagnosis for the individuals with AD as well as to ensure that poor performance on the EF tasks could not be attributed to lower cognitive ability. The participants were not matched according to VIQ, PIQ, or FSIQ, as research has shown that individuals with AD typically demonstrate a specific profile of intellectual abilities and the purpose of the control group was to provide a comparison of individuals typical of the population. The participant groups did not differ with respect to age ($t(64) = -0.94, p = 0.925$), VIQ ($t(64) = 1.796, p = 0.077$), PIQ ($t(64) = 0.112, p = 0.911$), or FSIQ ($t(64) = 1.303, p = 0.197$). Consistent with many findings in the research literature, the participants with AD did demonstrate significantly greater VIQ than PIQ ($t(32) = 2.727, p = 0.01$).

The diagnosis of the individuals with AD was confirmed using DSM-IV-TR (American Psychiatric Association, 2000) diagnostic criteria. These participants were required to have a documented history of qualitative impairment in social interaction, repetitive or stereotypical patterns of behaviour, and in-tact language development in early childhood in addition to a clinical diagnosis of AD made by a licensed professional not associated with the current study (e.g., Psychologist, Psychiatrist, Developmental Pediatrician). Participants were required to provide documentation specifying the professional who provided their diagnosis as well as information pertaining to their

developmental history. This information was subsequently reviewed by the researcher to ensure that adherence to DSM-IV criteria for AD was met prior to inclusion into the study. A more strict diagnostic process involving such measures as the Autism Diagnostic Interview – Revised (Lord, Rutter, & Le Couteur, 1994) was not possible as appropriate individuals (e.g., parents) were unavailable to complete this measure for the majority of the participants. Participant demographic characteristics are described in Table 2 on page 63.

Measures

Verbal, nonverbal, and full-scale intelligence. VIQ, PIQ, and FSIQ were assessed using the Wechsler Abbreviated Scales of Intelligence (WASI; Wechsler, 1999), an individually administered abbreviated test of cognitive intelligence linked to both the Wechsler Intelligence Scale for Children (WISC-III; Wechsler, 1991) and the Wechsler Adult Intelligence Scale (WAIS-III; Wechsler, 1997). It is appropriate for assessing the general intellectual ability of adults or children (aged 8-89). The WASI was standardized on a sample of 2,245 American individuals, stratified according to 1997 US census data. Internal consistency estimates are high and range from .92 to .98 for the IQ scores. Stability coefficients for the VIQ range from .92 to .97, indicative of high reliability. With reference to evidence for validity, scores on the WASI were highly correlated with scores on the WISC-III (ranged from .69 to .74 for subtests; .76 to .87 for IQ scores) and the WAIS-III (.66 to .88 for subtest scores; .84 to.92 for IQ scores).

The VIQ domain on the WASI is comprised of the Similarities and Vocabulary subtests while the PIQ domain is comprised of the Block Design and Matrix Reasoning subtests. This measure was administered following the standardized instructions outlined

in the administration manual. Raw scores were converted to norm-referenced standard scores ($M = 100$, $SD = 15$). The VIQ, PIQ, and FSIQ performance for the sample are presented in Table 2 on page 63.

Executive functioning. The Delis-Kaplan Executive Function System (D-KEFS) (Delis, et al., 2001) is a comprehensive measure of cognitive functions related to executive processes including planning, reasoning, mental flexibility, and inhibition. The D-KEFS is comprised of nine subtests that may be administered individually or in conjunction with others. As there are no composite scores, the clinician may administer only those specific subtests of interest. A simplified list of the subtests used in this study appears in Table 3 on page 64. These subtests were administered following the standardized instructions outlined in the administration manual. Raw scores were converted to norm-referenced scaled scores ($M = 10$, $SD = 3$).

The D-KEFS was standardized on a stratified sample of 1750 non-clinical individuals in the United States based on 2000 US census data. Reliabilities of the D-KEFS tests were demonstrated to be comparable to other commonly available tests of executive function (Delis, Kramer, Kaplan, & Holdnack, 2004). The authors of the D-KEFS explain that, since the D-KEFS consists of various distinct subtests, comparison to single measures of executive function has not been conducted. Rather, correlational analyses of conditions for each subtest in relation to each other in normal functioning individuals are provided. Results indicate that 1) the relative contribution of each executive function differs between age groups (as would be expected in developmental neuropsychological theory) and, 2) overall low correlations between tests indicate that each measures distinct, relatively independent executive functions (Delis et al., 2001).

Reliability of the D-KEFS is reported through the use of split-half reliability. Values varied depending upon the age range of the sample and the specific task being evaluated. For example, moderate to high split-half reliabilities were reported for the Trail Making Number-Letter Switching (0.57 to 0.81), Color-Word Interference (0.62 to 0.86), and Proverb (0.68 to 0.80) tasks. Low to moderate split-half reliabilities were reported for the Verbal Fluency - Category Switching (0.37 to 0.68), Word Context (0.47 to 0.74), and Tower (0.43 to 0.78) tasks. The nature of the Design Fluency task precluded a split-half reliability coefficient from being calculated. Overall, while some of the reliability coefficients are low, the majority are adequate.

Validity of the D-KEFs subtests was provided through the use of intercorrelations of measures within the individual D-KEFS tests, correlations between D-KEFS tests with other related tasks, and findings from pilot studies with clinical populations. Intercorrelations of tasks within individual subtests were low to moderate. However, it should be noted that different tasks within the individual D-KEFS subtests are designed to evaluate component processes of a higher-order primary task. For example, the Trail Making subtest consists of five tasks (Visual Scanning, Number Sequencing, Letter Sequencing, Letter-Number Switching, and Motor Speed) with the Number-Letter Sequencing task being the primary task and the others consisting of component tasks. Therefore, it is unsurprising that the reported intercorrelations are at this level.

Trail Making Task. The Trail-Making Task is a measure of flexibility of thinking. This subtest contains five tasks: TM1: Visual Scanning, TM2: Number Sequencing, TM3: Letter Sequencing, TM4: Number-letter Switching, and TM5: Motor Speed. The task of primary interest is TM4: Number-letter Switching where the

examinee is asked to connect numbers and letters in alternating ascending order. Performance on this task can then be compared to the other (and simpler) tasks to measure cognitive flexibility and motor speed.

Verbal Fluency Task. The Verbal Fluency subtest is a measure of fluency of production, as well as cognitive flexibility ability, in which examinees are required to generate verbal labels fitting within provided categories. It is comprised of three tasks. In the VF1: Letter Fluency task, the examinees are asked to say as many words as they can that begin with a specified letter in 60 seconds (e.g., words beginning with the letter "T"). Three such trials are given, each with a different letter. In the VF2: Category Fluency task, examinees are asked to name as many words belonging to a specific category as they can in 60 seconds (e.g., vehicles). Two such trials are given with a different category for each. Finally, the primary task is the VF3: Category Switching task, that requires examinees to provide words belonging to a specific category, alternating between two categories (e.g., articles of clothing and musical instruments).

Design Fluency Task. The Design Fluency subtest is a visual counterpart to the Verbal Fluency task. The Design Fluency task measures fluency of production, as well as cognitive flexibility. The examinee is presented with a row of boxes, each of which contains an array of dots. The examinee is asked to connect the dots using only four lines, making a different design in each box, for 60 seconds. In the DF1: Dots Filled condition, the boxes shown to the examinee contain five filled dots to be connected. In the DF2: Empty Dots Only condition, the boxes shown to the examinee contain five filled and five unfilled dots, and the examinee is asked to connect only the empty dots, inhibiting the previously correct response of connecting the filled dots. The primary task

is the DF3: Switching task which requires the examinee to connect empty and filled dots in alternating fashion (e.g., an empty dot to a filled dot to an empty dot to a filled dot).

Color-Word Interference Task. The Color-Word Interference subtest is a modification of the classic Stroop test which measures inhibition of an automatic response. It contains two baseline conditions. The CW1: Naming task requires the examinee to visually scan and name color patches whereas the CW2: Reading task requires the examinee to read and say a series of words denoting colors that are printed in black ink. The primary task for this study is the CW3: Inhibition task which requires the examinee to say the color of ink in which a word denoting a contrasting color is printed. For example, the examinee would be asked to say "blue" when shown the word green printed in blue ink. Finally, the CW4: Inhibition/Switching task requires the examinee to switch between naming the color of the ink and reading the word, providing measures of both inhibition and cognitive flexibility.

Word Context Task. The Word Context subtest assesses verbal evaluative ability, as well as deductive reasoning and flexibility of thinking. In this task, examinees are provided made-up words and are required to determine the meaning of the word based upon five sentence clues, each of which provides increasingly direct hints as to the meaning of the word (e.g., "A druxle makes a sound" leading to "A druxle is a handheld musical instrument with strings commonly used in rock music").

Tower Task. The Tower subtest is a modification and improvement of the Tower of Hanoi (TOH; Borys, Spitz, & Dorans, 1982) and Tower of London (TOL; Morris, Ahmed, Syed, & Toone, 1993) tests, commonly used measures of planning ability and mental flexibility. Participants are shown a display consisting of three pegs with several

disks in a pre-arranged format. The objective is to transfer the entire tower to one of the other pegs, moving only one disk at a time and never a larger piece onto a smaller. The Tower test of the D-KEFS contains improved psychometric properties from the TOH and TOL tests through the addition of easier and more difficult tasks that measure an individual's ability on different difficulty levels.

Proverb Task. The Proverb subtest is a measure of verbal abstraction ability consisting of Free Inquiry and Multiple Choice conditions in which eight sayings are presented, both common and uncommon. The primary task is the Free Inquiry condition in which the proverbs are read to the examinee who is then asked to interpret them without assistance. In the Multiple Choice condition, the same proverbs are read and four alternative explanations are provided for each. The examinee is asked to choose the provided explanation that best fits each proverb.

Procedure

Participants were administered the WASI at the onset of the testing session to determine if the inclusion criteria of VIQ, PIQ, and FSIQ greater than 85 was met. Once these criteria were met, participants were administered selected subtests of the D-KEFS. Specifically, the Trail Making, Verbal Fluency, Design Fluency, Color-Word Interference, Word Context, Tower, and Proverb subtests were administered. Each of these subtests consists of a primary task and several component tasks. The specific tasks analysed in this study were Trail Making 4 (TM4), Verbal Fluency 3 (VF3), Design Fluency 3 (DF3), Color-Word Interference 3 (CW3), Word Context Total Consecutively Correct (WC), Tower Total Achievement Score (T) and Proverb Free Inquiry Total Achievement (PFI). Based upon the abilities evaluated by and the descriptions of these

tasks in the technical manual for the D-KEFS, subtests deemed to be verbally-mediated were the VF3, WC, and PFI tasks whereas those deemed to be visually-mediated were the TM4, DF3, CW3, and T tasks.

Analyses

Exploratory factor analysis was initially used to determine if the subtests did indeed group together into verbally-mediated and visually-mediated categories. Cluster analysis was then used to determine if participants could be categorized based upon performance on the D-KEFS subtests. Lastly, receiver operating characteristics (ROC) was used to determine the clinical usefulness of these specific D-KEFS subtests.

Results

Exploratory factor analysis (EFA) was used to determine if subtests deemed to be verbally and visually mediated did indeed group together. Initial investigation of the normality (e.g., skewness and kurtosis) of the EF task data revealed that the data were not normally distributed (see Table 4 on page 65). Specifically, the sample data for the TM4, CW3, and WC tasks were negatively skewed. Additionally, the WC task was quite leptokurtic, with a kurtosis value of 2.116. For this reason, the principle axis factoring method, which is robust to violations of the assumption of normality (Fabrigar, Wegener, MacCallum, & Strahan, 1999), was utilized. The direct oblimin rotation method was selected to allow the EF task variables to be correlated. Two matrices are obtained when this rotation method is performed: a pattern matrix and a structure matrix. The pattern matrix indicates the contribution of each variable to each factor. The structure matrix represents the correlation between the factors. These matrices are reported in Table 5 on page 66.

In determining factor composition, the guidelines established by Tabachnik and Fiddel (2007), which state a factor loading of 0.32 with no cross-factor loading of this amount or greater as indicative of factor membership, was utilized. As can be seen from the reported pattern matrix data, 2 factors underlie the EF tasks. The first factor was comprised of the visually-mediated tasks (TM4, DF3, CW3, and T) whereas the second was comprised of verbally-mediated tasks (VF3, WC, and PFI). Examination of the structure matrix suggests that the four visually-mediated tasks in factor 1 and the 3 verbally-mediated tasks in factor 2 are not significantly correlated to the other factor.

Two-step cluster analysis was then used to determine if subgroups of participants could be empirically derived on the basis of performance on these specific tasks. The two-step cluster analysis procedure is a multivariate technique designed to reveal natural groupings within a data set. The goal of this statistical procedure is to maximize the variability between the clusters relative to the variability within clusters. It is an exploratory procedure rather than a hypothesis testing technique.

This procedure was utilized without *a priori* designation of number of clusters, allowing the analysis to determine the optimum number and pattern of clusters arising from the data. The subgroups were then examined to determine diagnostic composition of each, as well as any differences in performance that may have resulted in the final clustering solution.

The final cluster solution was based upon the following parameters: Two-step cluster analysis using Schwarz's Bayesian Criterion (BIC), the log-likelihood distance measurement, and automatic generation of the optimum number of clusters. Seven D-KEFS tasks (TM4, VF3, DF3, CW3, WC, T, and PFI) were entered as continuous

variables. The results of this analysis yielded an optimum two-cluster solution as indicated by the BIC. Thirty-six individuals were classified into cluster 1 whereas thirty were classified into cluster 2. Cluster 1 was comprised primarily of individuals with AD (24 individuals, 66.6%) whereas cluster 2 was comprised primarily of control participants (21 individuals, 70%). Overall, 72.7% of AD participants were classified into cluster 1 whereas 63.6% of control participants were classified into cluster 2. Cluster 1 was labelled "Poor performers" and cluster 2 was labelled "High performers". Cognitive and performance information of the participants in these clusters appear in Table 6 on page 67.

Inspection of the variable importance plots revealed that performance on the following D-KEFS tasks were important in differentiating participants in either cluster (listed in order of importance):

Cluster 1 (n=36) (Poor Performers): DF3, CW3, T, TM4

Cluster 2 (n=30) (High Performers): TM4, CW3, DF3, WC, T

The significance of each task in determining which cluster participants were assigned was calculated via t-tests with a Bonferonni correction (significance value set at $p = 0.007$) for multiple testing. Performance on the DF3 task ($M = 10.00$, $SD = 2.50$) was the largest contributor to assignment into cluster 1 ($t(64) = -5.72$, $p < 0.001$). Subsequent to this, performance on the CW3 ($M = 7.58$, $SD = 3.76$; $t(64) = -3.49$, $p < 0.001$), T ($M = 9.81$, $SD = 2.41$; $t(64) = -3.16$, $p < 0.001$), and TM4 ($M = 8.11$, $SD = 3.40$; $t(64) = -3.12$, $p < 0.001$) tasks was a significant contributor to classification into cluster 1. Performance on the WC, VF3, and PFI tasks did not significantly contribute to cluster 1 classification.

Conversely, the TM4 performance of the participants in cluster 2 ($M = 12.00$, $SD = 1.15$) was the largest contributor to assignment into that cluster ($t(64) = 10.15$, $p < 0.001$). Subsequent to this, cluster 2's performance on the CW3 ($M = 12.40$, $SD = 1.99$; $t(64) = 7.22$, $p < 0.001$), DF3 ($M = 15.13$, $SD = 2.29$; $t(64) = 6.71$, $p < 0.001$), WC ($M = 12.07$, $SD = 1.66$; $t(64) = -3.12$, $p < 0.001$), and T ($M = 12.60$, $SD = 2.57$; $t(64) = 3.25$, $p < 0.001$) tasks was a significant contributor to classification into that cluster. Performance on the VF3 and PFI tasks did not significantly contribute to cluster 2 classification.

Specific t-tests to investigate the significance of differences in performance between the participants classified into cluster 1 and cluster 2 were not conducted given that purpose of cluster analysis is to separate and classify participants based upon differences in performance. In other words, the cluster analysis process separates participants and assigns them to differential subgroups based upon performance. This process maximizes the likelihood of differential performance between the groups thereby reducing the usefulness of statistical tests, such as t-tests, in determining the significance of the differences in performance. However, as indicated in Table 6, the performance of cluster 1 participants on both the cognitive and EF tasks was poorer than that demonstrated by the participants in cluster 2 (although the exact statistical significance of this cannot be determined). Indeed, the cluster 2 participants' cognitive performance was greater than that of the cluster 1 participants by 6.91 to 8.79 standard score units while EF task performance was greater by 1.21 to 5.13 scaled score units. The only task where this difference was minimized was the PFI task, with a performance differential of 1.21.

Given the nature of the present study, it was of interest to further examine the nine participants with AD who were classified into cluster 2 along with a majority of the

typically-developing control participants. Cognitive and EF task performance for these 9 participants appears in Table 7 on page 68. As can be seen, the nine "high performer" participants with AD did indeed demonstrate higher cognitive and EF task performance than did the 24 "low performer" participants. Specific t-tests to investigate the significance of these differences were not conducted given that purpose of the cluster analysis was to separate and classify participants based upon differences in performance. However, as indicated in Table 7, the performance of cluster 1 participants with AD on both the cognitive and EF tasks was poorer than that demonstrated by the participants with AD in cluster 2. Indeed, the cluster 2 participants' cognitive performance was greater than that of the cluster 1 participants by 13.38 to 15.64 standard score units while EF task performance was greater by 2.85 to 6.76 scaled score units.

Finally, the EF task data were examined via receiver operating characteristics (ROC) analysis to determine the effectiveness of the EF tasks in a diagnostic framework. ROC analysis is a tool used to describe diagnostic accuracy or the ability to correctly classify participants into clinically relevant subgroups. All seven administered D-KEFS subtests were entered into this analysis as well as each participant's diagnostic status (AD or control). The ROC analytical process then evaluated each participant's performance in comparison to the others in their classified group and determined which, if any, subtests were useful in determining an individual's diagnostic status. ROC plots demonstrate the limits of a test's ability to discriminate a correct true positive designation (sensitivity) and a true negative designation (specificity) (Zweig & Campbell, 1993). Essentially, ROC analysis provides information pertaining to the clinical usefulness of a measure in correctly identifying individuals with and without a specific disorder or condition. The

results of this analysis appear in Table 8 on page 69 and Figure 1 on page 70. Only the TM4 (0.305, $p = 0.007$) and DF3 (0.266, $p = 0.001$) tasks yielded significant areas under the curve following a Bonferonni correction (significance value set to $p = 0.007$). None of the remaining tasks yielded a significant area under the curve (VF3 = 0.511, $p = 0.883$; CW3 = 0.321, $p = 0.012$; WC = 0.440, $p = 0.401$; T = 0.331, $p = 0.018$; PFI = 0.678, $p = 0.013$). In looking at the curves in Figure 1, the TM4 and DF3 curves appear lowest and closer to the lower right hand corner of the graph whereas the curves representing the remaining tasks appear closer to the midway reference line. Given this characteristic, the TM4 and DF3 tasks possess significant specificity compared to the other tasks. However, none of the plotted ROC curves denoted significant sensitivity. In other words, only the TM4 and DF3 tasks were able to identify a true negative designation (typically-developing participant) and none of the subtests were effective in identifying a true positive designation (AD participant).

Discussion

The results of the exploratory factor analysis indicated that the seven D-KEFS tasks were classified into two factors. Consistent with the hypothesized differentiation of EF tasks based upon modality, the first factor consisted of the visually-mediated EF tasks (TM4, DF3, CW3, and T) while the second factor consisted of the verbally-mediated EF tasks (VF3, WC, and PFI). Consistent with the guidelines put forth by Comrey and Lee (1992), two of the tasks within factor 1 can be considered excellent measures of this visual factor. Specifically, the DF3 and CW3 tasks each had a factor loading in excess of 0.71 on factor 1 and a minimal or negative loading on factor 2. The TM4 task can be considered a very good measure of this visual factor and the T task can be considered a

fair measure. Each of these tasks has similar requirements: visual scanning of a spatial display with mental processing of the specific information. Moreover, each of these tasks requires inhibition of pre-potent or overlearned skills in order to succeed. Success in the TM4 task requires rapid mental switching between letters to numbers rather than staying within the same symbol type whereas the CW3 task requires saying the color of ink a word is printed in rather than reading the word. The DF3 task requires visual scanning of an array of dots along with appropriate working memory and inhibitory skills to reduce the production of previously generated responses, while the T task requires visual scanning of a starting point and a solution to a logical puzzle and planning/inhibition to solve the puzzle as efficiently as possible.

In comparison, only one of the tasks in the verbal factor, the WC task, can be considered an excellent measure of this factor. The PFI task is a good measure while the VF3 task is a poor measure. This is likely due to the tasks in this factor each requiring different abilities in order to demonstrate success. The WC task requires analogical thinking and problem solving whereas the PFI task requires understanding of and the ability to interpret non-literal language. The VF3 task requires fluent verbal generation of items from two categories in alternating sequence. Thus, although each of these tasks does require the examinee to understand and use language in a flexible fashion, the specific requirements within each of the verbally-mediated tasks differ much more widely than the requirements for the visually-based tasks.

Despite the variability of task requirements in the verbally-mediated tasks, the results from the factor analysis provide the framework from which to investigate EF performance in adolescents and young adults with AD as compared to age- and gender-

matched typically developing controls. Specifically, the results of the exploratory factor analysis support the differentiation of task requirements in terms of visually-mediated versus verbally-mediated measures. However, it must be noted that the results of this exploratory factor analysis are based upon a relatively small sample size which may have affected the results. Specifically, factor analytical procedures are reported to be sensitive to effects of small sample sizes and results can change when larger samples of data are utilized. Therefore, the results from the current factor analysis should be interpreted with caution.

Previous research has indicated that individuals with AD demonstrate better developed verbal as compared to nonverbal cognitive skills. Results from the present study support this conclusion. The AD participants' VIQ was significantly higher than their PIQ. Further, although previous research has indicated that individuals with AD may possess an inherent modality-specific EF deficit (Kleinhans et al., 2005), these results were based upon a heterogeneous participant sample comprised of individuals with AD and HFA. Although the reported results indicated no significant difference in performance between these two clinical participant groups, the diagnostic differentiation of a delay or deficit in language development in the part of the participants with HFA and a lack of such a delay in the participants with AD, as well as the use of a small sample size, further adds to the inconsistent findings in the research literature regarding the EF skills and abilities of individuals with AD specifically.

The current study investigated the possibility of a modality-specific deficit in EF functioning in individuals with AD through differentiation of performance. Although the majority of previous research has utilized a quasi-experimental approach whereby

participants are initially separated upon a clinical dimension (e.g., participants with AD and control participants), the purpose of the current study was to determine if performance on specific EF tasks could determine clinical classification.

Results of the two-step cluster analysis indicated that the EF task performance was best described by a two-cluster solution. Consistent with the hypothesized performance differential, cluster 1 was predominantly comprised of individuals with AD (66.6%) whereas cluster 2 was comprised predominantly by control participants (70%). Furthermore, investigation of the performance of the participants in each cluster suggested that performance on specific EF tasks was the basis for cluster assignment. Overall, performance on the four visually-mediated tasks (DF3, CW3, T, and TM4) was a significant contributor to assignment into cluster 1. The participants in this cluster performed more poorly on these tasks than did the participants assigned to cluster 2. Of note was the fact that, although participants in cluster 1 performed within the Average range on the DF3 task, their performance was significantly poorer than that of the participants in cluster 2. Indeed, this performance difference was the largest contributor to the final clustering solution.

In general, the results are consistent with the hypothesized modality-specific EF deficit in individuals with AD. Although cluster 1's performance was poorer than cluster 2's on all EF tasks, the performance of the participants in cluster 1 on the four visually-mediated tasks was more poor than on the verbally-mediated tasks. The results of this study support many reported findings in the research literature. First, the performance of the participants with AD on all EF tasks was poorer than the control participants. Thus, individuals with AD can be seen to possess an overall EF deficit as compared to age- and

gender-matched typically developing individuals. Second, the performance of the individuals with AD on the visually-mediated EF tasks was particularly poorer than the control participants. That is, although the participants with AD did demonstrate some difficulty with the verbally-mediated EF tasks, they demonstrated a greater deficit on the visually-mediated tasks. This finding runs counter to the results reported by Kleinhans et al. (2005) in that individuals with AD demonstrated better verbally-mediated that visually-mediated EF task performance in the present study. As initially hypothesized, this may be due to the small sample size used by Kleinhans and colleagues which may have led to unrepresentative findings.

Results of the ROC analysis indicated that the seven tasks of the D-KEFS utilized in this study do not possess significant specificity to be diagnostically beneficial. That is, these specific tasks did not provide adequate ability to accurately identify individuals with AD based upon their performance. Indeed, only the TM4 and DF3 tasks achieved significance in this analysis. However, these tasks were beneficial only in correctly identifying individuals without AD (specificity) as indicated by the ROC curve generated by the performance data. In other words, good performance on these two tasks was indicative of an individual being properly identified as belonging in the control participant group whereas neither good nor poor performance on any task was significantly indicative of belonging to the AD participant group. Based upon this evidence, it would appear that the D-KEFS tasks utilized in this study are not appropriate for use as diagnostic tools in an assessment for AD, as they do not possess the ability to effectively differentiate individuals with and without AD based upon performance. However, the fact remains that EF is a primary theorized deficit in individuals with AD

and, as such, information regarding EF skills and abilities can help in identifying specific areas of strength and those in need of support. Such information can then be effectively utilized in an intervention plan tailored to an individual's needs. Indeed, researchers investigating the neuropsychological profiles of the D-KEFS subtests of adults with AD via a quasi-experimental research approach reported similar results to the present study and reached similar conclusions (Heiger, 2006). Therefore, the use of EF tasks such as the D-KEFS in a diagnostic assessment is warranted so long as the results of these measures are restricted to providing of information regarding an individual's specific EF skills and abilities rather than diagnostic decision-making.

Two findings in this study were of interest. First, nine participants (27%) with AD were classified as belonging in cluster 2. What performance characteristics did these individuals demonstrate that resulted in this cross-classification? Second, given the propensity of individuals with an ASD, and AD in particular, to demonstrate difficulty in understanding and utilizing non-literal forms of speech, why was the performance differential between cluster 1 and cluster 2 on the PFI task the smallest of all the EF tasks and why was this task not a significant contributor to cluster assignment? Each of these issues will be addressed in turn.

Regarding the nine individuals with AD who were cross-classified into cluster 2, their cognitive and EF performance was higher than those participants with AD classified into cluster 1. The VIQ, PIQ, and FSIQ performance differential of the cluster 2 AD participants was 14.54, 13.38, and 15.64 standard scale units respectively with their average performance in each of these domains falling within the Above Average to Superior ranges. They similarly outperformed the cluster 1 participants with AD on all of

the EF tasks. Indeed, the performance of the nine "high performing" AD participants was between 2.85 and 6.76 scaled score units above the 24 "poor performing" AD participants, a performance differential of nearly one standard deviation to over two standard deviations. A similar pattern was found amongst the 12 typically-developing participants who were cross-classified into cluster 1. Their performance on the cognitive and EF tasks fell below that of the 21 typically-developing participants classified into cluster 2.

As is frequently mentioned in the research literature, individuals with AD often possess well-developed cognitive and information processing skills. It is their difficulties with social interaction and behavioural management that are the hallmark characteristics of the disorder. Thus, many individuals with AD demonstrate high intellectual abilities (Above Average, Superior, or Very Superior ranges), typically in the verbal domain, but with poorly developed social skills and the ability to utilize their knowledge to develop and maintain social relationships. However, this is not always the case, and a large proportion of such individuals demonstrate cognitive abilities in the Average to Low-Average ranges. Thus, it would appear that there is a degree of heterogeneity in the cognitive and EF abilities of individuals within this population. Although some individuals possess well-developed cognitive skills and intact EF abilities as measured by the seven tasks of the D-KEFS reported in this study, a large proportion of individuals with AD possess an EF deficit. They have difficulties in fluidly changing mental state, or set-shifting (as evaluated by the TM4 task), they struggle with inhibitory skills (as evaluated by the CW3 and T tasks), and they find fluency of production challenging (as measured by the DF3 task). Moreover, they appear to be most challenged when required

to utilize these skills in a visually-mediated context. Although this could be related to their relatively stronger verbal information processing abilities, the exact nature and cause of this difficulty is has not been conclusively identified.

Another interesting finding in this study was that the PFI task was not a significant contributor to cluster assignment. This finding is particularly remarkable given the well-documented difficulty of individuals with AD in interpreting and understanding non-literal language. Indeed, this difficulty in non-literal social communication exists despite intact speech and language and is a hallmark clinical feature of AD (Adachi et al., 2006; Adachi et al, 2004; Baron-Cohen, 1988; Boucher, 2003; Eales, 1993; Gnanathusharan, Kjelgaard, & Tager-Flusberg 2001; Martin and McDonald 2003; Mitchell & Rickards, 2005; Ozonoff & Miller 1996; Tager-Flusberg, 2006, 1996, 1981). However, despite the considerable amount of literature on the pragmatic difficulties of individuals with AD, there is a paucity of research on pragmatic reasoning or the ability to make inferences that go beyond the linguistic meaning of utterances (Pijnacker, Hagoort, Buitelaar, Teunisse, & Guerts, 2009). Despite this, some researchers have recently reported similar findings to those reported in this study (Towgood, Meuwese, Gilbert, Turner, & Burgess, 2009). Towgood et al. (2009) used a quasi-experimental comparative approach and reported that adults with AD did not demonstrate a significant deficit on the PFI task compared to typically-developing controls. One potential reason why this deficit may not exist is that the PFI task does not accurately represent the everyday scenarios and encounters people experience with non-literal language. That is, typical examples of non-literal language use may include the use of simile and metaphor, exaggeration, hyperbole, irony, sarcasm, humour, and other

subtle implied nuances associated with the pragmatics of language. For example, the phrase, "Can you answer the phone?" implies a request to engage in the action rather than the literal interpretation of an inquiry into a person's physical capability to engage in the action. Although individuals with AD typically interpret these forms of figurative language literally (Dennis, Lazenby, & Lockyer, 2001; Emerich, Creaghead, Grether, Murray, & Grasha, 2003; Happe, 1993, 1995; Martin & McDonald 2004), they appear to be able to understand and interpret proverbs, or at least the eight items in the PFI task, at a level commensurate with typically-developing controls. This result could be because the initial five items on this task are relatively common proverbs that would likely have been heard in everyday conversation (e.g., "All's well that ends well"). Although the individuals with AD may not have correctly interpreted these saying upon initial exposure to them, they may have been previously informed of their non-literal meaning and thus have been privy to their proper proverbial interpretation. The remaining three items on the PFI task are uncommon proverbs to which many people, typical or otherwise, have not been exposed (e.g., " All cats are grey in the dark"). Thus, many individuals with AD, as well as typically-developing individuals, are likely to demonstrate difficulties in interpreting these uncommon proverbs. Essentially, the PFI task does not appear to be an effective method by which to evaluate and interpret the social-communicative skills of individuals with AD.

Overall, the results of this study indicate that individuals with AD demonstrate poor performance on the visually-mediated EF tasks and relatively better performance on the verbally-mediated EF tasks of the D-KEFS. This result is unsurprising given that the diagnostic criteria for this disorder require intact language and communication which

would necessarily influence ability to perform on verbally-mediated EF tasks. Essentially, it would appear that individuals with AD do indeed demonstrate a modality specific bias within EF in favour of verbally-based tasks. Moreover, the specific tasks of the D-KEFS do not appear to be effective in terms of diagnostic specificity for use in a clinical diagnostic assessment. However, they do provide important information regarding the current skills and abilities of individuals with AD, particularly in terms of cognitive flexibility, inhibition, and set shifting. As such, although these tasks may not specifically indicate the presence or absence of AD, their continued use in a comprehensive multi-method assessment process continues to be of benefit.

Limitations

This study has five primary limitations. First, the sample size was relatively small given the nature and extent of statistical analyses used to draw conclusions. The general consensus regarding minimal sample size is 10 participants per variable being investigated to achieve sufficient power and confidence in the statistical conclusions. As this study examined seven D-KEFS tasks, the overall sample size of 66 falls slightly short of this requirement. Therefore, the conclusions made in this study may not necessarily be truly indicative of the population of individuals with AD due to inadequate power. This limitation is particularly the case with factor analysis where conclusions drawn from examination of small sample sizes are often not an accurate representation of the factor structure given a larger and more representative sample.

Second, strict diagnostic rigor was not possible given the unavailability of individuals familiar with the early childhood development of each participant. The ability to administer diagnostic measures such as the Autism Diagnostic Interview –

Revised to confirm the presence or lack of an AD diagnosis of each participant would have been ideal. However, due to the age and relative independence of the majority of participants in this study, access to parents or other individuals familiar with the early development of each participant was not possible. As a result, diagnosis was confirmed through the examination of documentation provided by the participants with AD to determine if DSM-IV-TR criteria for this disorder were met.

Third, there is a potential selectivity bias regarding the participants with AD. Locating and recruiting of these participants was difficult based largely upon the fact that a number of potential participants declined to participate as doing so would force them to acknowledge their disorder either to themselves or to the researchers. The majority of participants who declined to participate indicated that they do not agree with their current clinical diagnosis or did not want others to be aware of their diagnosis. Rather, they preferred to remain diagnostically anonymous thereby protecting their confidentiality. Given this selectivity, there is the possibility that those individuals with AD who did agree to participate differed in some systematic way from those who did not, thereby affecting the results.

Fourth, as individuals with AD have a well-documented deficit in pragmatic language use, and this deficit was not found with the PFI task, the PFI task does not appear to be an effective measure of non-literal language use. As such, the results of this task, as a measure of verbal EF functioning, may not accurately represent the areas of specific deficit that individuals with AD typically demonstrate. Therefore, its effectiveness as a potential diagnostic tool is limited. It is suggested that the use of the

PFI task in future research investigating verbal EF abilities or non-literal language use and interpretation in this population be limited.

Finally, participant recruitment of the typically-developing control group often occurred via a snowballing method whereby one participant would inform others about the nature of the study and these secondary individuals would inquire and potentially participate. This recruitment technique may have affected the results of the current study in that roughly half of the participants in this group were associated in some fashion. Therefore, these participants may not be treated as a true random sampling of typically-developing individuals, and their performance may have been systematically similar in some unknown fashion.

Future Directions

The current study was an investigation of specific EF abilities in adolescents and young adults with AD. Although the results indicated a deficit in a specific type of EF functioning in the AD population, the results are restricted to only this population. Future research could extend these findings into an investigation of EF functioning in related disorders. A follow-up study investigating EF performance on these tasks of the D-KEFS in a comparable participant group of individuals with HFA would afford the opportunity to explore the possibility of differential EF performance between these two groups. As these two disorders are clinically differentiated by the presence of a delay in language development in the case of HFA, it could be the case that individuals in that population would demonstrate a differing pattern of performance on these EF tasks. Specifically, it is hypothesized that individuals with HFA would demonstrate a deficit in verbally-mediated EF tasks in addition to the visually-mediated tasks.

A second line of future research could extend the findings reported in this study into an investigation of EF abilities in a younger population of individuals with AD. As the D-KEFS is appropriate for use with individuals 8-21 years of age, a comparable follow-up study of children with AD aged 8-12 would allow for the exploration of a potential modality-specific bias in EF functioning in a younger age group. This follow-up study would provide insight into a potential developmental component of EF functioning within this population whereby performance on specific tasks becomes enhanced through further EF development during this younger age span. Based upon the results of the current study, it is hypothesized that children with AD aged 8-12 will demonstrate a comparable visually-mediated EF deficit in comparison to verbally-mediated tasks.

A third line of future research could investigate EF abilities in individuals in other clinical samples known to demonstrate an EF deficit such as those with Attention-Deficit/Hyperactivity Disorder (ADHD), Oppositional Defiant Disorder (ODD), or Conduct Disorder (CD). Findings from this follow-up research could then allow for further clarification of potential specific EF strengths and deficits in these populations as well as provide evidence in support of the utility of the D-KEFS, and subsequently EF, as a diagnostic tool differentiating between these clinical disorders and AD.

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Table 1

DSM-IV-TR (American Psychological Association, 2000) diagnostic criteria for Asperger's Disorder and Autistic Disorder.

Asperger's Disorder	Autistic Disorder
1. Qualitative impairment in social interaction	1. Qualitative impairment in social interaction
2. Restricted repetitive and stereotyped patterns of behaviour, interests, and activities	2. Restricted repetitive and stereotyped patterns of behaviour, interests, and activities
3. There is no clinically significant general delay in language	3. Qualitative impairments in communication
3. There is no clinically significant delay in cognitive development or in the development of age-appropriate self-help skills, adaptive behaviour (other than in social interaction), and curiosity about the environment in childhood.	4. Delays or abnormal functioning in at least one of the following areas, with onset prior to age 3 years: (1) social interaction, (2) language as used in social communication, or (3) symbolic or imaginative play.
4. Criteria are not met for another specific Pervasive Developmental Disorder or Schizophrenia.	5. The disturbance is not better accounted for by Rett's Disorder or Childhood Disintegrative Disorder.

Table 2

Participant demographic information.

	Total Sample (n = 66)	Asperger's Disorder (n = 33)	Controls (n = 33)
Age	18.85 +/- 1.56	18.83 +/- 1.55	18.86 +/- 1.59
Gender (% male)	78.8	78.8	78.8
VIQ	111.56 +/- 11.64	114.09 +/- 12.15	109.03 +/- 10.69
PIQ	108.80 +/- 9.85	108.94 +/- 9.85	108.67 +/- 10.01
FSIQ	111.62 +/- 9.78	113.18 +/- 10.61	110.06 +/- 8.76

Note. Age is reported in decimalized format (e.g., 19 years, 6 months is 19.5 years). The Wechsler Abbreviated Scale of Intelligence (WASI) is from Wechsler, 1999. VIQ refers to Verbal Intelligence Quotient, PIQ refers to Performance Intelligence Quotient, and FSIQ refers to Full Scale Intelligence Quotient. Mean and standard deviation performance for each of these measures is reported in scaled score units.

Table 3

Description of the D-KEFS (Delis et al., 2001) subtests and the primary tasks in each.

D-KEFS Subtest	**Primary Task**	**Modality**	**Description of the primary task**
Trail Making Task	Number-Letter Switching (TM4)	Visual	Connect numbers and letters in alternating ascending order.
Verbal Fluency	Category Switching (VF3)	Verbal	Provide words belonging to a specific category, alternating between two categories.
Design Fluency	Switching (DF3)	Visual	Connect empty and filled dots in alternating fashion.
Color-Word Interference	Inhibition (CW3)	Visual	Say the color of ink in which a word denoting a contrasting color is printed.
Word Context	Word Context Total Score (WC)	Verbal	Determine the meaning of a nonsense word based upon five sentence clues, each of which provides increasingly direct hints as to the meaning of the word.
Tower	Tower Total Score (T)	Visual	Move circular discs to re-create a pictured tower from a pre-determined starting point without violating two primary rules.
Proverb	Free Inquiry (PFI)	Verbal	Interpret common and uncommon proverbs without assistance.

Table 4

Descriptive data for the EF tasks.

Variable	Mean	Standard Deviation	Skewness	Kurtosis
TM4	9.88	3.26	-1.122	0.852
VF3	10.74	3.11	0.045	-0.461
DF3	12.33	3.49	0.023	-0.520
CW3	9.77	3.90	-0.785	0.014
WC	11.00	2.13	-0.842	2.116
T	11.08	2.84	0.351	-0.098
PFI	9.44	3.46	-0.260	-0.827

Note. The D-KEFS is from Delis et al., 2001. TM4 refers to Trail Making 4, VF3 refers to Verbal Fluency 3, DF3 refers to Design Fluency 3, CW3 refers to Color-Word Identification 3, WC refers to Word Context, T refers to Tower, and PFI refers to Proverb Free Inquiry. Mean and standard deviation performance for each of these measures is reported in scaled score units.

Table 5

Pattern and structure matrices from the EFA.

Variable	Pattern Matrix		Structure Matrix	
	Factor 1	Factor 2	Factor 1	Factor 2
TM4	0.693	-0.141	0.646	0.089
VF3	0.200	0.344	0.315	0.411
DF3	0.729	0.150	0.779	0.393
CW3	0.737	0.090	0.767	0.336
WC	0.245	0.742	0.492	0.824
T	0.495	0.017	0.501	0.182
PFI	-0.125	0.566	0.064	0.525

Table 6

Cluster demographic information.

Variable	Total Sample (n = 66)	Cluster 1 (n = 36)	Cluster 2 (n = 30)	Performance Differential
Diagnostic (% AD)	50 %	72.7%	27.3%	
Age	18.85 +/- 1.56	18.50 +/- 1.50	19.26 +/- 1.54	
Gender (% male)	78.8	77.8	80.0	
VIQ	111.56 +/- 11.64	108.42 +/- 11.20	115.33 +/- 11.18	6.91
PIQ	108.80 +/- 9.85	104.81 +/- 7.57	113.60 +/- 10.23	8.79
FSIQ	111.62 +/- 9.78	107.72 +/- 8.06	116.30 +/- 9.73	8.58
TM4	9.88 +/- 3.26	8.11 +/- 3.40	12.00 +/- 1.15	3.89
VF3	10.74 +/- 3.11	9.58 +/- 2.89	12.13 +/- 2.81	2.55
DF3	12.33 +/- 3.49	10.00 +/- 2.45	15.13 +/- 2.29	5.13
CW3	9.77 +/- 3.90	7.58 +/- 3.76	12.40 +/- 1.99	4.82
WC	11.00 +/- 2.13	10.11 +/- 2.10	12.07 +/- 1.66	1.96
T	11.08 +/- 2.84	9.81 +/- 2.14	12.60 +/- 2.57	2.79
PFI	9.44 +/- 3.46	8.89 +/- 3.55	10.10 +/- 3.28	1.21

Note. Mean and standard deviation performance for VIQ, PIQ, and FSIQ is reported in standard score units (M = 100, SD = 15). Mean and standard deviation performance for the TM3, VF3, DF3, CW3, WC, T, and PFI tasks is reported in scaled score units (M = 10, SD = 15).

Table 7

Cognitive and EF performance for the AD participants in each cluster.

Variable	Total Sample (n = 33)	Cluster 1 (n = 24)	Cluster 2 (n = 9)	Performance Differential
VIQ	114.09 +/- 12.15	110.13 +/- 10.34	124.67 +/- 10.48	14.54
PIQ	108.94 +/- 9.85	105.29 +/- 7.17	118.67 +/- 9.68	13.38
FSIQ	113.18 +/- 10.61	108.92 +/- 7.32	124.56 +/- 9.80	15.64
TM4	8.91 +/- 3.55	7.88 +/- 3.58	11.67 +/- 1.32	3.79
VF3	10.70 +/- 3.00	9.62 +/- 2.70	13.56 +/- 1.51	3.94
DF3	10.97 +/- 3.92	9.13 +/- 2.42	15.89 +/- 2.67	6.76
CW3	8.55 +/- 4.33	7.21 +/- 4.05	12.11 +/- 2.85	4.90
WC	10.82 +/- 2.38	10.04 +/- 2.16	12.89 +/- 1.62	2.85
T	10.42 +/- 3.24	9.29 +/- 2.31	13.44 +/- 3.54	4.15
PFI	10.48 +/- 3.52	9.67 +/- 3.56	12.67 +/- 2.40	3.00

Table 8

Results of the receiver operating characteristics analysis.

Variable	Area under the curve	Std. Error	Asymptotic Significance
TM4	0.305	0.066	0.007
VF3	0.511	0.072	0.883
DF3	0.266	0.065	0.001
CW3	0.321	0.067	0.012
WC	0.440	0.071	0.401
T	0.331	0.069	0.018
PFI	0.678	0.066	0.013

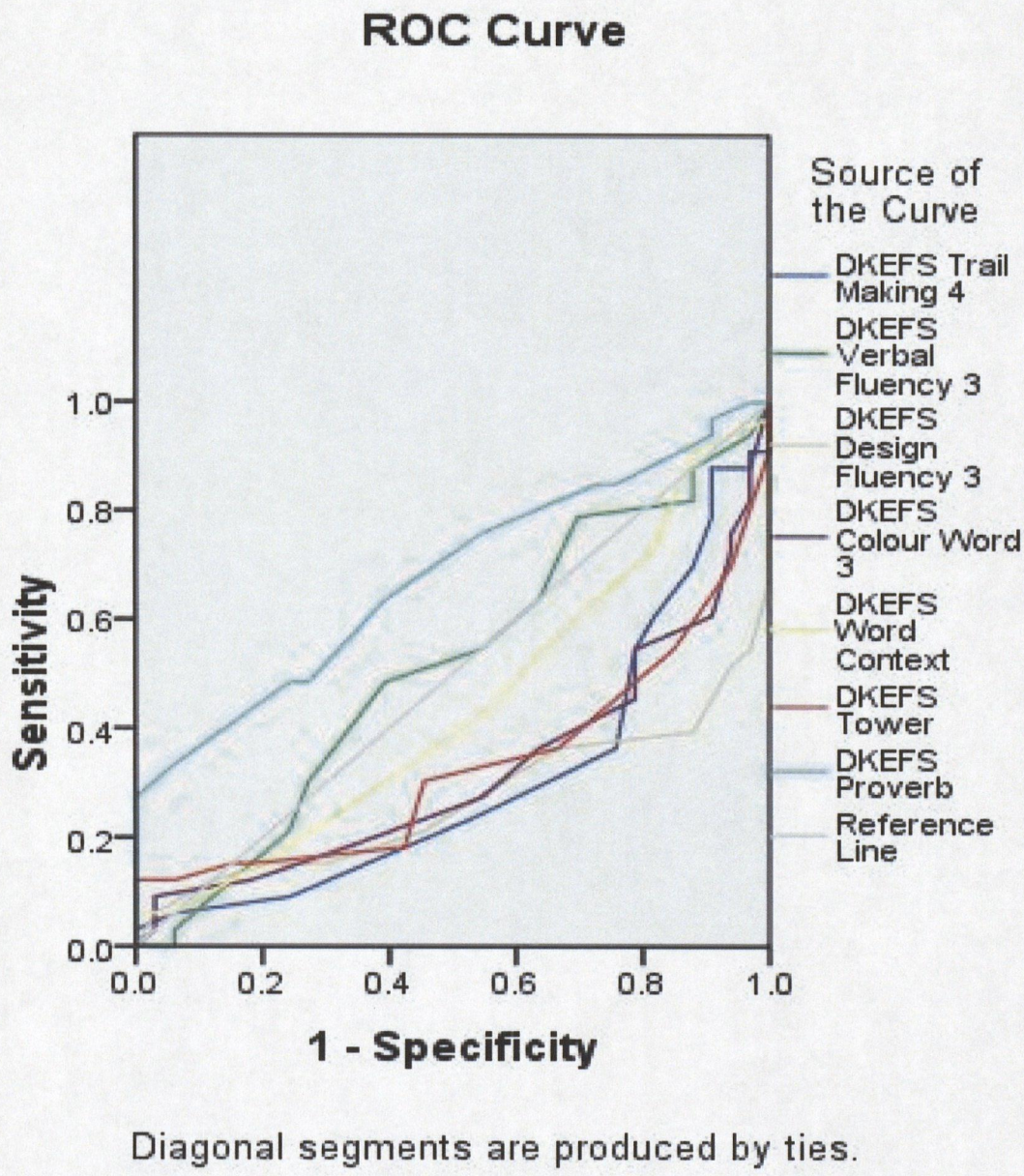

Figure 1. Receiver operating characteristics graph for the EF tasks.

Appendices

APPENDIX A: Parent/Guardian Consent Form

You are invited to participate in a study interested in understanding **Complex Decision Making in youth with Autism Spectrum Disorders**. Please read this form carefully and feel free to ask any questions you may have. Also, feel free to discuss this information with your son/daughter.

Purpose and Procedure

The main objective of this study is to obtain information towards answering the questions:

1) What measures are most appropriate to use in understanding social and emotional abilities in youth diagnosed with Autism Spectrum Disorders?
2) Can emotional capabilities provide an alternate or complementary explanation for the social challenges faced by individuals with Autism Spectrum Disorders?
3) What factors might influence decision making in youth with Autism Spectrum Disorders?

This study will investigate the emotional and social abilities of youth (aged 17-21) with Autism Spectrum Disorders by analyzing performance on various measures of emotional, social, and cognitive abilities. These tasks are intended to measure attentional, memory, social and emotional abilities, as well as organizational and planning skills. Finally, we are interested in abilities that best promote social and emotional resiliency in youth with Autism Spectrum Disorders. In order to obtain multiple perspectives about the emotional and social abilities of the youth participants, additional information will be gathered from parents/guardians and teachers/instructors of individuals with Autism Spectrum Disorders who have also agreed to participate in this study.

The amount of time needed for participation in this study will vary. Some participants will complete only one **15-20 minute task**, while others will complete multiple tasks and questionnaires that will take **approximately 6 hours to complete, and will occur in two sessions, each approximately 3 hours in length**. Parents/guardians of participants who are minors will be asked to remain at the research site for the initial 15-20 minutes. Upon completion of the initial measure, youth and their parents/guardians will be informed as to whether or not the full 2 sessions will occur. It is preferable if your son/daughter is available for the entire time (potentially 3 hours) on the first day of the research session.

In order to understand your adolescent/young adult from multiple perspectives, a parent/guardian and a teacher/instructor will also be asked to complete questionnaires regarding the social and emotional abilities of the youth with Autism Spectrum Disorders. Guardians will be required to commit 45-60 minutes of their time, and it is anticipated that teachers will need approximately 15 minutes to complete the required questionnaire.

Potential Risks

There are no known discomforts or risks associated with this study. The study involves simple tasks and questionnaires.

Potential Benefits

It is expected that the information collected in this study will provide us with a better understanding of the social and emotional characteristics of individuals with Autism Spectrum Disorders. There is surprisingly little research examining the social and emotional abilities that best promote success and resiliency in youth in Autism Spectrum Disorders. The researchers involved in this study believe that it is important to understand these characteristics because youth with Autism Spectrum Disorders are likely to encounter many social and emotional challenges, particularly in the transition to adulthood.

We expect that the results of this study will be helpful for scientists and professionals around the world interested in social and emotional abilities of youth with Autism Spectrum Disorders. We want to thank you very much in advance for your help in furthering this research.

Confidentiality

Data generated from this study are primarily intended to be used in doctoral and master's level student research. All materials will be stored in a locked facility by the researcher or one of the committee members, Dr. Vicki Schwean, Dr. Don Saklofske, Dr. Brian Noonan, or Dr. Laurie Hellsten. While the information generated from this study may be published and/or presented at academic conferences, the data will be reported in aggregate form, which ensures individual participants are not identifiable. **Please understand that all information collected during the course of this study will remain strictly confidential and the participant's name will not be identified at any time or associated with any published results.**

Right to Withdraw

It is important to acknowledge that a significant time commitment is likely necessary for participation in this study. As such, fatigue may occur and participants are encouraged to take breaks as they desire. **Participants may withdraw from the study for any reason, at any time, without penalty of any sort.** If participants do withdraw from the study, the data contributed will be destroyed. Further, participants will be informed if any new information arises that may affect the decision to remain in the study.

Questions

If participants or parents have any questions about the study at any point in time, please feel free to ask. You may also contact any of the researchers at the contact information provided on the final page of this form, should you have any questions at any time. This research has been approved by the University of Saskatchewan's Behavioural Sciences Research Ethics Board (file #06-106) on May 29th, 2006, the University of Manitoba on June 26, 2006 (#P2006:052), and the University of Calgary on June 23, 2006. Any questions regarding your rights as a participant may be addressed to that committee via

the Office of Research Services at the University of Saskatchewan (306) 966-2084. Out of town participants are encouraged to call collect.

Study Results

The research questions we are interested in examining involve understanding youth with Autism Spectrum Disorders as a group. Consequently, we will not have study results for individual participants. However, when the study is completed and the data have been analyzed, participants should feel free to contact any of the researchers if they would like a summary of the group results.

Please return the consent form to the researcher. If you are interested in allowing your son/daughter to participate in this study, please complete the form (see following page) and return it in the stamped and addressed envelope provided. Your prompt response will enable the researcher to mail out materials and schedule your son/daughter's participation in this study. Again, participation is purely voluntary.

Parental/Guardian Consent

I give my son/daughter consent to participate in the research study being conducted by the researchers listed below from the Universities of Manitoba, Saskatchewan and Calgary. My signature at the end of this consent form will indicate that the researchers have answered all of my questions and that I voluntarily consent to my son/daughter's participation in this investigation. I understand that no individual assessment results will be shared from my son/daughter's participation in this study. However, I understand that I may contact the researchers at the numbers provided to enquire about the results of this project. **I realize that I am free to withdraw my son/daughter from participation at any time, for any reason without penalty.**

I have read, understood and been provided with a copy of this consent from. I realize that I may ask questions in the future about the study and I indicate my free consent to research participation by signing this research consent form.

I give my consent to be contacted after participation in this study should the researchers have further questions regarding this study **(check one) Yes**_____ **No**_____

I give my consent to contact the following individuals for the purposes of this study as outlined previously. **(check one) Yes**_____ **No**_____

Teacher/instructor _____ _____
(name) (phone number)

Parent/guardian _____ _____
(name) (phone number)

Finally, I give consent for future contact for a follow-up study should there be one **(check one) Yes** _____ **No** _____

_____ _____
(Name of Participant) (Signature of Participant)

_____
(Date)

_____ _____
Contact Number Alternate Contact (cell or email)

_____

_____
(Mailing Address)

_____
(Signature of Researcher)

Research Team

Please remove this page and keep for your records

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kjthorne@ucalgary.ca

APPENDIX B: Student Assent to Participate in Research

This form is to be completed by participants with Autism Spectrum Disorders who are under 18 years of age.

You are invited to participate in a study interested in understanding **Complex Decision Making in youth with Autism Spectrum Disorders.** The Purpose of this research project is to collect information about the emotional and social skills of youth with Autism Spectrum Disorders. Additionally, information about your strengths will be collected in order to understand how to build success for youth with Autism Spectrum Disorders. The hope is that the collection of such information will assist teachers and others who work with youth with Autism Spectrum Disorders to better understand the youth with whom they work. In addition, it is hoped that this study will provide information to researchers that will help to develop appropriate ways to teach social and emotional skills to individuals with Autism Spectrum Disorders.

Procedures:
If you chose to participate in this study, you will first be asked to complete a 10-15 minute test that will help researchers to confirm that you fit the definition of Autism Spectrum Disorders we wish to use for this study. Additionally, one of your parents and one of your teachers will be asked to complete brief questionnaires about your social skills. If after completing these tasks, you meet the requirements for this study, you will be asked to complete a series of tasks that will help to understand your social and emotional skills, thinking processes, strengths, and overall abilities. **Your participation in this research will take approximately 6 hours in total to complete, and will occur on two different days (each with about 3 hours of participation).** However, you will be free to take breaks whenever you fell you need to.

The purpose of this study is to collect information from many youth with Autism Spectrum Disorders. Consequently, **it will not be possible to share your individual results** on the various tasks. However, the information we collect about how you think and interact will help the researchers to understand youth with Autism Spectrum Disorders so that appropriate information can be shared with many professionals that work with individuals with Autism Spectrum Disorders.

Potential Risks:
There are no foreseeable risks associated with participation in this study.

Potential benefits:
The information collected in this study will help researchers and professionals to understand the emotional and social skills of youth with Autism Spectrum Disorders. It is hoped that this information will lead to further research to develop appropriate plans to help youth with Autism Spectrum Disorders.

Confidentiality:
The information collected in this study may be published and presented at academic conferences. However, the data will be reported in aggregate form, which ensures individual participants are not identifiable. All forms will be coded and stored separately so that your personal information or responses cannot be identified.

All materials will be stored in a locked facility by the researcher or one of the committee members, Dr. Vicki Schwean, Dr. Don Saklofske, Dr. Brian Noonan, or Dr. Laurie Hellsten.

Right to Withdraw:
You may withdraw from the study for any reason, at any time, without penalty of any sort. If you withdraw from the study, the information that you have contributed will be destroyed. Since **participation in the study is purely voluntary,** participants may choose to answer some or all of the questions on the questionnaires, while leaving out any questions you may be uncomfortable at answering. Further, you will be informed if any new information arises that may affect your decision to remain in the study.

Questions:
If you have any questions about the study at any point in time, please feel free to ask. You may contact the researchers at the number or email address provided if you have any questions now or at any other time.

This study has been approved on ethical grounds by the University of Saskatchewan Behavioural Sciences Research Ethics Board on (file #06-106) on May 29th, 2006, the University of Manitoba on June 26, 2006 (#P2006:052), and the University of Calgary on June 23, 2006.Any questions regarding your rights as a participant may be addressed to that committee via the Office of Research Services at (306) 966-2084. Out of town participants are encouraged to call collect.

When the study is completed, participants should feel free to contact the researcher if they would like a summary of the results.

Please return the following page to the researcher. If you are interested in participating in this study, please complete this form and return it in the stamped and addressed envelope provided. Your prompt response will enable the researcher to mail out materials and schedule your participation in this study. Again, **participation is purely voluntary and you should feel free to withdraw from the study at anytime and for any reason.**

In order to participate in this study, the researchers ask that both you and one of your parents agree to your involvement. In addition, we ask that you agree to let the research team contact a teacher identified by your parent or guardian on *Parental/Guardian Consent* page.

Student Assent to Participate

(participants under the age of 18 are required to complete the form below)

I _____ (first and last name) also understand the reason for this study, the contents of the consent form, and my expectations as a participant in this study. I agree to participate in this study. **I understand that I am free to withdraw from this study and any time and for any reason. There will be no penalty if I choose to withdraw.** I understand that this study has been designed to collected information about my social and emotional skills from several perspectives. I agree that the researchers can contact the individual named on the contact page for the purposes of this study.

_____ _____
(Signature of Student) (Date)

_____ _____
(Signature of Parent/Guardian) (Date)

_____
(Signature of Researcher)

Research Team

Please remove this page and keep for your records

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kjthorne@ucalgary.ca

APPENDIX C: Participant Consent Form

You are invited to participate in a study interested in understanding **Complex Decision Making in youth with Autism Spectrum Disorders.** Please read this form carefully and feel free to ask any question you may have.

The Purpose of this research project is to collect information about the emotional and social skills of youth with Autism Spectrum Disorders. Additionally, information about your strengths will be collected in order to understand how to build success for youth with Autism Spectrum Disorders. The hope is that the collection of such information will assist teachers and others who work with youth with Autism Spectrum Disorders to better understand the youth with whom they work. In addition, it is hoped that this study will provide information to researchers that will help to develop appropriate ways to teach social and emotional skills to individuals with Autism Spectrum Disorders.

Procedures:
If you chose to participate in this study, you will first be asked to complete a 10-15 minute test that will help researchers to confirm that you fit the definition of Autism Spectrum Disorders we wish to use for this study. Additionally, one of your parents and one of your teachers will be asked to complete brief questionnaires about your social skills. If after completing these tasks, you meet the requirements for this study, you will be asked to complete a series of tasks that will help to understand your social and emotional skills, thinking processes, strengths, and overall abilities. **Your participation in this research will take approximately 6 hours in total to complete, and will occur on two different days (each with about 3 hours of participation).** However, you will be free to take breaks whenever you fell you need to.

The purpose of this study is to collect information from many youth with Autism Spectrum Disorders. Consequently, **it will not be possible to share your individual results** on the various tasks. However, the information we collect about how you think and interact will help the researchers to understand youth with Autism Spectrum Disorders so that appropriate information can be shared with many professionals that work with individuals with Autism Spectrum Disorders.

Potential Risks:
There are no foreseeable risks associated with participation in this study.

Potential benefits:
The information collected in this study will help researchers and professionals to understand the emotional and social skills of youth with Autism Spectrum Disorders. It is hoped that this information will lead to further research to develop appropriate plans to help youth with Autism Spectrum Disorders.

Confidentiality:
The information collected in this study may be published and presented at academic conferences. However, the data will be reported in aggregate form, which ensures

individual participants are not identifiable. All forms will be coded and stored separately so that your personal information or responses cannot be identified.

All materials will be stored in a locked facility by the researcher or one of the committee members, Dr. Vicki Schwean, Dr. Don Saklofske, Dr. Brian Noonan, or Dr. Laurie Hellsten.

Right to Withdraw:
You may withdraw from the study for any reason, at any time, without penalty of any sort. If you withdraw from the study, the information that you have contributed will be destroyed. Since **participation in the study is purely voluntary**, participants may choose to answer some or all of the questions on the questionnaires, while leaving out any questions you may be uncomfortable at answering. Further, you will be informed if any new information arises that may affect your decision to remain in the study.

Questions:
If you have any questions about the study at any point in time, please feel free to ask. You may contact the researchers at the number or email address provided if you have any questions now or at any other time.

This study has been approved on ethical grounds by the University of Saskatchewan Behavioral Sciences Research Ethics Board on (file #06-106) on May 29th, 2006, the University of Manitoba on June 26, 2006 (#P2006:052), and the University of Calgary on June 23, 2006.Any questions regarding your rights as a participant may be addressed to that committee via the Office of Research Services at (306) 966-2084. Out of town participants are encouraged to call collect.

When the study is completed, participants should feel free to contact the researcher if they would like a summary of the results.

Please return the following page to the researcher. If you are interested in participating in this study, please complete this form and return it in the stamped and addressed envelope provided. Your prompt response will enable the researcher to mail out materials and schedule your participation in this study. Again, **participation is purely voluntary and you should feel free to withdraw from the study at anytime and for any reason.**

In order to participate in this study, the researchers ask that both you and one of your parents agree to your involvement. In addition, we ask that you agree to let the research team contact a teacher identified by your parent or guardian on *Parental/Guardian Consent* page.

Consent to Participate in Research Study

I consent to participate in the research study being conducted by the researchers listed below from the Universities of Saskatchewan and Calgary. My signature at the end of this consent form will indicate that the researchers have answered all of my questions and that I voluntarily consent to participate in this investigation. I understand that no individual assessment results will be shared from my participation in this study. However, I understand that I may contact the researchers at the numbers provided to enquire about the results of this project. **I realize that I am free to withdraw from participation at any time, for any reason without penalty.**

I have read, understood and been provided with a copy of this consent from. I realize that I may ask questions in the future about the study and I indicate my free consent to research participation by signing this research consent form.

I give my consent to be contacted after participation in this study should the researchers have further questions regarding this study **(check one) Yes**_____ **No**_____

I give my consent to contact the following individuals for the purposes of this study outline previously. **(check one) Yes**_____ **No**_____

Teacher/instructor _____ _____
(name) (phone number)

Parent/guardian _____ _____
(name) (phone number)

Finally, I give consent for future contact for a follow-up study should there be one **(check one) Yes** _____ **No** _____

_____ _____
(Name of Participant) (Signature of Participant)

_____
(Date)

_____ _____
Contact Number Alternate Contact (cell or email)

_____

_____
(Mailing Address)

_____
(Signature of Researcher)

Research Team

Please remove this page and keep for your records

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Keoma Thorne
Master's Student
University of Calgary
Department of Applied Psychology
Phone: (403) 220-3585
kjthorne@ucalgary.ca

APPENDIX D: Teacher/Instructor Consent Form

Dear Teacher/Instructor,

You have been suggested as a teacher/instructor who could complete a rating scale about the social and emotional skills of _____.
(name of student)
Both the previously mentioned student and their parent/guardian have consented to our contact with you in order to facilitate research for a study entitled understanding **Complex Decision Making in youth with Autism Spectrum Disorders.** Please read this form carefully and feel free to ask any questions you may have.

Purpose and Procedure
The main objective of this study is to obtain information towards answering the questions:

1) What tests are most appropriate to use in understanding social and emotional abilities in youth diagnosed with Asperger syndrome?
2) Can emotional capabilities provide an alternate or complementary explanation for the social challenges faced by individuals with Asperger syndrome?

This study will investigate the emotional and social abilities of individuals with Asperger syndrome. For those individuals with Asperger syndrome who have consented to participate, a battery of tests will be administered that examine a number of abilities thought to relate to social and emotional skills and that promote social and emotional resiliency in youth. There are three sources of information for this study: 1) the youth with Asperger who has agreed to participate 2) a parent of the youth who has chosen to participate, and 3) a teacher or instructor of the youth participant. The individual named above has suggested you as an appropriate contact for our purposes in this study.

Teachers who agree to participate in this study will be asked to complete on rating scale about the social and emotional skills of the student listed above that will take **approximately 15 minutes** to finish. Your participation in this study will provide the researchers with a valuable perspective on the social and emotional interactions of students within the school setting. It is anticipated that this information will provide better understanding of individuals with Asperger syndrome and may indirectly lead to research on appropriate interventions for youth with Asperger syndrome.

Potential Risks
There are no known discomforts or risks associated with this study. The study involves completion of a simple questionnaire.

Potential Benefits
It is expected that the information collected in this study will provide us with a better understanding of the social and emotional characteristics of individuals with Asperger syndrome. There is surprisingly little research examining the social and emotional

abilities that best promote success and resiliency in youth with Asperger syndrome. The researchers involved in this study believe that it is important to understand these characteristics, because youth with Asperger syndrome, in particular, are likely to encounter many social and emotional challenges, particularly in the transition to adulthood.

We expect that the results of this study will be helpful for scientists and professional around the world interested in social and emotional abilities of youth with Asperger syndrome. We want to thank you very much in advance for your help in furthering this research.

Confidentiality

Data generated from this study are primarily intended to be used in doctoral and master's level student research. All materials will be stored in a locked facility by the researcher or one of the committee members, Dr. Vicki Schwean, Dr. Don Saklofske, Dr. Brian Noonan, or Dr. Laurie Hellsten. The results may also be published in scholarly journals and/or presented at academic conferences. While the information generated from this study may be published and presented at academic conferences, the data will be reported in aggregate form, which ensures individual participants are not identifiable. **Please understand that all information collected during the course of this study will remain strictly confidential and your name will not be identified at any time or associated with any published results.**

Right to Withdraw

It is important to acknowledge that participation is completely voluntary so **participants may withdraw from the study for any reason, at any time, without penalty of any sort.**

Questions

If teachers have any questions about the study at any point in time, please feel free to ask. You may also contact any of the researchers at the contact information provided on the final page of this form, should you have any questions at any time. This research has been approved by the University of Saskatchewan's Behavioural Sciences Research Ethics Board (file #06-106) on May 29th, 2006, the University of Manitoba on June 26, 2006 (#P2006:052), and the University of Calgary on June 23, 2006. Any questions regarding your rights as a participant may be addressed to that committee via the Office of Research Services at (306) 966-2084. Out of town participants are encouraged to call collect.

Study Results

The research questions we are interested in examining involve understanding youth with Asperger syndrome as a group. Consequently, we will not have study results for individual participants. However, when the study is completed and the data have been analyzed, participants should feel free to contact any of the researchers if they would like a summary of the group results.

Please return this form to the researcher. If you are interested in participating in this study, please complete this form and return it in the stamped and addressed envelope provided. Your prompt response will enable the researcher to mail out materials required for your participation in this study. Again, participation is purely voluntary.

Teacher Consent

I give my consent for participation in the research study being conducted by the researchers listed below from the Universities of Saskatchewan and Calgary. My signature at the end of this consent form will indicate that the researchers have answered all of my questions and that I voluntarily consent to participate in this investigation. **I realize that I am free to withdraw from participation at any time, for any reason without penalty.**

I have read, understood and been provided with a copy of this consent from. I realize that I may ask questions in the future about the study, and I indicate my free consent to research participation by signing this research consent form.

I give my consent to be contacted after participation in this study should the researchers have further questions regarding this study **(check one) Yes**_____ **No**_____

Finally, I give consent for future contact for a follow-up study should there be one **(check one) Yes** _____ **No** _____

_____
(Name of Teacher)

_____ _____
(Signature of Teacher) (Date)

_____ _____
Contact Number Alternate Contact (cell or email)

_____

_____
(Mailing Address)

_____
(Signature of Researcher)

APPENDIX E: Parent Instructions I

Dear Parent/Guardian,

Thank-you for agreeing to participant in our study examining Complex Decision Making in youth with Autism Spectrum Disorders. The information you provide will help us to determine if your adolescent/young adult's participation is appropriate and provide us with a rich understanding of the individual characteristics of your adolescent/young adult. If your youth is selected to participate in this study based on the information collected in this form, then the researchers will contact you to arrange a mutually convenient time. At this visit, you will be asked to complete two additional questionnaires.

Please complete the following forms as best you can. Follow the instructions at the top of each form and feel free to contact the researcher (at the number below) at any time if you have questions.

Thank-you again for agreeing to participate in this study.

Regards,

NAME
Doctoral Student
DEPARTMENT
UNIVERSITY
PHONE NUMBER

APPENDIX F: Parent Instructions II

Dear Parent/Guardian,

Thank-you again for agreeing to participant in our study interested in understanding Complex Decision Making in youth with Autism Spectrum Disorders. The following questionnaire will provide the researchers with information about how your adolescent/young adult functions in daily life. Please complete the BASC-2 (PRS) as per the instructions at the top of the form. If you have any questions, please feel free to contact the researcher or ask for clarification at the end of your session.

Regards,

NAME
Doctoral Student
DEPARTMENT
UNIVERSITY
PHONE NUMBER

Researcher: _____
(signature)

APPENDIX G: Participant Information Questionnaire

This questionnaire should be completed by a parent/guardian of the participant, as it asks about early developmental history. If a parent/guardian is unavailable, a close relative who has knowledge of the individual's early history is acceptable.

In order to establish the appropriateness of your son/daughter's participation in a study interested in understanding **Complex Decision Making in youth with Autism Spectrum Disorders**, the researchers require background information about your adolescent/young adult. Please complete the following questionnaire.

Adolescent/Young Adult's name: Gender:

Adolescent/Young Adult's date of birth: Age:

School/Educational Institution: Grade/Year of Program:

If your adolescent/young adult is enrolled in a college/university program, please name the program:

Name and school phone number of a teacher/instructor you would be willing to allow the researchers to contact:

Name and phone number of a peer you would be willing to allow the researchers to contact:

Official Diagnosis

Who originally diagnosed your adolescent/young adult (name and title)?

How old was your adolescent/young adult at the time of the original diagnosis?

Has anyone else given a diagnosis to your adolescent/young adult?

If so, who gave the diagnosis and what is their title?

What was the diagnosis?

Has your adolescent/young adult been diagnosed with any other psychological disorders?

Has your child been diagnosed with any medical disorders? If so, please provide a general description.

Has your child ever experienced a head injury? (Circle) Yes No

If yes, were they unconscious? Yes No

If yes, for how long was your child unconscious?_____

Was your child adult hospitalized for the head injury? (Circle) Yes No

If yes, how long was the hospitalization?_____

Language Development

Did your adolescent/young adult receive speech therapy before the age of 5?

As far as you recall, how old was your adolescent/young adult when s/he began speaking in single words?

How old was your adolescent/young adult when s/he began speaking in short but meaningful phrases?

Do you consent to the researcher contacting the individuals you have listed in order to participate in this study?

- ☐ Yes
- ☐ No

Signature_____ Date_____
(parent)

Signature_____
(researcher)

APPENDIX H: Recruitment Poster I

Have you been diagnosed with an Autism Spectrum Disorder?

Are you 17 to 21 years old?

Would you like to participate in a research study examining
Complex Decision Making in youth with Autism Spectrum Disorders?

The purpose of the study is to examine the performance of individuals with Autism Spectrum Disorders on measures of emotional and social abilities. Individual participants will be asked to complete 6 hours of tasks and activities measuring emotional abilities, executive mental processes, and social competencies. Participants in this research study will have the opportunity to contribute to research that may lead to an enhanced understanding of Autism Spectrum Disorder and may provide important information about appropriate support services. If you are interested in participating in this research project please contact:

NAME
DEPARTMENT
INSTITUTION
CITY
PHONE
EMAIL

Please note: In the interest of facilitating recruitment, a brochure outlining the details of our research project has been developed and has been included in this document package for your review.

APPENDIX I: Recruitment Poster II

UNIVERSITY OF CALGARY

Applied Psychology

FACULTY OF EDUCATION

PARTICIPANTS NEEDED FOR RESEARCH

We are looking for MALE Volunteers, 17 years of age, to take part in a study of intellectual, social and emotional abilities.

As a participant in this research, you would be asked to complete questionnaires, paper and pencil and computer-based tasks.

If you are deemed eligible to participate, your participation would involve one, approximately 3 hour research session at the University of Calgary.

All eligible participants will receive a $50 Gift Certificate for Future Shop

For more information about this research, or to volunteer for this research, please contact:

Adam McCrimmon

at

awmccrim@ucalgary.ca

This research has been reviewed by, and received ethics clearance through, the Conjoint Faculties Research Ethics Board, University of Calgary.

APPENDIX J: Recruitment Brochure

Frequently Asked Questions

Who is Eligible to Participate?

- Individuals between the ages of 17 and 21 who have received a diagnosis of or treatment for an ASD (such as High Functioning Autism or Asperger Disorder) are eligible to participate.

What Does Participation Involve?

- Participation typically involves two sessions at the University of Calgary. Participants will complete various tasks related to social and emotional abilities. Each session will take approximately 2-3 hours.
- Drinks and snacks are provided and all participants will be entered into a lottery draw (cash & donation prizes)
- We will arrange appointments at a time that is most convenient for you, including weekends & evenings.
- Participants will be provided with free and easily accessible parking, and a research assistant would be pleased to assist you to our centre.

Investigative Team

Principal Investigators:

Dr. Vicki Schwean
Associate Dean, Division of Applied Psychology, University of Calgary

Dr. Don Saklofske
Professor, Division of Applied Psychology, University of Calgary

Graduate Students:
Janine Montgomery
Danielle Dyke
Adam McCrimmon
Jo-Anne Burt
Candace Kohut
Yvonne Hindes
Keoma Thorne

For more information on participation in this study, please contact the ASD Research Group at:

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2nd Floor, Education Tower (Rm. 281)
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Calgary, Alberta
T2N 1N4

Phone: 220-3642
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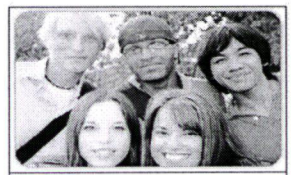
Email: asdgroup@ucalgary.ca

UNIVERSITY OF CALGARY



Learning More About Autism Spectrum Disorder (ASD) in Adolescents & Young Adults: A Research Project

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Our research is funded by:

Do you or someone you care about struggle with:

- Difficulties in social interaction
- Repetitive patterns of behaviours, interests, and activities
- Relationship or career challenges

- Current research has demonstrated that youth who experience challenges in social interaction and emotional regulation, as commonly displayed in Autism Spectrum Disorders (ASD), also experience challenges with successful life transitions .
- However, there is surprisingly little research examining the social and emotional abilities that best promote life success for individuals with ASD.
- Subsequently, the Autism Spectrum Disorder Research Group has developed a research project to learn more about social and emotional abilities in adolescents and young adults with ASD.
- The researchers involved in this study believe it is important to understand these abilities so that we can better understand how to promote resiliency and success in individuals with ASD

Research Objectives

The main objectives of this study are to obtain information towards answering the following questions:

1) What assessment measures are most appropriate to use in understanding social and emotional abilities in youth diagnosed with Autism Spectrum Disorder (ASD)?

2) How are emotional abilities related to the social challenges faced by individuals with ASD?

3) Do the strengths exhibited by individuals with ASD on measures of social and emotional abilities help us to understand life satisfaction and the ability to succeed?

4) What complex decision –making skills best promote resiliency and successful life transitions in youth with ASD?

Additional Information:

Participants in this study include individuals with ASD, the parents/ guardians of the individual with ASD, and potentially a teacher/instructor who knows the individual well.

- Parental information regarding early development will provide a valuable perspective on the social and emotional characteristics of individuals with ASD. Parental involvement will require only 20-25 minutes of participation.
- It is anticipated that the information we obtain will provide a better understanding of individuals with ASD and may inform research in appropriate interventions with individuals with ASD.
- There are no known discomforts or risks associated with this study.
- **We want to thank you in advance for your help in furthering this research.**

ASD Research Group
Division of Applied Psychology,
University of Calgary
2nd Floor, Education Tower (Rm. 281)
2500 University Drive, N.W.
Calgary, Alberta
T2N 1N4

Phone: (403) 220-3642
Fax: (403) 282-9244
Email: asdgroup@ucalgary.ca

APPENDIX K: Clinician Script and Procedure Summary

The following script is to be read to primary participant at initiation of testing.

Clinician: Thank-you for agreeing to help us with this study. Today we are going to do a number of tasks designed to measure how you behave, think, and act in social situations and daily life. The tasks may take from a half hour* to 4 hours to complete. In addition, you will complete some tasks designed to understand your thinking processes.

If at any time you want to take a break, or need to go to the washroom, please ask. I may also initiate a break if I think I need one. Please remember that your participation in this study is purely voluntary and that you may choose to stop at any time. Also, if you have any questions at any time, please feel free to ask me.

Are you ready to begin?

Procedures:

1. Administer WASI according to instructions in the test manual (while participant completes one of the self-report measures listed below, researcher will score the WASI). If a FSIQ of 85 or higher is not achieved, then testing should be discontinued. In order to maintain rapport, the researcher will allow the participant to complete the self-report, and then thank them for their time and willingness to co-operate.
2. If the participant meets the IQ eligibility requirements, the researcher will administer the following tests, alternating between test 1 for one participant, and test 2 for the next.
    Test 1: Bar-On EQ-i: S (self report)
    Test 2: BASC-2 (self-report)
3. The researcher will subsequently administer the following tests in random order (as determined by computer assignment)
    Test 3: MSCEIT
    Test 4: EYES
    Test 5: D-KEFS
    Test 6: CANTAB
    Test 7: WCST
    Test 8: Iowa Gambling Task
    Test 9: Resiliency Scales for Adolescents
    Test 10: Satisfaction with Life Scales
    Test 11: GARS-2
    Test 12: Autism Quotient (AQ)

APPENDIX L: Ethical Approval Certificates

University of Saskatchewan
Behavioural Research Ethics Board (Beh-REB)

9-Jun-2006

Certificate of Approval

PRINCIPAL INVESTIGATOR	DEPARTMENT	BEH#
Vicki Schwean	Educational Psychology and Special Education	06-106

STUDENT RESEARCHERS
Janine Montgomery, Danielle Dyke, Jo-Anne Burt, Candace Kohut, Yvonne Hindes

SPONSOR
UNFUNDED

TITLE
Emotional Intelligence and Resiliency in Individuals with Asperger Disorder

CURRENT APPROVAL DATE	CURRENT RENEWAL DATE
29-May-2006	01-May-2007

The University of Saskatchewan Behavioural Research Ethics Board has reviewed the above-named research project. The proposal was found to be acceptable on ethical grounds. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this research project, and for ensuring that the authorized research is carried out according to the conditions outlined in the original protocol submitted for ethics review. This Certificate of Approval is valid for the above time period provided there is no change in experimental protocol or consent process or documents.

Any significant changes to your proposed method, or your consent and recruitment procedures should be reported to the Chair for Research Ethics Board consideration in advance of its implementation.

ONGOING REVIEW REQUIREMENTS
The term of this approval is five years. However, the approval must be renewed on an annual basis. In order to receive annual renewal, a status report must be submitted to the REB Chair for Board consideration within one month of the current expiry date each year the study remains open, and upon study completion. Please refer to the following website for further instructions: *httD://www.usask.ca/research/ethical.shtml*

APPROVED

Dr. Valerie Thompson, Chair
Behavioural Research Ethics Board
University of Saskatchewan

Please send all correspondence to:

Ethics Office
University of Saskatchewan
Room 306 Kirk Hall, 117 Science Place
Saskatoon SK S7N sca
Telephone: (306) 966-2084
Fax: (306) 966-2069

UNIVERSITY OF MANITOBA

APPROVAL CERTIFICATE

26 June 2006

TO: **Janine Montgomery**
Principal Investigator

FROM: **Bruce Tefft, Chair**
Psychology/Sociology Research Ethics Board (PSREB)

Re: **Protocol #P2006:052**
"Emotional Intelligence and Resiliency in Individuals with Asperger Disorder"

Please be advised that your above-referenced protocol has received human ethics approval by the **Psychology/Sociology Research Ethics Board**, which is organized and operates according to the Tri-Council Policy Statement. This approval is valid for one year only.

Any significant changes of the protocol and/or informed consent form should be reported to the Human Ethics Secretariat in advance of implementation of such changes.

Please note:

- if you have funds pending human ethics approval, the auditor requires that you submit a copy of this Approval Certificate to Kathryn Bartmanovich, Research Grants & Contract Services (fax 261-0325), including the Sponsor name, before your account can be opened.

- if you have received multi-year funding for this research, responsibility lies with you to apply for and obtain Renewal Approval at the expiry of the initial one-year approval; otherwise the account will be locked.

UNIVERSITY OF CALGARY

MEMO

Conjoint Faculties Research Ethics Board (CFREB)
Research Services Office
Main Floor, Energy Resources Research Building
Research Park
Telephone: (403) 220-3782
Fax: (403) 289-0693
Email: bonnie.scherrer@ucalgary.ca

To: Dr. Vicki Schwean
Division of Applied Psychology,
Faculty of Education

Date: June 23, 2006

From: Dr. J. Kent Donlevy, Acting Chair
Conjoint Faculties Research Ethics Board

Re: Certification of Institutional Ethics Review – "Emotional Intelligence and Resiliency in Individuals With Asperger Disorder"

On behalf of the Conjoint Faculties Research Ethics Board (CFREB), this is to acknowledge receipt of the proposal, consent forms, and recruitment materials submitted to the University of Saskatchewan Behavioural Research Ethics Board for the above-named project, and copy of the ethical clearance from the University of Saskatchewan dated 29 May 2006. The University of Calgary accepts your application in this format, and herewith confirms ethical clearance. Accordingly, a copy of this letter should be attached to your original clearance granted by the University of Saskatchewan.

In accordance with the approval issued by the University of Saskatchewan REB, you have been named as principal investigator for this project on the University of Calgary ethics clearance. Referral for individuals with questions regarding their rights as participants, however, will be to the University of Saskatchewan REB (as outlined in the study consent forms), since there is a student researcher, Ms. Janine Montgomery, at the University of Saskatchewan, and the original approval was issued by that institution's REB; we have advised the University of Saskatchewan Behavioural REB that we attorn to their jurisdiction with respect to the action of the student researcher in this instance.

The CFREB should be kept apprised of any modifications to the protocol that are authorized by the principal investigator's institution. A progress report must be submitted 12 months from the date of this letter, and you should provide the expected completion date for the project. A form for this purpose is available at the following website: http://www.ucalgary.ca/UofC/research/html/ethics/info_facres.html
Written notification must be sent to the CFREB when the project is complete or terminated.

In closing, let me take this opportunity to wish you well in your research endeavors.

Sincerely,

J. Kent Donlevy, M.Ed., LLB, Ph.D., Assistant Professor
Faculty of Education and
Acting Chair, Conjoint Faculties Research Ethics Board

UNIVERSITY OF CALGARY

CONJOINT FACULTIES RESEARCH ETHICS BOARD
Annual Renewal / Progress / Final Report
Research Services, ERRB Building, Research Park
Submit by email to: rburrows@ucalgary.ca

1. Applicant: (USE RESTRICTED: Faculty, students, staff from the UofC)

Name
Dr. Vicki Schwean; Associate Dean, Faculty of Education

Department/Faculty
Division of Applied Psychology/ Faculty of Education

E-mail Address	Telephone:
vischwea@ucalgary.ca	**(403) 220- 5655**

If you are a student, include your supervisor's name and email address here

2. Other Participants: If another person is involved in the project, please provide their name, department or other details as required to identify them. Use an attachment, if necessary

1. Dr. Donald Saklofske; Professor, Division of Applied Psychology; Associate Dean (Research), Faculty of Education

2. Danielle Dyke, M.A.; Doctoral Student; Division of Applied Psychology

3. Adam McCrimmon, M..A.; Doctoral Student; Division of Applied Psychology

3. Project Details:

3.1 Exact Title of the Project (and File No. if available)

"Emotional Intelligence and Resiliency in Individuals With Autism Spectrum Disorder" (CFREB file # 4871)

3.2 Have you commenced this research? [X] Yes When did it commence? Date: **February, 2007**
[ ] No If no, why not (attach)

3.3 Is the study completely closed to all research activity? [ ] Yes When was it closed? Date: _____
If the study is not completely closed, what is the expected date? Date: **August 31, 2010**

3.4 How many people participated in the research? **To date: approximately 55 participants. Data collection is still ongoing as we are currently in the process of collecting our control group data.**

3.5 Have all modifications been reported? [X] Yes [ ] No (If no, please attach)

3.6 Have the results been published or presented? [ ] No [X] Yes, if yes, indicate where results can be located.

International Meeting for Autism Research (May 2007; Seattle, WA)

Canadian Psychological Association Annual Conference (June 2007, Ottawa, ON; June 2008, Halifax, NS)

Montgomery, J.M., Schwean, V.L., Burt, J.G., Dyke, D.I., Thorne, K.J., Hindes, Y.L., McCrimmon, A.W. & Kohut, C.S. (2008). Emotional intelligence and resiliency in young adults with Asperger's disorder: Challenges and Opportunities. *Canadian Journal of School Psychology*, 23(1), 70-93.

3.7 Have there been any complaints about the research [X] No [ ] Yes, if yes, please attach information with details.

Signature of Applicant: *Dr. Vicki Schwean*

Thank you for submitting your report on the above protocol.

As Chair of the Conjoint Faculties Research Ethics Board, I am pleased to advise you that ethical approval for this proposal has been extended to: AUG 31 2010. Please note that this approval is contingent upon strict adherence to the original protocol. Prior permission must be obtained from the Board for any contemplated modification(s) to the original protocol. An annual progress/final report concerning this study will be required by JUN 30 2010

Please accept the Board's best wishes for continued success in your research.

Janice P. Dickin, Ph.D., LLB, Faculty of Communication and Culture and
Chair, Conjoint Faculties Research Ethics Board

Date: MAY 27 2009