THE UNIVERSITY OF CALGARY

Hand Preference in Children with Autism

by

Joy Alison Hauck

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER OF SCIENCE

PROGRAMME IN CLINICAL PSYCHOLOGY

CALGARY, ALBERTA

SEPTEMBER, 1997

ABSTRACT

This study has investigated hand preference in young children with autism, compared to matched developmentally delayed and normally developing children. In addition, it examined the relationship between hand preference and the following variables: fine and gross motor skills, receptive verbal ability and mental age. The results indicate that the lack of development of a hand preference in autistic children is not a function of their cognitive delay, and also does not appear to be related to a lack of motor development. Distributions of hand preference were similar for the children with autism and normally developing children of the same developmental level. Children with autism with a definite hand preference have better cognitive, verbal and motor functioning. This pattern was also seen to a lesser degree in the comparison groups, but did not reach statistical significance. Severity of autistic characteristics was not related to degree, or classification of hand preference.

ACKNOWLEDGEMENTS

There are numerous people to acknowledge for their support of this research study. Many agencies were involved, and their helpfulness made the project manageable. My sincerest gratitude goes to Terry Creighton, who was incredibly supportive of the study, and to all his staff at Providence Children's Centre. I would also like to thank staff at the Society for Treatment of Autism, and at the Alberta Children's Hospital for their assistance in retrieving data and recruiting participants. I would also like to extend my gratitude to Dr. Kim Ward for her advice throughout the project. Thanks also to the staff at the University Child Care Centre for their participation and patience.

I am grateful to the staff at the Behavioural Research Unit for their help with this project. Especially to my supervisor, Dr. Deborah Dewey, my sincerest thanks. Her support and encouragement was constant, and she was always available for questions, and to give suggestions and guidance. My deepest gratitude is also extended to my fellow students, whose friendship has made the last two years more tolerable.

My biggest thanks go to my family. Their love and support continues to be a source of strength. And last, but definitely not least, to Greg. I could not have done this without you. Your support has taken many forms, and has been my lifeline throughout graduate school.

This project was supported by an Alberta Heritage Foundation for Medical Research (AHFMR) Studentship to the author.

DEDICATION

To all the families who participated in this project who have a child with autism. Especially to Leslie, Terry and Julie. Your love for your families, and dedication to your sons is an example to us all. Also to Scott. You have taught me to look far beyond the label, to the child that is always waiting to be discovered. You are a very special boy. I cherish my time with you.

TABLE OF CONTENTS

APPROVAL PAGE ii

ABSTRACT iii

ACKNOWLEDGEMENTS iv

DEDICATION v

TABLE OF CONTENTS vi

LIST OF TABLES x

LIST OF FIGURES xiii

INTRODUCTION 1
- What is Autism? 3
- Theories of Autism 3
- Impairments Associated with Autism 4
- Cerebral Lateralization and Handedness 6
- Normal Development of Laterality and Handedness 7
- Hand Preference and Lateralization in Developmentally Delayed Children 9
- Hand Preference in Children with Autism 10
- Cerebral Lateralization in Autism 12
- Hand Preference and Other Abilities in Normally Developing Children, Children with Developmental Delays, and Children with Autism 14
  - Normally Developing Children 14
  - Children with Developmental Delays 16
  - Children with Autism 17
- Appropriate Control Groups for Children with Autism 18
- Hand Preference in Children - Conclusions 19
- Hypotheses 22

METHOD 24
- Participants 24
- Measures 28
  - The Hand Preference Demonstration Test 29
  - Hand Preference Questionnaire 30
  - The Bayley Scales of Infant Development - Second Edition 31

Table of Contents (continued)

The Peabody Picture Vocabulary Test - Revised 32
The Battelle Development Inventory - Motor Domain 32
Fine and Gross Motor Questionnaire 33
The Childhood Autism Rating Scale 33
Pregnancy and Birth Complications Questionnaire 34
Sociodemographic Questionnaire 34
Procedure 35

RESULTS 36
Family Background 36
Comparison of Fine and Gross Motor Questionnaire and BDI - Motor Domain 39
Comparison of Handedness, Verbal Ability and Motor Skills Across Groups 41
Hand Preference Categorization 48
Age in Relation to Hand Preference Classification 50
Strength and Consistency of Hand Preference 50
Inconsistency Within Hand Preference Categories 55
Bimanual Responses 55
Hand Preference Classification and Relationship to Pregnancy and Newborn Problems 58
The Relationship of Hand Preference to Verbal, Cognitive and Motor Abilities 58
Pregnancy and Birth History 72
Group Differences in Pregnancy and Delivery Problems 72
Group Differences in Newborn Problems 73
Overall Comparison of Total Problems During Pregnancy and Total Newborn Problems 73
CARS Score and Relationships to Receptive Verbal Ability, Cognitive Ability, Motor Skills and Handedness 74
Severity of Autism Characteristics on a Continuum 74
Categorization of Autism Severity 79
Hand Preference in the Family 79
Fine and Gross Motor Questionnaire 83

DISCUSSION 87
Group Differences in Hand Preference 87
Comparison of Verbal, Cognitive, and Motor Skills Across Groups 97
Hand Preference Classification and its Relationship to Other Abilities 98
Severity of Autism 102
Comparison of Questionnaire Data 103

Table of Contents (continued)

Limitations of the Study and Suggestions for Future Research 104
Concluding Remarks 107

REFERENCES 109

APPENDIX A: Letter to Parents in the Autism Calgary Association 120

APPENDIX B: Consent Form for the Children with Autism recruited through the Autism Calgary Association 123

APPENDIX C: Letter to Parents of Children who Previously Attended the Society for Treatment of Autism 127

APPENDIX D: Consent form for Children who Previously Attended the Society for Treatment of Autism 130

APPENDIX E: Letter to Parents with Children in the Early Intervention Program, at the Society for the Treatment of Autism 134

APPENDIX F: Consent Form for Children with Autism in the Early Intervention Program, at the Society for the Treatment of Autism 137

APPENDIX G: Letter to Parents of Children with Developmental Delays at Providence Children's Centre 141

APPENDIX H: Consent Form for Children with Developmental Delays at Providence Children's Centre 144

APPENDIX I: Letter to Parents of Children with Developmental Delays Recruited Through the Alberta Children's Hospital 148

Table of Contents (continued)

APPENDIX J: Consent Form for Children with Developmental Delays Recruited Through the Alberta Children's Hospital 151

APPENDIX K: Letter to Parents of Normally Developing Children at Providence Children's Centre 155

APPENDIX L: Consent Form for Normally Developing Children at Providence Children's Centre 158

APPENDIX M: Letter to Parents of Normally Developing Children at the University Child Care Centre 162

APPENDIX N: Consent Forms for Normally Developing Children at the University Child Care Centre 165

APPENDIX O: Consent Form for Parents of Normally Developing Children (non-agency) 169

APPENDIX P: Hand Preference Demonstration Test (HPDT; Soper et al., 1986) 173

APPENDIX Q: Hand Preference Questionnaire, and Pregnancy and Birth Complications Questionnaire 175

APPENDIX R: Fine and Gross Motor Questionnaire 181

APPENDIX S: Sociodemographic Questionnaire 191

LIST OF TABLES

TABLE TITLE PAGE

Table 1 Family Background....37

Table 2 Correlations Between SES and the Dependent Variables (Measurement Scores)....38

Table 3 Correlations Between BDI - Motor Domain Scores, and Fine and Gross Motor Questionnaire Scores (All Groups)....40

Table 4 Correlations Between BDI - Motor Domain Scores and Fine and Gross Motor Questionnaire Scores for the Children with Autism....42

Table 5 Correlations Between BDI - Motor Domain Scores and Fine and Gross Motor Questionnaire Scores for the Children With Developmental Delays....43

Table 6 Correlations Between BDI - Motor Domain Scores, and Fine and Gross Motor Questionnaire Scores for the Normally Developing Children....44

Table 7 Group Means for the Performance and Hand Preference Measures....45

Table 8 Correlations Between Performance and Hand Preference Measures....46

Table 9 MANOVA for the Performance and Hand Preference Measures....47

Table 10 Frequency of Hand Preference Categorization by Group....49

Table 11 Comparison of Mean Ages by Hand Preference....51

Table 12 Frequency of Hand Preference Inconsistencies on More Than Two Activities for the Hand Preference Demonstration Test....56

TABLE TITLE PAGE

Table 13 Frequency of Bimanual Responses by Hand Preference Task 57

Table 14 Comparison of Pregnancy and Birth Complications by Hand Preference.....59

Table 15 Comparison of Newborn Complications by Hand Preference 60

Table 16 MANOVA for Verbal, Cognitive, and Motor Abilities.....62

Table 17 Group Comparisons of Receptive Verbal Ability by Hand Preference.....68

Table 18 Group Comparisons of Cognitive Ability by Hand Preference 69

Table 19 Group Comparisons of Fine Motor Ability by Hand Preference.....70

Table 20 Group Comparisons of Gross Motor Ability by Hand Preference.....71

Table 21 Group Means for Pregnancy and Newborn Details 75

Table 22 MANOVA for Reported Pregnancy and Newborn Problems.....76

Table 23 Correlations Between CARS Score, and Performance and Hand Preference Measures (Children with Autism) 77

Table 24 Hand Preference Groups Means on the CARS (Children With Autism) 78

Table 25 MANOVA for Performance and Hand Preference Measures According to CARS Score Classification.....80

Table 26 Category of Autism Means for Performance and Hand Preference Measures..81

Table 27 Groups Means for Parents' Degree of Handedness, Number of Left-handed Siblings, and Relativity Index for Left Handedness Including and Excluding the Child..82

Table 28 MANOVA for Fine and Gross Motor Questionnaire Scores.....84

TABLE TITLE PAGE

Table 29 Group Means on the Fine and Gross Motor Questionnaire 85

LIST OF FIGURES

FIGURE TITLE PAGE

Figure 1 Distribution of Laterality Indices for Children with Autism 52

Figure 2 Distribution of Laterality Indices for Children with Developmental Delays 53

Figure 3 Distribution of Laterality Indices for Normally Developing Children 54

Figure 4 Group Means for Receptive Verbal Ability Scores 63

Figure 5 Group Means for Cognitive Ability Scores 64

Figure 6 Group Means for Fine Motor Scores 65

Figure 7 Group Means for Gross Motor Scores 66

INTRODUCTION

Autism is a diagnosis under the umbrella term of Pervasive Developmental Disorders, which is characterized by pervasive and severe deficits in communication, and social skills, and includes the presence of abnormal repetitive and stereotyped behaviours. Approximately 5 children per 10,000 have Autistic Disorder. Improved cognizance and recognition of the disorder has brought individuals with autism increasingly into the public focus. Autism is one of the most researched topics in child psychology, despite its relatively low prevalence rate. This may be due to the mystery that persists about the disorder in regards to its origins, and perhaps due to the children themselves, who are outwardly often normal in appearance, but inwardly appear to reject the essence of what make us social human beings.

There is no cure for autism, although early intervention has been instrumental in increasing some skills in children who have been identified with autism at an early age. Pinpointing other areas of need in these children may suggest where further intervention may be required. Also exploring measures that may help to predict future functioning can only increase our understanding of the disorder. The main purpose of this study was to examine hand preference in young children with autism, and whether the lack of development of hand preference may be related to verbal, cognitive and motor functioning. On the basis of these results, predictions about future functioning may be hypothesized, and suggestions for areas of early intervention may be identified.

Research in the area of hand preference in individuals with autism, and with any group of individuals in general, has shown inconsistencies, mainly because of the lack of reliable and consistent measures of hand preference, and the variety of classification criterion used in studies (Bryson, 1990). It has been difficult to draw conclusions regarding likely patterns of cerebral lateralization from these studies, when

misclassification can result in a very different distribution of preferences. Conclusions regarding patterns of brain dysfunction may be inappropriate; for example, if a child is called left handed when a classification of ambiguous hand preference is more appropriate, a diagnosis of Pathological Left Handedness may be incorrectly assumed, as well as an assumption of unilateral damage to the brain, instead on bilateral (Harris & Carlson, 1988). A second purpose of this study was to employ a reliable instrument to classify hand preference (i.e., the Hand Preference Demonstration Test; HPDT. Soper et al., 1986) which has been used in several other studies. This instrument not only gives a classification of hand preference, but also allows handedness to be viewed as a continuum. Hence, degree of handedness can be explored, as well as consistency of hand preference.

Research involving abilities of children with autism, by necessity, has to use a comparison group of children. The majority of children with autism have a cognitive deficit. Therefore, in order to control for mental and physical development and years of experience, the control group most often used is chronological and mental age matched children with developmental delays (Fein et al., 1984). However, few studies have actually documented hand preference reliably in this group, especially in relation to other abilities, such as motor skills, and language abilities. Therefore, another purpose of this study is to document the distribution of hand preference in a group of children with developmental delays using the HPDT.

Research that has looked at the hand preferences of children with autism, has found an increased prevalence of left handedness (approximately 18%) and a significant percentage of children who appeared to have not developed a hand preference. In other words, they had an ambiguous preference, as opposed to being ambidextrous, where there is consistency of preference within but not across tasks (Soper et al. 1986). It has

also been suggested that ambiguously handed children with autism may have lower levels of cognitive functioning (Fein et al. 1985), although there has not been a systematic exploration of other abilities. Research in this area looking at normally developing children has also suggested that ambiguous handedness may be associated with lower levels of verbal ability (Annett, 1970), and lower cognitive and motor performance in preschool children (Kaufman, Zalma, & Kaufman, 1978). However, there are several studies that have not been supportive of ambiguous handedness indicating impaired abilities (for example, Newcombe et al., 1975). Hence this study seeks to explore the issue of handedness in young children with autism, children with developmental delays and normally developing children, and clarify the question of what association ambiguous handedness may have with ability measures in all three groups of children.

What is Autism?

Autism is developmental disorder, which is reported to occur in the population at rate of 4 to 5 per live 10,000 births, although the latest figures released by Bryson, Clark and Smith (1988) suggest that the prevalence may be double that which was previously reported. The disorder is anywhere from 2.5 to 5 times more common in boys (Bryson et al.; Lord, Schopler, & Revicki, 1982). Currently there is no known etiology underlying the disorder, although various explanations have been put forward as theories for autism.

Theories of Autism

One of the earliest theories explaining the development was psychogenic (Bettleheim, 1967), suggesting that the disorder was a result of the social environment provided by parents. There is little empirical evidence to substantiate this theory (Cantwell, Baker & Rutter, 1978; Rimland, 1964). It is now generally accepted that autism is a neurological disorder (Fein, Pennington, Markowitz, Braverman &

Waterhouse, 1986); however, researchers have been unable to pinpoint a particular neurophysiological or biochemical abnormality specific to autism. Twin and family studies suggest that the disorder has a strong genetic component (Smalley, Asarnow & Spence, 1989). Research in the last seven years has suggested a genetic liability for a range of social and cognitive irregularities in families with an identified autistic member. The abnormalities, similar to what is seen in autism, occur in family members with normal intelligence to varying degrees of disadvantage (Bailey, Phillips, & Rutter, 1996). Thus, there may be a broader autistic phenotype.

Aitken (1991) has suggested that autism may be a result of multiple aetiologies, that lead to a final common pathway (equifinality). These causes would include genetic, viral, and organic insults. However, it may be the timing of the insult at a critical stage of fetal development which causes the spectrum of behaviours we know as autism.

Impairments Associated with Autism

Wing and Gould (1979) suggested that the impairments seen in individuals with autism could be described as consisting of a triad of impairments: impairment in nonverbal and verbal communication, impairment of imaginative activities and impairment in social abilities and relationships. Researchers have also added a pattern of stereotyped and repetitive behaviour as a common feature of autistic disorder (Bailey et al., 1996).

To expand on these categories of impairments, the most striking social deficits in autism are a lack of understanding of social relationships: how relationships work, understanding and perception of social cues, reading the emotions and communications of others, as well as limited interest for social interaction and sharing (Bailey et al., 1996). In addition to a delay in language development, the speech of persons with autism is also noticeable for specific abnormalities: immediate or delayed echolalia, pronoun

reversal, abnormal prosody, and idiosyncratic language (Klinger & Dawson, 1996, p. 315). The pragmatic use of language is also deviant in that autistic individuals will perseverate on topics, introduce irrelevant details when speaking with another person, and generally be oblivious to social rules of conversation (Klinger & Dawson). Attention to concrete meanings of language is also a feature of autism, so that metaphors are taken for their literal meaning. Repetitive behaviours include motor stereotypies, such as finger and hand flapping, and rocking, routines and rituals, insistence on the same sequence of events and perseverative interests that are very focused in nature. Abnormal responses to sensory stimuli, self injury, eating disturbances, decrease in imitation abilities, lack of symbolic play and lack of joint attention are also all features of Autistic Disorder (see Klinger & Dawson for a more comprehensive review).

It has been widely documented that the majority of individuals with autism are mentally retarded. Bryson et al. (1988) reported that approximately 75% of their Canadian sample had IQs below 50, while Ritvo & Freeman (1978) suggested that 60% of individuals with autism had IQs below 50, 20% had IQs in the range 50 to 70, and only 20% had measured IQs above 70. However, as Bailey, Phillips and Rutter (1996) note, Autistic Disorder is also noted for associated cognitive skills, or "islets of ability", as well as a specific pattern of deficits. Visual-spatial abilities are usually better in autistic individuals, resulting in a higher performance IQ than verbal IQ, and an uneven cognitive profile.

Although autistic characteristics may be apparent in a child as young as one year of age, the disorder is not often brought to the attention of parents and professionals until a child is between two and three years of age, when the gap between normal and abnormal development becomes more obvious (Bailey, et al., 1996). The Diagnostic and Statistical Manual of Mental Disorders, fourth edition (DSM-IV; American

Psychiatric Association, 1994) requires that there be a delay or appearance of abnormal functioning in one or more areas of social interaction, symbolic or imaginative play or language used for social communication before the age of three years.

Autism is a lifelong disorder, however, specific developmental features are indicative of a better prognosis. Klinger and Dawson (1996) cited recent studies that consistently found that higher IQ scores (average or above), the development of communicative language before the age of 5, and involvement in early intervention services predict a more hopeful outcome for individuals with autism, although deficits always remain to some degree, especially in the social realm.

Cerebral Lateralization and Handedness

Molfese and Segalowitz (1988) supported the recent position that brain functions are lateralized from early infancy. Kinsbourne (1988) suggested that functional asymmetry of the brain is a determining factor in what distinguishes the behavioural control evidenced by humans versus non-humans. Language, the control of complex voluntary movement, and other sequential processes are usually lateralized in one hemisphere, most often the left. Skills such as those used during spatial simultaneous tasks are lateralized in the other (right) hemisphere (Kolb & Wishaw, 1985). However, most of this data is in reference to right handed individuals. Non-right handers do not simply have the reversed lateralization of right handers. Hicks and Kinsbourne (1976) noted that left handers are less asymmetrical in their brain shape, as well as in their brain organization. Kinsbourne (1988) also noted that left handers have a higher prevalence of language being represented bilaterally, although the majority of left handers are believed to evidence left hemisphere lateralization for language, as do most right handers. Rasmussen and Milner (1977) suggested from their study of patients with early brain

damage, that lateralization of language to the left hemisphere and right hand preference are actually quite resistant to displacement to the other hemisphere and to the other hand. They indicated that only if there is significant damage directly to the locus of classic language or manual control, will switching of language lateralization and hand preference occur.

Dewey (1996) reported that handedness is often used as an indirect measure of cerebral lateralization. Group data has indicated that there are significant relationships between handedness and other measures of cerebral specialization. In individuals, however, hand preference is not as dependable as an indicator of lateralization.

Another handedness group which has been identified is individuals with ambiguous hand preference. That is, individuals who have no hand preference across, or within tasks (i.e., they are not ambidextrous, as this implies a consistent hand preference for a particular task, although one hand is not dominant across tasks). However, little is known about the actual cerebral organization of function in individuals with ambiguous handedness, mainly because they are, as a group, not very prevalent in the adult normal population, and the group has only been recognized in the last decade or so.

Normal Development of Laterality and Handedness

Over the past ten to fifteen years, the normal development of laterality and handedness has become a focus of research (Harris & Carlson, 1988). There is now documentation that lateral biases exist from birth, and even may exist in a foetus in the womb. Hepper, Shahidullah & White (1991) used ultrasound observations of foetuses, and found that from as young as 15 weeks after conception, there appears to be a bias for sucking the right thumb. Prevalence of left hand thumb sucking was 8%. In newborn infants one of the lateral motor biases observed is for head position. Many studies have

shown that a high percentage of newborns and young infants (between 70 and 90%) show a preference for turning their heads to the right when lying on their backs, even when they have first had their head turned to the left, or to midline (see Harris & Carlson for a review). Ramsay (as cited in Harris & Carlson) reported that by the age of one year, infants have begun to use their hands differentially when manipulating objects and toys with both hands, for example, one hand will be used for holding the item, while the other hand turns the dial, or lid, or whatever there is to be grasped, depending on the toy or object.

Handedness begins to emerge more strongly in the 1 year to 4 year old period, as motor skills related to hand use become more refined and precise, especially in the fine motor area. McManus et al. (1988) stated that the degree of hand preference seen in children increases until approximately 7 years of age, when it plateaus or changes very slowly. They also found that among left handed children, their degree of lateralization appears to increase more quickly in the age range of three to seven years than among right handed children. However, direction of hand preference (i.e., left or right) is stable by age five, and may, in fact, be stable by the age of three. Thus, the results of McManus and his colleagues suggest that degree of hand preference is on a continuum. Kaufman, Zalma and Kaufman (1978) in their sample of normally developing children found that 58% of the two-and-a-half year olds had developed a hand preference, approximately 70% of the three to six-and-a-half year olds indicated a dominant hand, while 75% of the seven-and-a-half year olds and 85% of the eight-and-a-half year olds had an established hand preference (either left or right). Kaufman et al. employed a strict criteria of classifying dominance, so that a child was considered to have a preferred hand only if 100% of their responses were performed with one particular hand.

Annett's (1970) study of children age 3 and a half, to 15 years of age indicated

interesting sex differences in hand preference distribution. In the 3.5 to 8 year range, 6% of males were left handed compared to 2% in females, 31% of males showed mixed handedness with a corresponding 19% of females, and 63% of males were right handed, compared to 79% of females. In the 9 to 15 year old age range, percentages for males stayed very similar (6% left, 34% mixed, 62% right), while the females in the 9 to 15 age range showed a slightly higher percentage of left and mixed handedness, and lower right handedness (left 4%, mixed 22%, and right 74%). Annett also used a 100% criterion for hand preference. Therefore, it is not surprising that the mixed handedness group has a larger frequency than expected. Further, Annett used several tasks, but observed each task only once. Thus, it is impossible to determine whether the children in the mixed handedness group were ambidextrous or ambiguous in their hand preference.

Hand Preference and Lateralization in Developmentally Delayed Children

Batheja and McManus (1985) compared handedness in normally developing and mentally handicapped children and reported a significant difference between the groups for direction of handedness, with left handers being more prevalent in the mentally handicapped group. This group was also less strongly lateralized. Others research studies have supported the increased prevalence of left handedness in this population (i.e., approximately 18%), which is about double the rate seen in the normal population (which is approximately 9%) (Ross, Lipper & Auld, 1987).

Research suggests that the increase in left handedness in the mentally retarded population appears to be a direct reflection of severity of retardation. Hicks and Barton (1975) reported that the prevalence of left hand preference in mild and moderately retarded individuals is approximately the same as that found in the normal population. It

is in the severely retarded subgroup where the increase in left handedness is prevalent. Bryson (1990) suggested that this shift towards left handedness in the severely retarded group can be viewed as the result of left cerebral pathology, or to atypical or incomplete lateralization of the brain.

Deficits in areas such as language and reading skills have long been ascribed to a weak or deviant pattern of hemispheric lateralization (Orton, cited in Obrzut, 1988). Obrzut attacked this position, stating that there has been little evidence to confirm this hypothesis, mainly due to the severe methodological difficulties that have plagued research in the area of lateralization, and handedness in particular. He asserted that there is "little or no relationship between handedness and poor achievement on cognitive tasks" (p. 569). However, the studies he cited as evidence were done on normal children. As Obrzut stated, few studies have used a sample of children with learning disabilities that has been well defined. Hence, it may have been premature to draw a definitive conclusion.

There has been one study that has used the HPDT with children with learning difficulties. Arnold and Askew (1993) investigated the handedness distribution of deaf children with severe learning difficulties, and found 14% of the children were left handed, 32% right handers, and 54% were classified as having ambiguous hand preference (using the 90% criterion for right and left handedness). The mean age of the children in the Arnold and Askew study was 13.19 (age range of 6 to 23).

Hand Preference in Children with Autism

The majority of research points to an increased prevalence of left handedness (approximately 18%) in children with autism, (Bryson, Porac & Smith, cited in Bryson, 1990; Fein, Humes, Kaplan, Lucci, & Waterhouse, 1984), almost double that of the

normal population (approximately 9%). It has also been reported that individuals with autism have a much greater prevalence of mixed or ambiguous (inconsistency within tasks not ambidextrous) handedness (Fein et al., 1985, 30%; Soper at al., 1986, 36%; Tsai, 1983, 47%). However, many previous studies have ignored mixed-handers in their studies, and utilized a dichotomous classification. Hand preference percentages reported appear to be variable depending on the criterion used to classify a child as right or non-right handed. For example, both the Fein et al. (1985) and Tsai studies employed an extreme 100% criterion for classifying right and left handedness, while Soper et al. used a 90% criterion. Barry and James (1978) used a generous 60% criterion.

Tsai (1983), and Barry and James (1978) both found in their studies that children with autism who had a definite hand preference were chronologically older than the group who did not show a hand preference. Tsai also found that ambiguous handedness was more frequent in children with autism under the age of five years. Conversely, Fein, Waterhouse, Lucci, Pennington and Humes (1985) found that in their study group of 75 children with Pervasive Developmental Disorder, there was no relationship between ambiguous hand preference and age. The handedness distribution for their study was as follows: 13% were left handed, 36% were right, and 30% showed ambiguous handedness. Dawson (1988) suggested that the differences in handedness distribution in the Fein et al. study, compared to other reports may be due to the heterogeneity of their sample, which was not restricted to children with Autism, but covered the whole spectrum of PDD. The handedness measure used in the Fein et al. study was also limited; only 3 tasks were examined, two of which involved using a pen/pencil for either writing or drawing.

The increased proportion of non-right handedness in the autistic population is reported not to be due to an increase of sinistrality in their families (Boucher, 1977;

Boucher, Lewis & Collins, 1990; Fein, Waterhouse, Lucci, Pennington & Humes, 1985; Tsai, 1982). However, Bryson (1990) suggested that there is a proportion of children with autism whose left handedness appears to be genetic in origin, resulting from both familial left hand preference and a predisposition in the family for a variety of developmental disorders, such as mental retardation and language disorders.

Cerebral Lateralization in Autism

Bryson (1990) has suggested that handedness is an interesting area of research with individuals with autism, because it may be a biological marker for the disorder, and "is of particular interest because of its relationship to neuropathology and cerebral organization" (p. 443). Hauser, DeLong and Rosman (1975) cited the increase of left hand preference in individuals with autism as evidence of left hemisphere dysfunction. Hecean and Ajuriaguerra (cited in Fein et al., 1984) suggested that damage to the left hemisphere results in a switching of hand preference, to the left hand, because handedness is now controlled by the right hemisphere. Fein et al. (1984) argued that there is little evidence for left hemisphere dysfunction in autism per se, although it may exist on an individual basis. Instead they perceive the neurological impairments seen in individuals with autism to be more ubiquitous and diffuse than restricted to a particular hemisphere. It is generally accepted that an increased prevalence of left handedness in individuals with autism may be attributed to nonspecific early brain insult in at least a percentage of that clinical population (Fein et al., 1985).

It is still uncertain what relationship an increased prevalence of ambiguous handedness has to lateralization of cerebral dysfunction. Annett (1970) suggested that mixed or ambiguous handedness in children is a sign of developmental immaturity, since it is more characteristic of younger than older children. Hence, Fein et al. (1984)

suggested that ambiguous hand preference may represent a developmental lag. Satz, Soper and Orsini (1988) concurred, suggesting that ambiguous handedness may be indicative of an arrested state of development, at a very early stage, due to early brain insult.

Tsai (1983), and Soper, Satz, Orsini, McCallum and Henry (1984) (cited in Fein et al., 1985) proposed that the increased prevalence of ambiguous handedness in the autistic population is the result of bilateral brain damage. In normal subjects, it has been suggested that usually the left hemisphere of the brain processes language and stimuli that are related to language. Tsai theorized that individuals with autism who have not developed a hand preference have severe bilateral damage so that neither hemisphere becomes dominant. Those who develop lateralization to one hemisphere are thus less severely damaged, which he believes would account for the data showing that those with a hand preference usually have better cognitive and language skills. However, Bishop (1990) suggested that the increased prevalence of non-right handedness seen in individuals with autism may be a consequence of generally poor motor functioning, and not a direct consequence of brain damage. As a result, these individuals are unable to adequately perform the types of lateralized motor skills used to assess hand preference.

Kinsbourne (1987, 1988) put forward the hypothesis that the symptoms seen in autistic disorder may be a function of overarousal, and that the development of asymmetrical manual behaviour may be obstructed because of the overarousal. In extreme cases, he suggested that ambiguous handedness may result. Kinsbourne (1987) went on to suggest that in that individuals who experience the most hyperarousal are most likely to be those with an ambiguous pattern of hand preference, and would also exhibit more severe autistic symptoms. To date, however, there has been no research to evaluate this hypothesis.

It is openly acknowledged that hand preference is an indirect measure of cerebral lateralization (Leboyer, Osherson, Nosten & Roubertoux, 1988) and Dawson, Warrenburg and Fuller (1982) have stated that hand preference in children with autism is not a viable predictor of cerebral dominance. However, there are still questions to be answered in regards to hand preference in children with autism (i.e., "The question of whether handedness pattern is associated with level of impairment and/or locus of brain dysfunction in autism deserves further study", Dawson, 1988, p. 440).

Hand Preference and Other Abilities in Normally Developing Children, Children With Developmental Delays, and Children With Autism

Normally Developing Children

There have been several studies performed in the area of handedness in normally developing children that document the distribution of handedness patterns and the possible impact these preferences may have on intellectual and other abilities. Several researchers have found that right-handed subjects did not perform any better than left-handed subjects on ability and attainment tasks (e.g., Annett & Turner, 1974; Douglas, Ross & Cooper, 1967; Newcombe et al., 1975). However, Newcombe et al. reported that subjects who had an inconsistent hand preference scored slightly higher on IQ measures, while Berman (1971) reported deficits in IQs in this group. It is unclear how Newcombe et al. classified inconsistent performance, thus there is a possibility that they were referring to ambidexterity as opposed to ambiguousness. Calnan and Richardson (1976) reported that both left handers and ambiguous handers scored marginally but significantly below right handers on measures of achievement and general ability tests (eleven year olds).

Kaufman et al. (1978) compared children with and without a hand preference on

cognitive and motor abilities. They found that in the two-and-a-half to four-and-a-half year old group, there were significant differences between those who had developed a hand preference (either left or right) compared to those whose preference was inconsistent, on the cognitive and motor indexes of the McCarthy Scales (1972). Their results suggested that children who had developed a hand preference at a younger age were more intelligent and had developed better motor skills. In the older age group, comprising five to eight-and-a-half year olds, there were no significant differences between groups that had an established hand preference, compared to the no preference group on the basis of cognitive and motor indices.

In Annett's study (1970) of 219 children aged 3 years 6 months to 15 years, she found that consistent left handers had a superior vocabulary score compared to mixed and right handers. Children with mixed handedness tended to have lower vocabulary scores than those who showed a preference. She also reported that there tended to be a wider distribution of vocabulary scores within the mixed handedness group. When Annett separated out all children with an IQ below 70, more than half of this group consisted of children with mixed handedness. McManus et al. (1988) reported that degree and direction of handedness had no correlation with general intelligence or reading ability in normal children.

There are several recent reports in the literature concerning hand preference in normally developing children and the relationship to specific motor performance measures (i.e., the motor measure is not part of a battery, such as the McCarthy Scales (1972)). Gabbard, Hart and Gentry (1995a, 1995b) looked at both fine motor skills and gross motor skills. Their 1995b study looked at finger-tapping speed in a sample of 4 to 6 year olds. The handedness measure they used looked at three activities on two occasions, with a 71% criterion for designating hand preference. Equal numbers of right,

left and mixed handers matched for age and sex were compared (24 in each group). Results indicated that there were no differences in tapping speed between the three groups. Gabbard et al. (1995a) examined performance on the Bruininks-Oseretsky Test of Motor Proficiency (1978). Three groups of children (mean age 7.2) representing the three hand preference groups, as defined in their previous study, were compared. In terms of overall motor performance, the right handed group showed higher scores than both the mixed handedness and left handed groups, who were not significantly different from each other. Fine and gross motor skills were significantly higher for the right handed group compared to the left handed group. The mixed handedness group placed (insignificantly) in between the right and the left handedness groups. As the groups were matched for age and gender, age was not a factor in the results.

Children With Developmental Delays

Ross, Lipper and Auld (1987) reported that in their sample of 4 year olds, with IQs under 85, 19% were left handed, whereas, the normal comparison group had an prevalence of 11%. Lucas, Rosenstein and Bigler (1989) reported that non right handed children who were mentally retarded (both left and ambiguous handers) showed poorer language abilities than individuals with a right hand preference.

Unfortunately, the majority of the studies that have looked at hand preference and abilities in children with autism, failed to include a group of children with developmental delays for comparison (e.g., Colby & Parkinson, 1977; Fein et al., 1985; Gillberg, 1983; Soper et al., 1986; Tsai, 1983). Studies which have included children with developmental delay or children with learning disabilities are methodologically flawed: Barry and James (1978) used a subjective weighting system with their hand preference measure (after Colby & Parkinson, 1977). Items that were believed to have a higher demand on dexterity, as opposed to strength, were given more importance, and hence a

higher weighting value. The number of tasks observed for each child was also variable. Cornish and McManus (1996) supposedly matched their groups, although there were different numbers in each group, and the developmentally disabled group had a significantly lower score than the children with autism on the Merrill-Palmer Scale of Mental Tests.

Children with Autism

Few studies have examined the relationships among intellectual, language, motor abilities and hand preference in children with autism. Researchers who have studied cognitive ability in relation to the handedness patterns of individuals with autism, have found that those who show ambiguous handedness or lack of preference are often more intellectually impaired and have lower language abilities than those who have a specific hand preference (Fein et al., 1985; Soper et al., 1986; Tsai, 1982). Manjiviona and Prior (1995) studied children with Asperger's Syndrome and high-functioning children with autism and found a significant negative relationship for both groups between level of intelligence and motor impairment. Specifically, lower IQ scores were associated with more motor difficulties. However, they cautioned that this relationship appears to be complex, and some individuals evidenced the opposite relationship. Fein et al. (1985), in their study of children with Pervasive Developmental Disorder, found no relationship between motor measures and handedness groups. The motor measures used in the Fein et al. study, however, were not global and wide ranging, but confined to a peg-moving task, a measure of grip strength and a finger tapping task.

The results of these studies suggest that the relationships among motor functioning, intelligence, language ability, and hand preference in children with autism are still unclear due to the lack of studies in this area and the complex relationships that appear to be present. A thorough assessment of global motor skills would be

recommended to help clarify any possible relationship that may exist.

Appropriate Control Groups for Children with Autism

As Fein, Humes, Kaplan, Lucci, & Waterhouse, (1984) succinctly pointed out, control groups for comparison with autistic individuals are fraught with pitfalls, "There is no completely satisfactory solution to the problem of selecting a control group..." (p. 265). It is impossible to control for every variable at the same time (Hobson, 1991), hence, several groups are often utilized to assess the relative contributions that mental or chronological age may make. In order to research which deficits are specific to autism, separate from effects of mental retardation, studies have attempted to control for intellectual level by using matching comparison or control groups. Children with autism are usually matched to mentally retarded children on the basis of chronological age and some form of IQ measure (Hobson). In theory, this should also control for physical development and years of experience. Matching, however, has its difficulties. If matching on full scale IQ, the children with autism are likely to have higher functioning on some subscale abilities than the matched delayed children, who are likely to have a more flat cognitive profile. Verbal abilities are especially likely to be discrepant between the groups. Heterogeneity within the delayed group may also cloud any differences between the groups (Fein et al., 1984).

When including a normally developing control group, groups have been matched on the basis of mental age (MA) or chronological age (CA). A CA matched normal comparison group is often unsuitable, and rarely would provide any research information of value. MA matched normal comparison groups, however, can be advantageous in providing information on children developing normally, who are at the same developmental level as the autistic research group. The disadvantages to this group is

that IQ scores will be normal (average), and years of experience and physical development will be lower. However, if an MA and CA matched delayed group is also utilized, the disadvantages can be addressed through the delayed comparison group. Fein et al., (1984) provided a reminder to researchers to be careful to select and justify the control groups they use, and to draw only appropriate conclusions from the comparison groups.

Hand Preference in Children - Conclusions

The above review of the state of the literature in regards to hand preference in children indicates that there have been many studies, but a lack of firm conclusions is apparent, due to the severe methodological difficulties inherent in the field of hand preference classification. The methodological flaws have begun to be addressed in the last ten years or so, with the result that tentative conclusions can be drawn in certain areas. For example, it is now firmly established that there is an increased prevalence of left handedness in children with autism, and between 30 and 40% of individuals with autism do not develop a consistent hand preference. Research with adults with cognitive delays, and deaf children with severe learning difficulties indicate that ambiguous handedness is not restricted to the autistic population (Morris & Romski, 1993; Soper, Satz, Orsini, Van Gorp & Green, 1987). There are still no firm conclusions regarding the prevalence of ambiguous hand preference in children with developmental delays, as there has been a lack of consistency of handedness classification and in matching appropriately for cognitive level. Methodologically sound research is needed to clarify hand preference prevalence in delayed children who are of comparable chronological and mental age to the children with autism.

Several studies have utilized normally developing children of the same age as the

children with autism. Research is needed that looks at normally developing children at the same developmental level as the autism and delayed groups, to investigate whether the patterns of hand preference and skills can be attributed to a developmental lag, as suggested in the literature.

The above review suggests that there is an association between ambiguous handedness in children with autism and lower levels of cognitive and motor functioning. Also, it has been hypothesized by Kinsbourne (1987) that severity of autism may be linked to ambiguous handedness. There has been no research that has looked at severity of autistic characteristics in relation to hand preference groups. Severity of autism in relation to hand preference groups, and to other skills will be addressed in this study.

The current investigation was designed to look at hand preferences in three groups of children, using the measure of hand preference (Hand Preference Demonstration Test or HPDT) developed by Soper et al. (1986), which has already been used in several published studies. Comparisons could be directly made to Soper et al.'s results as the same classification system was used. The HPDT also gave a measure of degree of hand preference, and the amount of consistency across as well as between tasks, which allowed comparison of the results of the present study with previous research. The HPDT had a great advantage in that it was easy to use even with very young children. This study addressed past criticisms of research in this area by using the HPDT. As there has been no systematic exploration of language and motor skills in reference to hand preference with the three groups in question, performance on measures of language and motor skills were also included,

Previous research has often used groups that are disparate in their age ranges. Further, previous studies have usually looked at older groups of children, despite the fact that it is now widely accepted that an established hand preference is apparent in normally

developing children as young as two years old. The participants in this study were more limited in age range than those used in previous studies, in order to reduce the possibility of results being affected by age difference within a group.

It was considered necessary to have a comparison group of delayed children who had no identifiable genetic history or pathology. Children with specific disorders, such as cerebral palsy, identifiable syndromes (e.g., Down Syndrome), and Attention Deficit Disorder were excluded because of the motor difficulties that are often apparent in these children which are a result of the disorder.

Few measures are available that can be used with children with autism. Motor skills measures, in particular, have many items in their inventories where an autistic child would be at a disadvantage because of the nature of their deficits, for example when there are long and wordy instructions, or lots of imitation items. Hence, there is the question of whether the measure is actually measuring ability per se, or the child's ability to follow the instructions. The Battelle Development Inventory - motor domain (BDI; Newborg, Stock, Wnek, Guidubaldi & Svinicki, 1984) was chosen for this study because it involved both a fine and gross motor component, fit the age range of the children in the study, and could be administered with little difficulty to all three groups of children. As this measure had not been reported to have been used with an autistic population before, a questionnaire was completed by parents regarding their child's motor skills. This allowed a comparison to be made between the two measures and provided some assurance that the BDI - motor domain was a valid measure of motor skills for children with autism.

Additional experimental questions, other than the main hypotheses, became apparent when reviewing the literature. Tsai (1987) reported in his review, that pregnancy, birth and newborn complications appear to occur more frequently in children

with autism than in comparison control groups. Therefore, it was decided to examine pregnancy and birth history in all three groups of children by use of a parental report questionnaire. Familial prevalence of left handedness was also examined in order to investigate increases of left handedness in families of autistic and delayed children.

Hypotheses

Five specific hypotheses were tested in this study, in addition to comparison across groups on variables mentioned in the above section. It was hypothesized that:

1. A greater percentage of children with autism would show ambiguous patterns of preference than the matched delayed and normal controls.
2. Children with autism and delayed children would show the same amount of left handedness.
3. Both children with autism and delayed children would show greater amounts of left handedness than the normal comparison group.
4. Children with autism who have a definite hand preference (left or right) would show higher levels of functioning on receptive verbal ability, the intelligence measure, and would show better developed motor skills than children with autism who have no hand preference (ambiguous hand preference).
5. Children with a more severe rating of autism would have a higher percentage of ambiguous handedness and have more impaired receptive verbal skills, intelligence and less developed motor skills than children with a lesser rating of autistic characteristics.

Although specific hypotheses about pregnancy and birth complications, and familial patterns of handedness were not officially formulated, group differences between the children with autism, children with developmental delays, and normally developing children were examined. Differences in ability levels in children with developmental delays and normally developing children according to hand preference classification

were also evaluated for comparison with the autism group. Degree and consistency of hand preference was also compared for group differences.

METHOD

Participants

Children with autism were recruited through The Society for Treatment of Autism and the Autism Calgary Association. A presentation was made to the parents where possible, for example, at support or monthly meetings, explaining the study and its purpose. Interested parents were given a handout containing a letter explaining what the study would entail (see Appendix A), and two consent forms (see Appendix B). Children that were graduates of the Early Intervention Program at the Society for the Treatment of Autism were sent the package through the mail by Society for the Treatment of Autism staff (see Appendices C & D). Children that were currently in the Early Intervention Program took the introductory letter home in their schoolbags, and returned consent forms were collected by a member of staff. Appendices E and F show the introductory letters and consent forms sent home to the children currently in the Early Intervention Program.

All children with autism that were included in the study fulfilled the diagnostic criteria for Autistic Disorder as outlined in the Diagnostic and Statistical Manual of Mental Disorders - fourth edition (DSM-IV; American Psychiatric Association, 1994). Diagnosis was also confirmed by a chartered psychologist. Seven children who had a diagnosis of Pervasive Developmental Disorder - Not Otherwise Specified were rejected as participants. Twenty children with autism, between the ages of 2 years and 10 months, and 7 years, 0 months (average age of 4 years, 10 months), were included in the study. Eighteen of the participants were male, and two female. Two autistic children were not

included because of their age, and difficulty in matching them to children with developmental delays of the same level of cognitive ability; one child was 6 years 10 months, the other was 8 years and 10 months and both were functioning at the 2 year old level cognitively. Of the twenty children with autism included in the study, twelve were attending the Early Intervention Program at the Society for the Treatment of Autism, and the other eight were recruited through the Autism Calgary Association.

Twenty children with nonspecific developmental delays (i.e., no known genetic or chromosomal anomalies) were matched by chronological and mental age equivalence to the children with autism. These children were recruited from Providence Children's Centre, and through the Alberta Children's Hospital (Preschool Treatment Services and the Developmental Clinic). Staff at the Providence Children's Centre identified possible participants, and sent their own introductory letter to parents, asking them to return a slip of paper if they were interested in finding out more about the study. The slips were collected and given to the researcher, who then telephoned the parents to give them more information about the study. If the child was appropriate for the study, and parents were interested in their child participating, an introductory letter and the consent forms were sent home with the child in their schoolbag (see Appendices G & H).

For children that had been seen through the Alberta Children's Hospital staff identified children who were thought to be appropriate for the criteria given. A research assistant telephoned parents on the list, gave basic information about the study, and asked if they were interested in being contacted by the researcher. Parents who agreed were telephoned by the researcher, and the information package was sent to those who agreed

to participate in the study (see Appendices I & J). Appointments were made to test the children once the packages had been received and read by the parents.

The average age of the children with developmental delays was 4 years, 9 months (age range of 2 years and 9 months to 6 years and 10 months old). Gender composition of the group was 16 males and 4 females. Six additional children with developmental delays were recruited, but not included in the study, because their level of cognitive ability did not match that of the children with autism. Of the twenty children with developmental delays, eleven were recruited through Providence Children's Centre, eight were recruited through the Alberta Children's hospital, and one child was a sibling of a child with autism.

Twenty normally developing children were matched to the children with autism using mental age equivalence, based on performance on the Bayley Scales of Infant Development - Mental Development Index (Bayley, 1993) or the Stanford-Binet Intelligence Scale: Fourth Edition (SB:FE; Thorndike, Hagen & Sattler, 1986). They were recruited through Providence Children's Centre, the University of Calgary Child Care Centre, friends, and acquaintances. The same procedure was followed at the Providence Children's Centre for the normally developing children as it was for the delayed children (see Appendices K & L). The University Child Care Centre sent an introductory letter and consent forms home with children (see Appendices M & N) on behalf of the researcher. Friends who knew of parents with young children (and were willing) were asked to contact the parents by telephone to gain permission for the researcher to contact them. Once they had agreed, the researcher contacted the parents to

explain the study, and what participation would involve. Appointments to test the children were set up, and the consent forms (see Appendix O) were signed by the parent before testing began.

The average age of the normally developing children was 2 years, 8 months (age range of 2 years, 0 months to 5 years, 9 months of age). Fourteen of the children were females and six were males. Seven additional children were tested, but not included in the study as they did not meet the matching criteria. Of the twenty normally developing children included in the study, six were recruited through the University Child Care Centre, five were attending Providence Children's Centre, and the remaining nine were recruited through friends and acquaintances who were aware of the research study.

There was a significant difference between the three groups according to gender with χ^2 (2, $\underline{N}$ = 60) = 19.09, $\underline{p} < .0001$. Due to the fact that autism affects three to four times as many males as females, a gender difference for that group relative to the other two groups was expected; however, the 2.5 to one ratio of females to males in the normally developing group was unexpected. The ratio of males to female in the subject groups approached to participate in the study is unknown due to the requirement of confidentiality before agreement to participate was conferred. Gender effects were not explored in the analyses, due to a lack of power because of the small number of females in the autism and delayed groups, and small number of males in the normal comparison group.

The average mental age equivalent score for the groups were: children with autism 27.45 months, children with developmental delays 34.48 months, and 33.53

months for the normally developing children. A comparison between the groups using a one-way ANOVA indicated no differences between the groups for mental age equivalence, $F(2,56) = 2.23$, $p = 0.12$. A one-way ANOVA was also used to compare the ages of each group. Results indicated that there was a significant age difference between the groups, $F(2,57) = 29.15$, $p < 0.001$. Follow-up tests using Tukey's HSD with a significance level of 0.05 showed that the normally developing children were significantly younger than the children with autism and the children with developmental delays. No significant age differences were found between the children with autism, and the children with developmental delays. Hence the groups were matched as required: the three groups had similar mental ages and the children with developmental delays were the same chronological age as the children with autism.

Measures

It should be noted that in this study, scores of measures of ability (verbal, cognitive and motor) were expressed as age equivalents. These were used because there were no standard scores available for most of the children with autism, and children with developmental delays on cognitive measures, because they were functioning below age norms and outside the range of the test, i.e., the Bayley Scales of Infant Development - mental development index only has norms up to 36 months of age. Standard scores were also unavailable for many of the PPVT-R scores, as the children were functioning far below age norms provided for that test.

Each child was given a battery of test items and was also observed. The measures that were utilized were:

The Hand Preference Demonstration Test (HPDT; Soper et al., 1986) (see Appendix P) which was developed for its ease of use with special needs children, was given to all children. It is an 8 item test that assesses preferred hand usage over a wide range of activities. The items are: 1) eating with a spoon, 2) drinking from a cup, 3) brushing teeth, 4) drawing with a crayon, pen or pencil, 5) throwing a ball, 6) hammering the table with a plastic hammer, 7) picking up a small object, such as a raisin and 8) picking up a dime. Each item was given 3 times in two separate sessions, in quasi-random order to prevent perseveration on the task. Responses were recorded as left, right, bimanual or no response. A total of 48 responses were recorded for each child.

A Laterality Index (LI) was calculated based on the proportion of right hand responses to total unimanual responses (right plus left) times 48. Therefore, a range of scores from 0 to 48 was possible, with 0 representing consistent left hand preference, and 48 indicating consistent right hand responding. A 90% criterion was then used to separate groups into left, right and mixed preferences, so that an LI of 43 or more would classify a child as being right handed, an LI of 5 or less would classify a child as left handed, and a mixed hand preference classification would result for children with a LI score of between 6 and 42 inclusive.

Consistency of hand preference for the eight tasks was also noted. A task was scored as consistent if the child used the same hand preference (right, left or both hands) for all the six responses recorded for that task. Thus, the possible consistency scores

ranged from zero to eight (for eight tasks all consistent). A score of eight did not necessarily indicate extreme right or left hand preference, for example, it would be possible to use the right hand consistently for three tasks, the left hand on three tasks, and use both hands on two tasks, and obtain a score of eight for consistency of hand preference (this particular example would exhibit ambidextrous handedness, as preference is consistent within but not across tasks).

The LI was transposed to give a score that reflected strength of hand preference that was easier to interpret. Scores from the LI were taken, and a value of one for strength of hand preference was assigned for scores on the LI of 24 and 25. Values on the strength of hand preference scale increased as LI scores went up to 48 (i.e., extreme right handedness), therefore, a score of 48 on the LI corresponds to a score of 24 on the strength of hand preference scale. Strength of hand preference scores also increased as LI scores went down (i.e., extreme left handedness), therefore, a score of 0 on the LI corresponds to 24 on the strength of hand preference scale. This, in effect, combined extremes of handedness, so that a score of 1 on the strength of hand preference scale indicated very inconsistent responses, and a score of 24 indicates 100% of responses made unimanually with the left or the right hand. Therefore, as the score increased in value, the child demonstrated more consistent preference for using one hand over the other.

Hand Preference Questionnaire (family), was adapted from the Montreal Neurological Institute's scale for handedness. Biological parents were asked to indicate their hand preference for the same activities that are used in the HPDT (see Appendix Q).

Preference was indicated by circling the appropriate answer on a scale of doing a task: always left, usually left, either hand, usually right, and always right. A score of one was obtained for answers of always left, two for usually left, three for either hand, four for usually right, and 5 for always right. The range of possible total scores was from 8 (all answers always left hand) to 40 (always use right hand). The total score was used as a measure of degree of hand preference for the parents.

Questions were also included to obtain data on the number of siblings who were left handed, and if there were any known left-handed biological relatives (relationship to child was stated) to attain an index of left handedness in the family.

The Bayley Scales of Infant Development - Second Edition (Mental Development Index) (MDI; Bayley, 1993) or the Stanford-Binet Intelligence Scale: Fourth Edition (SB:FE; Thorndike, Hagen & Sattler, 1986) were given to all children. The test that was given depended on the level of ability evidenced on the PPVT-R (Dunn & Dunn, 1981). Children who obtained an age equivalent score above the 36 month level on the PPVT-R were given the SB:FE, while those who obtained age equivalent scores below 36 months were given the Bayley MDI. The Bayley MDI has a reported coefficient alpha of 0.88 on average across age groups. The test-retest reliability reported in the manual was 0.87, and the concurrent validity was reported to be good, with a correlation of 0.73 between the Mental Development Index of the Bayley and the WPSSI-R Full Scale IQ for a sample of children between 36 and 42 months of age. Sattler (1992) reported excellent reliability for the composite score of the SB:FE, ranging from .95 to .99 depending on the age group. A stability coefficient for a 5 year old age group was reported by Sattler to be

.91. Concurrent validity scores varied by group and by test. A correlation of .88 with the WISC-R was reported for a special education group of children (Hollinger & Baldwin, as cited in Sattler, 1992).

The Peabody Picture Vocabulary Test - Revised (PPVT-R; Dunn & Dunn, 1981) or The Preschool Language Scale - 3 (PLS-3; Zimmerman, Steiner & Pond, 1992) was given to all the children. The PPVT-R, a measure of receptive vocabulary, is untimed and requires no reading ability. Hobson and Lee (1989) and Tager-Flusberg (1985) suggested that the PPVT-R is a valid measure of the single-word receptive vocabulary in individuals with autism. The manual for the PPVT-R reported that split-half reliability ranged from 0.61 at age two years-six months, to 0.88 at age 18. Sattler (1992) stated that the PPVT-R has established concurrent validity as a measure of cognitive ability, although it should never be substituted as an IQ measure. The PLS-3 was given to children who had not yet developed the ability to point to pictures. The Auditory-Comprehension subtest provided the required information regarding receptive language skills. The manual for the PLS-3 reported that the internal consistency of the Auditory-Comprehension (A-C) scale ranged from .47 to .88 depending on age group. Inter-rater reliability for the A-C scale was reported as .98. Correlation with the Clinical Evaluation of Language Fundamentals - Revised (CELF-R) (Semel, Wiig & Secord, 1987) for the A-C scale was .69.

The Battelle Development Inventory - motor domain (BDI; Newborg, Stock, Wnek, Guidubaldi & Svinicki, 1984) was administered to all of the children in the three groups. The motor scale measures fine and gross motor skills for children in the age

range of 0 up to, and including 8 years. The test-retest reliability for the motor domain total, as reported in the manual, ranged from .88 to .99, depending on age group. Criterion-related validity is not reported in the manual where the motor domain is compared to another established motor test. However, the BDI and its component scales have been compared to tests such as the Vineland Social Maturity Scale (Doll, 1965), and the Developmental Activities Screening Inventory (DASI; DuBose & Langley, 1977), with good resulting correlations (fine motor component correlated .88 with the Vineland, .92 with the DASI ; gross motor component correlated .90 with the Vineland, and .92 with the DASI). Adaptations for testing children with severe motor, visual and hearing impairments are given in the instruction manual. Zittel (1994) in her critique of motor assessment instruments for use with preschool children with special needs rated the BDI as having strong technical adequacy, being easy to administer and having strong ecological validity.

Fine and Gross Motor Questionnaire was compiled from elements of the Vineland Adaptive Behavior Scales (Sparrow, Balla, and Cicchetti, 1984), the Brigance Diagnostic Inventory of Early Development (Brigance IED; Brigance, 1978), the Movement ABC checklist (Henderson & Sugden, 1992), and the AEPS (Bricker, 1993) (See Appendix R). It was given to parents to complete regarding the motor skills of their child. The results of this questionnaire were compared to the results from the BDI motor scale in order to look at the validity of the BDI with the populations used in this study.

The Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Renner, 1986) was used with the children with autism. This scale was completed by their

teacher, therapist, or parent (where therapists or teachers were not available) to provide a severity rating of autistic behaviours in 15 different areas on a four point scale, which ranged from age-appropriate behaviour to severely abnormal behaviour. An overall classification results, which ranges from normal to severe. Scores from 15 to 29.5 classify a child into the non-Autistic range, from 30 to 36.5 the child would be placed in the Mildly-Moderately Autistic category, and 37 and above constitutes a rating of Severely Autistic. Reliability of the scale reported in the manual suggested that the test-retest reliability of the CARS was good (.88) for diagnostic assessments occurring one year apart, while interrater reliability was quoted as 0.71. The manual also reported a high correlation of the CARS scores with criterion clinical ratings (.84) of the same children in a diagnostic session.

Pregnancy and Birth Complications Questionnaire, part of the Anser System Parent Questionnaire, Form 2P (Levine, 1980) was given to all parents for completion regarding their child (see Appendix R). The questions focus on abnormalities and problems that may have occurred during the pregnancy and delivery of the child, and any problems in the newborn after birth. There is no reliability or validity data available on this questionnaire, but the questionnaire has been used for assessing children with learning and motor difficulties (e.g. Dewey, 1990).

Sociodemographic Questionnaire. A general questionnaire eliciting demographic information, such as father's and mother's age, education level and current occupation was also completed by a parent (see Appendix S).

Procedure

Once written consent had been obtained for each child's participation in the study, arrangements were made to test the child. Children that were in a program during the day, for example, at Providence Children's Centre, or at The Society for Treatment of Autism, were tested at their program site, in a separate classroom, or a room designated for the purposes of testing where there were few distractions. The rest of the children were tested in their homes. Testing was done in two sessions. The first session included the motor skills testing, language testing, and the first half of the HPDT. This was done so that the child could become comfortable with the researcher by doing the more fun, and less structured activities. The second session included the cognitive testing, and the second half of the HPDT. Where there were recent cognitive and verbal ability testing results available through the child's program (within one year), these results were obtained from their file.

Parents were sent the questionnaires to complete and return either in the child's schoolbag if they attended a program, or were given the questionnaires in person when testing occurred at home. The return rate for the questionnaires was over 91%. Questionnaire data was missing for four of the children with developmental delays (two children from the same family), and for one child from the normally developing group. Data was also missing from some questionnaires, especially when a child was being fostered, or had been adopted. As a result, family history and birth details were often unknown.

RESULTS

Family Background

The means for the ages of the biological parents, the number of siblings and family socioeconomic status (SES) are presented in Table 1. Family socioeconomic status was determined from the parents' occupations using the Blishen index of Canadian occupations (Blishen, Carroll, & Moore, 1987). This index considers the income, education, and job prestige for each listed occupation. For each family, the Blishen index corresponding to the highest of the rated occupations of the parents was determined. The index value for each family was then converted into one of six class values suggested by Blishen and McRoberts (1976). This class value was used in the analyses involving SES.

Analyses of variance (ANOVA) indicated that there were no group differences on the following measures: Father's age F (2,43) = 1.32, $p > .05$; Mother's age F (2,46) = 1.63, $p > .05$; number of siblings F (2,52) = .55, $p > .05$. The ANOVA for SES indicated that there was a significant difference between the groups ($F(2,50) = 4.41$, $p < .05$. Follow-up analyses utilizing the Tukey-HSD test, indicated that there was a significant difference in SES between the children with developmental delays' families and the normally developing children's families. Correlations performed between SES and the dependent variables used in the following analyses (i.e., receptive verbal ability, cognitive ability, fine and gross motor scores, handedness consistency, and strength of hand preference) indicated that SES was not highly correlated with the measures of interest, (see Table 2). Therefore, SES level was not used as a covariate in the analyses.

Table 1

Family Background

	Group					
	Autistic		Developmentally delayed		Normally developing	
Participant Variables	M	SD	M	SD	M	SD
Father's age	38.06 (18)	4.87	36.36 (11)	4.61	39.42 (17)	3.74
Mother's age	34.74 (19)	4.62	33.15 (13)	5.52	36.35 (17)	4.50
Number of siblings	1.60 (20)	1.57	1.19 (16)	.98	1.32 (19)	.95
SES	3.95 (20)	1.61	3.43 (14)	1.09	4.79 (19)	1.18

Table 2

Correlations Between SES and the Dependent Variables (Measurement Scores)

	Receptive verbal ability	Cognitive	Fine motor	Gross motor	Hand preference consistency	Strength of hand preference
SES	.068	-.015	-.164	-.208	-.328*	-.226

*$p < .05$.

Marital status of both biological parents, and parental education level were compared across the three groups using chi-square analyses. No significant differences were found for any of the four variables in question: mother's marital status, χ^2 (8, $\underline{N}$ = 53) = 7.39, $\underline{p} > .05$; mother's education level χ^2 (8, $\underline{N}$ =53) = 9.32, $\underline{p} > .05$; father's marital status χ^2 (6, $\underline{N}$ = 50) = 6.75, $\underline{p} > .05$; and father's education level χ^2 (8, $\underline{N}$ = 49) = 12.41, $\underline{p} > .05$.

A comparison of children in the family (other than the identified child participant) who had been diagnosed with a disorder such as a chronic illness, language disorder, learning disability, developmental problem or attention problems was made across groups using a chi-square analysis, χ^2 (2, $\underline{N}$ = 55) = 1.99, $\underline{p} > .05$. Results revealed no significant group differences.

Comparison of Fine and Gross Motor Questionnaire and BDI - Motor Domain

There are no previous reports of the BDI - motor domain being used with children with autism. In order to check the validity of this measure for use with children with autism, scores from the BDI- motor domain were compared to the scores obtained from the Fine and Gross Motor Questionnaire. Correlations between the fine and gross motor scores on the BDI- motor domain and the Fine and Gross Motor Questionnaire are presented in Table 3. Significant correlations were found between all of the variables. Correlations were also performed for each group of participants separately. All

Table 3

Correlations Between BDI - Motor Domain Scores, and Fine and Gross Motor Questionnaire Scores (All Groups)

	Questionnaire (n = 55)	
	Fine motor	Gross motor
BDI		
Fine motor	.83***	.53***
Gross motor	.75***	.57***

***$p < .001$.

correlations were significant at either the .05 or .01 level, as reported in Tables 4, 5 and 6 (except for in the normally developing group where BDI fine motor score and gross motor parent report scores are not significantly correlated. However, this relationship is not of direct relevance and the fine motor scores are correlated). The above correlations suggest that the BDI - motor domain is an appropriate measure to use with this population of children, as well as children with developmental delays and normally developing children.

Comparison of Handedness, Verbal Ability and Motor Skills Across Groups

Table 7 presents the groups means and standard deviations for verbal ability, motor scores, strength of hand preference and handedness consistency score. Pearson product-moment correlations were used to assess relationships between the variables. All correlations were significant at the .05 level (see Table 8), therefore, a MANOVA was performed with receptive verbal ability, fine and gross motor scores, strength of hand preference and hand consistency. The main effect of Group was significant (Wilks Lambda $\underline{F}$ (2,25) = 5.57, $\underline{p} < .001$) (see Table 9). The follow-up univariate ANOVA indicated significant group differences for the receptive verbal ability score with $\underline{F}$ (2,57) = 7.62, $\underline{p} = .001$. Post-hoc comparisons revealed that the children with autism had significantly lower receptive verbal ability scores than both the delayed and normally developing children. The receptive verbal ability levels of the children with developmental delays and normally developing children were not found to be statistically

Table 4

Correlations Between BDI - Motor Domain Scores and Fine and Gross Motor Questionnaire Scores for the Children with Autism

	Questionnaire (n = 20)	
	Fine motor	Gross motor
BDI		
Fine motor	.77***	.54*
Gross motor	.85**	.55*

*p < .05. **p < .01. ***p < .001.

Table 5

Correlations Between BDI - Motor Domain Scores and Fine and Gross Motor Questionnaire Scores for the Children With Developmental Delays

	Questionnaire (n = 16)	
	Fine motor	Gross motor
BDI		
Fine motor	.90***	.54*
Gross motor	.73**	.54*

*p < .05. **p < .01. ***p < .001.

Table 6

Correlations Between BDI - Motor Domain Scores, and Fine and Gross Motor Questionnaire Scores for the Normally Developing Children

	Questionnaire (n = 19)	
	Fine motor	Gross motor
BDI		
Fine motor	.85***	.44
Gross motor	.82***	.57*

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 7

Group Means for the Performance and Hand Preference Measures

	Group					
	Autistic		Developmentally delayed		Normally developing	
Dependent measures	M	SD	M	SD	M	SD
Receptive verbal ability	25.10	10.25	35.05	9.44	36.90	11.09
Fine motor	37.28	12.68	42.70	9.13	33.58	9.89
Gross motor	41.18	14.59	47.55	14.05	33.83	12.03
Hand consistency	4.15	2.54	5.60	1.39	4.20	2.24
Strength of hand preference	15.55	6.43	20.15	5.22	15.85	6.29

Table 8

Correlations Between Performance and Hand Preference Measures

	Receptive verbal ability	Gross motor	Hand consistency	Strength of hand preference
Gross motor	.59***			
Hand consistency	.29*	.37**		
Strength of hand preference	.32*	.34**	.84***	
Fine motor	.64***	.85***	.33*	.36**

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 9

MANOVA for the Performance and Hand Preference Measures

Source	Mult. F[a]	Dependent Variable	Univ. F[b]
Group	5.57***	Receptive verbal ability	7.62**
		Fine motor	3.70+
		Gross motor	5.10**
		Hand consistency	3.03
		Strength of hand preference	3.68+

[a] For the multivariate ANOVA, df = 2,25. [b] For the univariate ANOVAs, df = 2,57. **$p < .01$. ***$p < .001$. +$p < .05$ is not considered significant when the Bonferroni correction is applied to the univariate Fs.

different from each other. The follow-up univariate F for fine motor skills (F (2,57) = 3.70, p = .031) was not considered significant when a Bonferroni correction was applied (.05/5 = .01), however, the trend was examined further for interest. A univariate F revealed significant group differences for gross motor skills F (2,57) = 5.10, p = .009. Tukey-HSD post-hoc comparisons revealed that the children with developmental delays had significantly higher fine motor and gross motor scores than the normally developing children. The fine and gross motor scores of the children with autism did not differ from the delayed children, or the normal comparison children.

Hand Preference Categorization

A child was classified as being right handed if their laterality index (LI) was 43 or greater, left handed if their LI was 5 or less, and ambiguously handed if their LI was from 6 to 42 inclusive. In order to examine the categorization of the laterality scores into right, left and ambiguous handedness by groups, a chi-square analyses was performed. Results indicated that the groups were significantly different in their hand preference categorizations (χ^2 (4, N = 60) = 11.39, p < .05) (see Table 10). For the children with autism, 35% showed a right hand preference, 0% left preference, and 65% showed an ambiguous hand preference (i.e., mixed between and across tasks). In the children with developmental delays, 70% were classified as right handed, 10% were left handed, and 20% were ambiguous, while among the normally developing children 45% were right handed, 0% were left handed, and 55% were classified as having an ambiguous hand preference. Follow-up chi-squares were performed to investigate the direction of the

Table 10

Frequency of Hand Preference Categorization by Group

Group	Hand preference category		
	Left	Ambiguous	Right
Autistic	0	13	7
Developmentally delayed	2	4	14
Normally developing	0	11	9

group differences. Results indicate that the children with autism had significantly different hand preferences from the children with developmental delays (χ^2 (2, N = 40) = 9.10, p <.05), as did the normally developing children (χ^2 (2, N = 40) = 6.35, p < .05). However, the children with autism and the normally developing children did not display a significant difference in their hand preference classifications (χ^2 (2, N = 40) = .52, p > .05).

Age in Relation to Hand Preference Classification

Independent samples t-tests were performed for each group, comparing the ages of those classified as having a definite hand preference (right or left) to those children who were classified as not having developed a definite hand preference. No significant differences were revealed for any of the three groups (see Table 11 for means and t-test results). Hence, within each group, children with a definite hand preference were not chronologically older than those classified as having an ambiguous preference.

Strength and Consistency of Hand Preference

The follow-up univariate F test showed a trend towards significant group differences for consistency of handedness (F (2,57) = 3.03, p = .056). A significant group difference for strength of hand preference (F (2,57) = 3.68, p = .032) was found, however, when a Bonferroni correction was applied, this result became non-significant (see Table 9). Given the interest in these trends, these differences were explored further. Figures 1, 2 and 3 show the distribution of laterality indexes for each group. Follow-up tests for strength of hand preference indicated a significant difference between the

Table 11

Comparison of Mean Ages by Hand Preference

Group	M	SD	n	df	t
Autistic					
Left/Right	62.57	16.39	7	18	1.12
Ambiguous	55.69	11.01	13		
Developmentally delayed					
Left/Right	56.88	11.84	16	18	-.32
Ambiguous	59.25	18.26	4		
Normally developing					
Left/Right	36.11	14.43	9	18	1.55
Ambiguous	29.09	3.96	11		

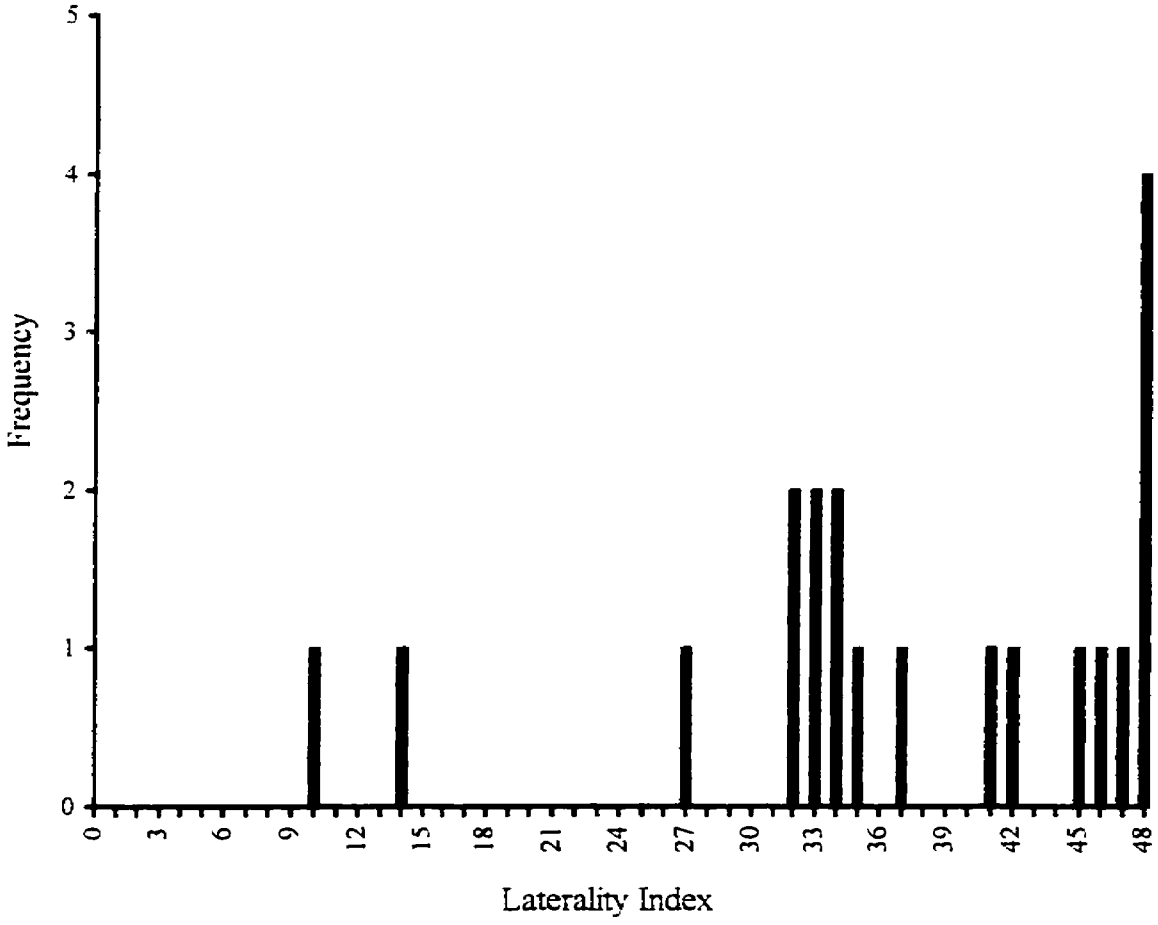


Figure 1. Distribution of laterality indices for children with autism

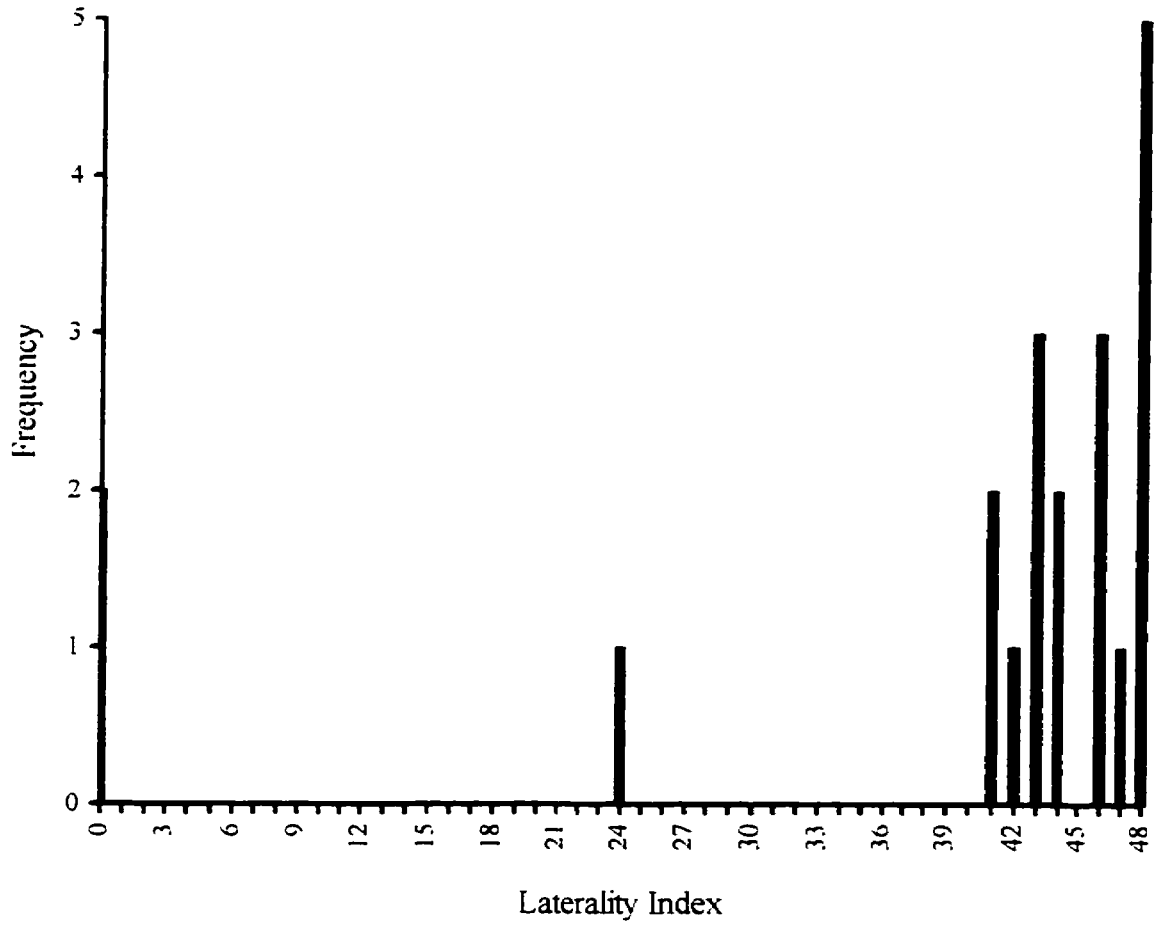


Figure 2. Distribution of laterality indices for children with developmental delays.

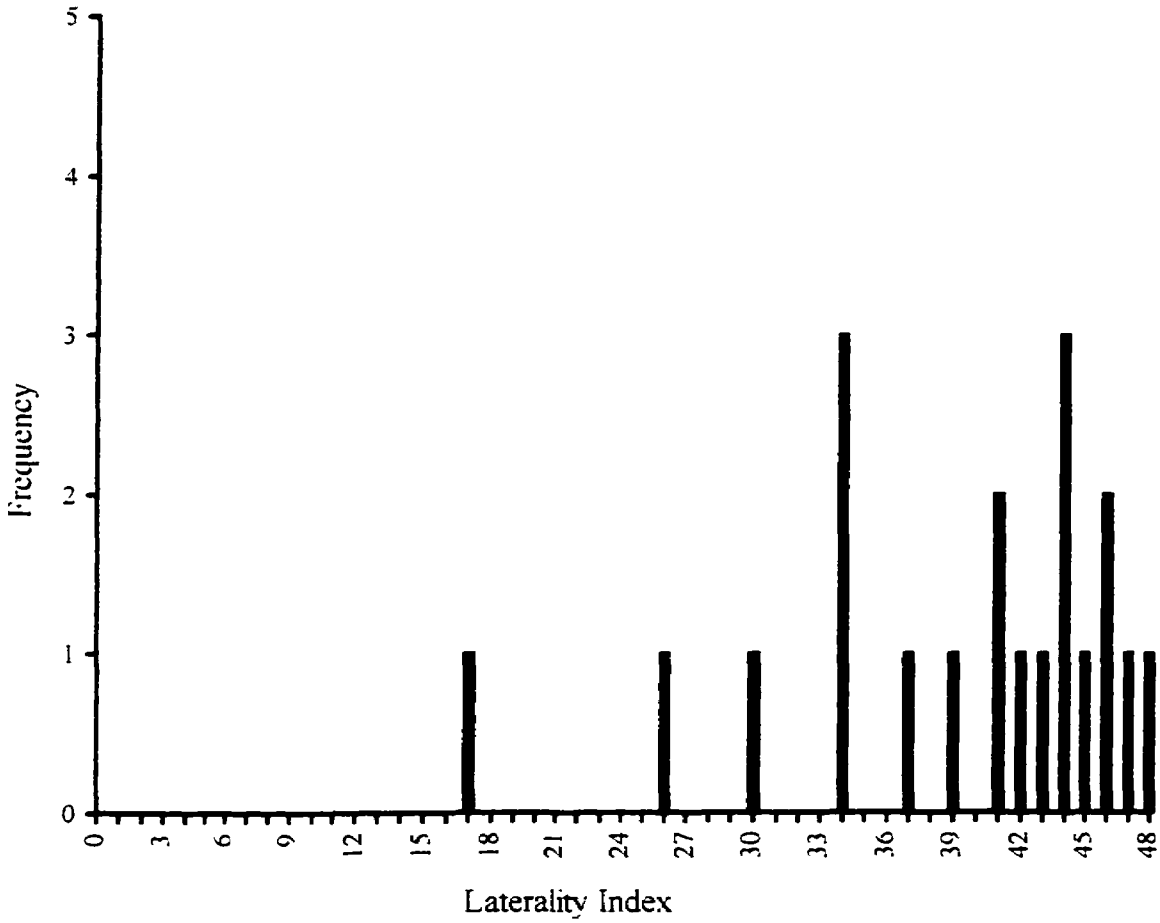


Figure 3. Distribution of laterality indices for normally developing children.

strength of hand preference scores of the children with autism and the children with developmental delays. The children with a developmental delay displayed a trend toward a more established hand preference than the children with autism. No differences were found in consistency of hand preference across the groups.

Inconsistency Within Hand Preference Categories

Soper et al. (1986) looked at the frequency of tasks where hand preference was not consistent to demonstrate that individuals in the ambiguous handedness group were inconsistent across and within tasks, and were therefore not ambidextrous. Frequency of hand preference consistency within items was tabulated for the present study. The results, which are presented in Table 12, show the number of participants within each hand preference category and group who were inconsistent on more than two of the eight tasks of the Hand Preference Demonstration Test (HPDT). Response inconsistency within items is clearly related to ambiguous handedness. There were no participants that were ambidextrous, i.e., fluctuating handedness between items, but not variable preference within items.

Bimanual Responses

Bimanual responses are not taken into consideration on the LI generated by the HPDT, but during the testing it was apparent that some of the responses fell into that category. Examination of the data indicated that 7.7% of the total number of hand preference responses were made bimanually. Of that 7.7%, 42% were shown by the normally developing children, 30% by the children with developmental delays, and 28% by the children with autism. Table 13 shows the breakdown of bimanual responses by

Table 12

Frequency of Hand Preference Inconsistencies on More Than Two Activities for the Hand Preference Demonstration Test

Group	Hand preference category		
	Left	Ambiguous	Right
Autistic		12/13 (92%)	0/7 (0%)
Developmentally delayed	0/2 (0%)	4/4 (100%)	5/14 (36%)
Normally developing		11/11 (100%)	3/9 (33%)
Overall	0/2 (0%)	27/28 (96%)	8/30 (27%)

Table 13

Frequency of Bimanual Responses by Hand Preference Task

Tasks	Group			Total number of bimanual responses
	Autistic	Developmentally delayed	Normally developing	
cup	46 (74.2%)	41 (62.1%)	79 (84.9%)	166 (75.1%)
ball	14 (22.6%)	23 (34.8%)	9 (9.7%)	46 (20.8%)
hammer	0	0	1 (1.1%)	1 (0.5%)
raisin	0	1 (1.5%)	0	1 (0.5%)
dime	2 (3.2%)	1 (1.5%)	4 (4.3%)	7 (3.2%)

tasks for each group. The task that elicited the vast majority of bimanual responses was drinking from a cup (75.1% of the 221 bimanual responses), the second most frequent being throwing a ball (20.8% of bimanual responses).

Hand Preference Classification and Relationship to Pregnancy and Newborn Problems

Independent-samples t-tests were performed for each group for total number of pregnancy and birth problems (see Table 14), and total newborn problems (see Table 15), comparing children with a left or right hand preference, to those classified with an ambiguous hand preference. No differences were found between the hand preference groups on either variable for the children with autism, children with developmental delays, or normally developing children. Thus, those children demonstrating ambiguous hand preference did not have significantly more pregnancy, birth and newborn problems than those children demonstrating a definite hand preference. However, the means reported in Table 14 suggest that there is a pattern for both the children with autism and children with developmental delays to have a greater number of pregnancy and birth problems reported if they display ambiguous handedness. There is also a pattern for a greater number of newborn problems in the autism and normally developing groups with ambiguous hand preference (see Table 15).

The Relationship of Hand Preference to Verbal, Cognitive and Motor Abilities

Analyses were performed to examine the relationships that hand preference classification had to receptive verbal ability, cognitive ability level, and motor skills by

Table 14

Comparison of Pregnancy and Birth Complications by Hand Preference

Group	M	SD	n	df	t
Autistic					
Left/Right	1.14	.90	7	18	-.73
Ambiguous	1.54	1.27	13		
Developmentally delayed					
Left/Right	1.75	1.48	12	13	-.61
Ambiguous	2.33	1.53	3		
Normally developing					
Left/Right	1.13	1.13	8	17	.67
Ambiguous	.82	.87	11		

Table 15

Comparison of Newborn Complications by Hand Preference

Group	M	SD	n	df	t
Autistic					
Left/Right	.86	1.16	7	18	-.57
Ambiguous	1.23	1.36	13		
Developmentally delayed					
Left/Right	1.58	1.88	12	14	.34
Ambiguous	1.25	.50	4		
Normally developing					
Left/Right	.63	1.06	8	17	-.77
Ambiguous	1.18	1.83	11		

group. Due to an extremely small number of left handers in this study population, the results of left and right handed participants were combined into one group (those with a definite hand preference), and were compared with children who did not evidence a hand preference. A MANOVA was used to assess group and hand preference differences in receptive verbal ability, cognitive ability, and motor skills (two between subject factors). Results revealed a nonsignificant Group x Hand Preference effect, with Wilks' lambda F (2,24) = .51, $p > .05$ (see Table 16). A trend towards significance was found for the main effect of Hand Preference (Wilks' lambda F (2,24) = 2.49, $p = .055$). Given the focus of the study the univariate Fs were explored however, and interpretation is tentative. Applying a Bonferroni correction of .0125 (i.e., .05/4) univariate Fs for receptive verbal ability and cognitive ability were both significant (receptive verbal ability F (1,54) = 10.27, $p = .002$, and cognitive ability F (1,54) = 6.86, $p = .011$). A trend towards significance was found for gross motor skills (F (1,54) = 4.48, $p = .039$), and fine motor skills (F (1,54) = 5.46, $p = .023$).

Follow-up independent-samples t-tests of all four univariate F tests (receptive verbal ability, cognitive ability, fine and gross motor abilities) indicated that for each variable, scores were consistently lower for those children classified as not having a hand preference, compared to children who were classified a having a definite hand preference (see Figures 4, 5, 6 & 7). This was reflected in significant t values (probabilities all less than 0.05) for all four variables, indicating differences by hand preference when collapsed across the group variable.

Table 16

MANOVA for Verbal, Cognitive, and Motor Abilities

Source	Mult. F[a]	Dependent variable	Univ. F[b]
Group	.51	Receptive verbal ability	.32
X		Cognitive	.29
Hand preference		Fine motor	.71
		Gross motor	.60
Hand preference	2.49	Receptive verbal ability	10.27[#]
		Cognitive	6.86[#]
		Fine motor	5.46[+]
		Gross motor	4.48[+]
Group	7.31[***]	Receptive verbal ability	.89
		Cognitive	5.66[*]
		Fine motor	2.54
		Gross motor	3.99[+]

[a] For the multivariate ANOVA, df = 2,24. [b] For the univariate ANOVAs, df = 2,54. [#] $p < .0125$ (Bonferroni correction applied). [***] $p < .001$. [+] $p < .05$ is not considered significant when the Bonferroni correction is applied to the univariate Fs.

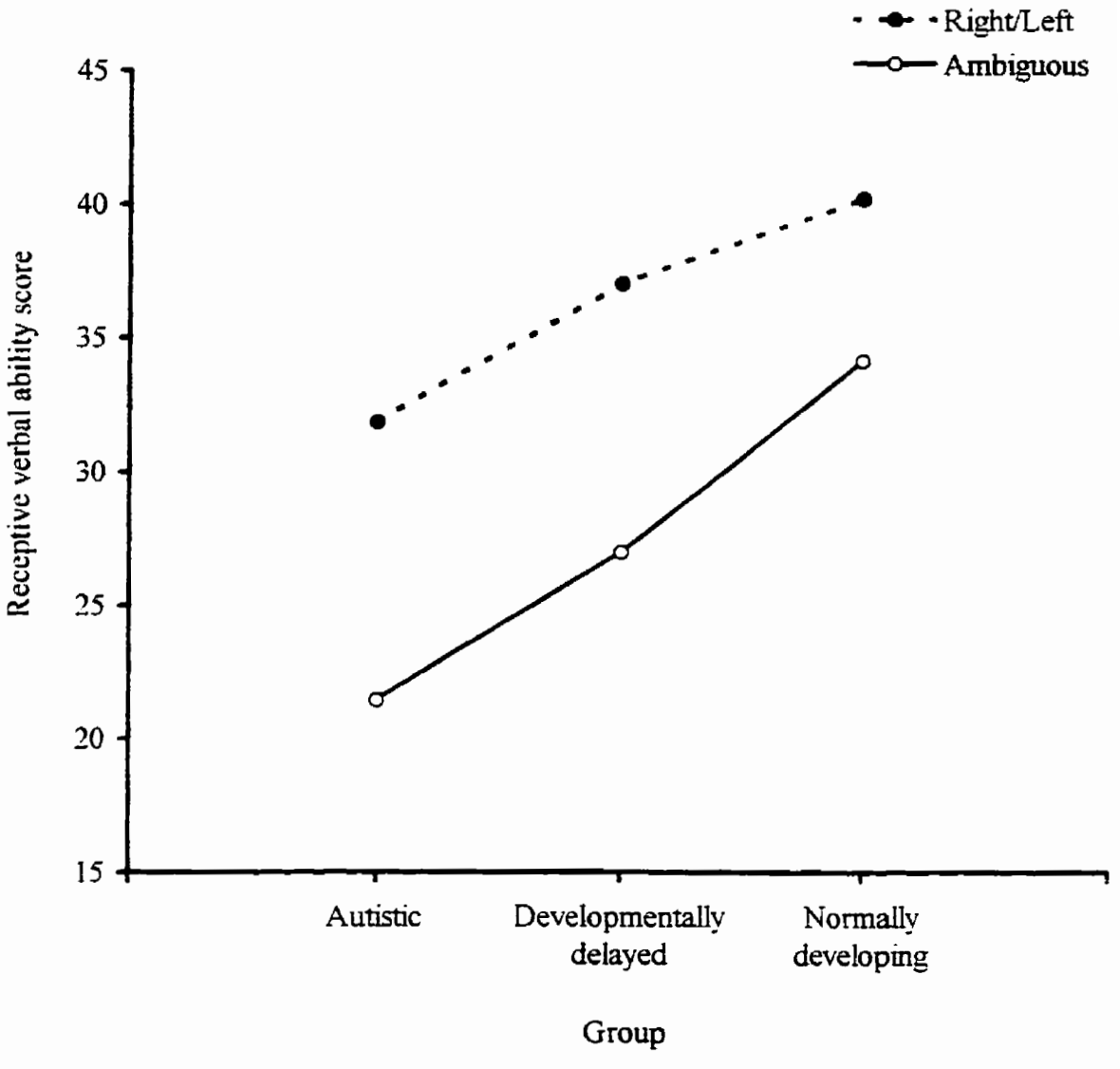


Figure 4. Group Means for Receptive Verbal Ability Scores.

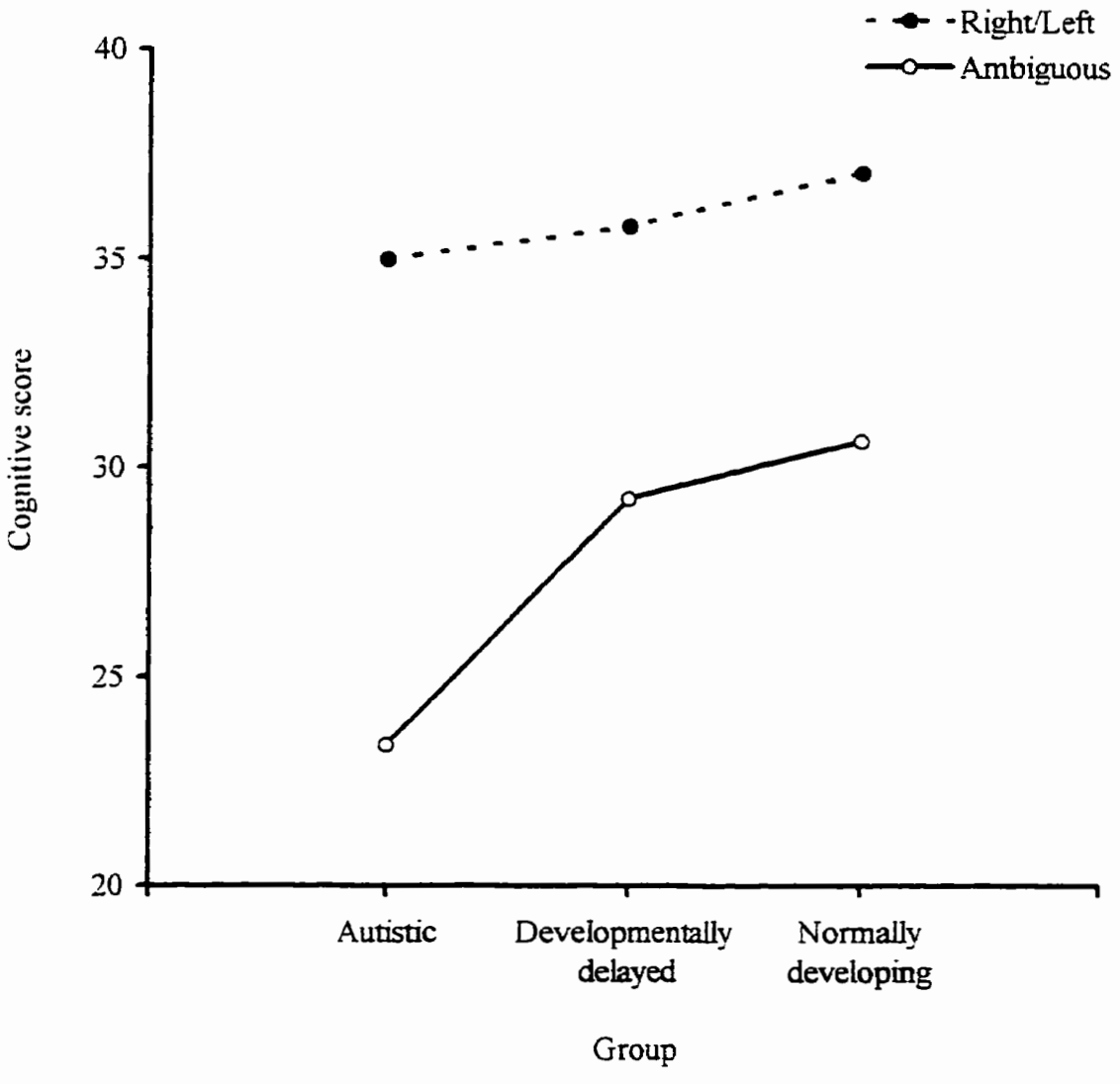


Figure 5. Group Means for Cognitive Ability Scores.

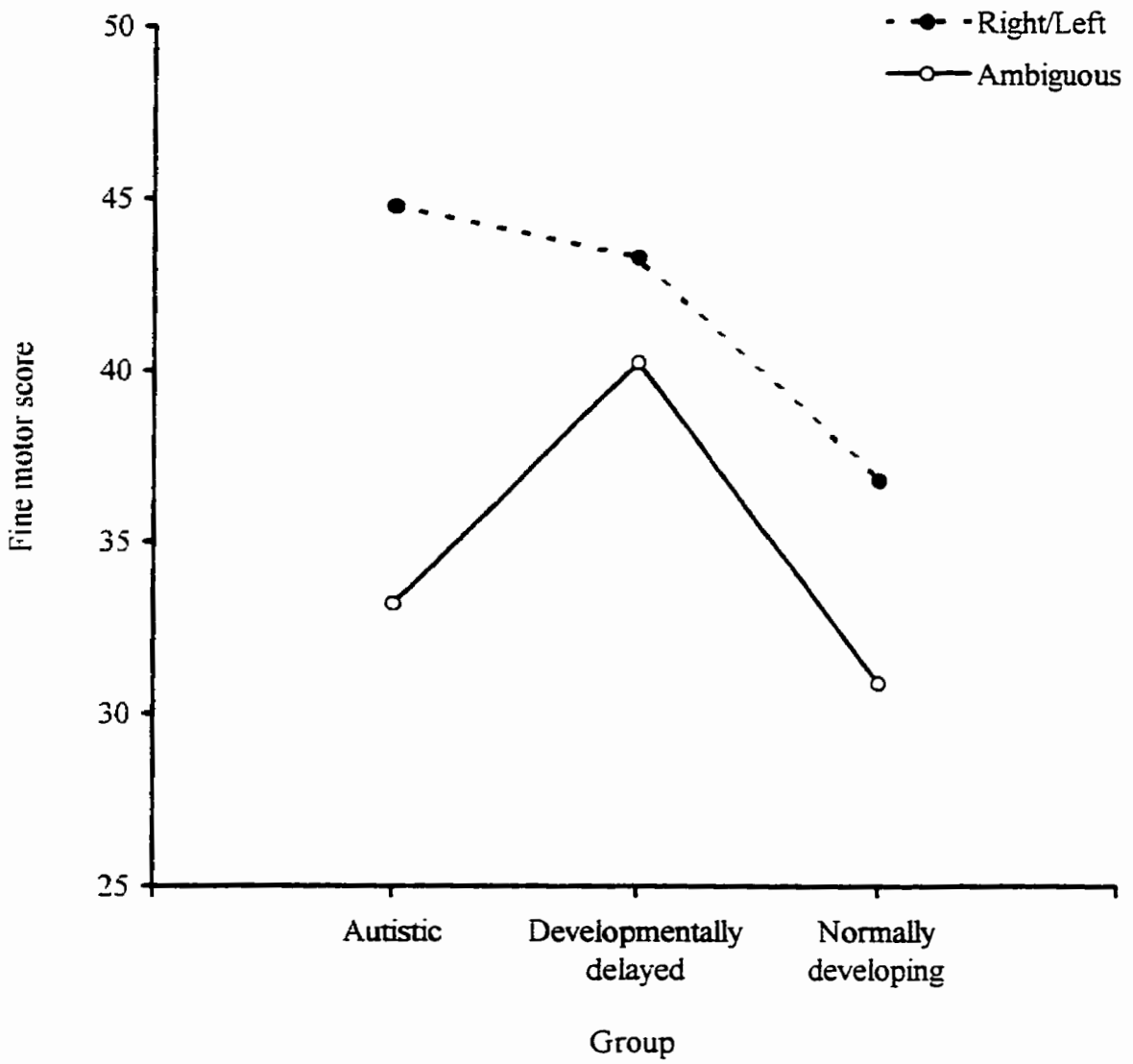


Figure 6. Group Means for Fine Motor Scores.

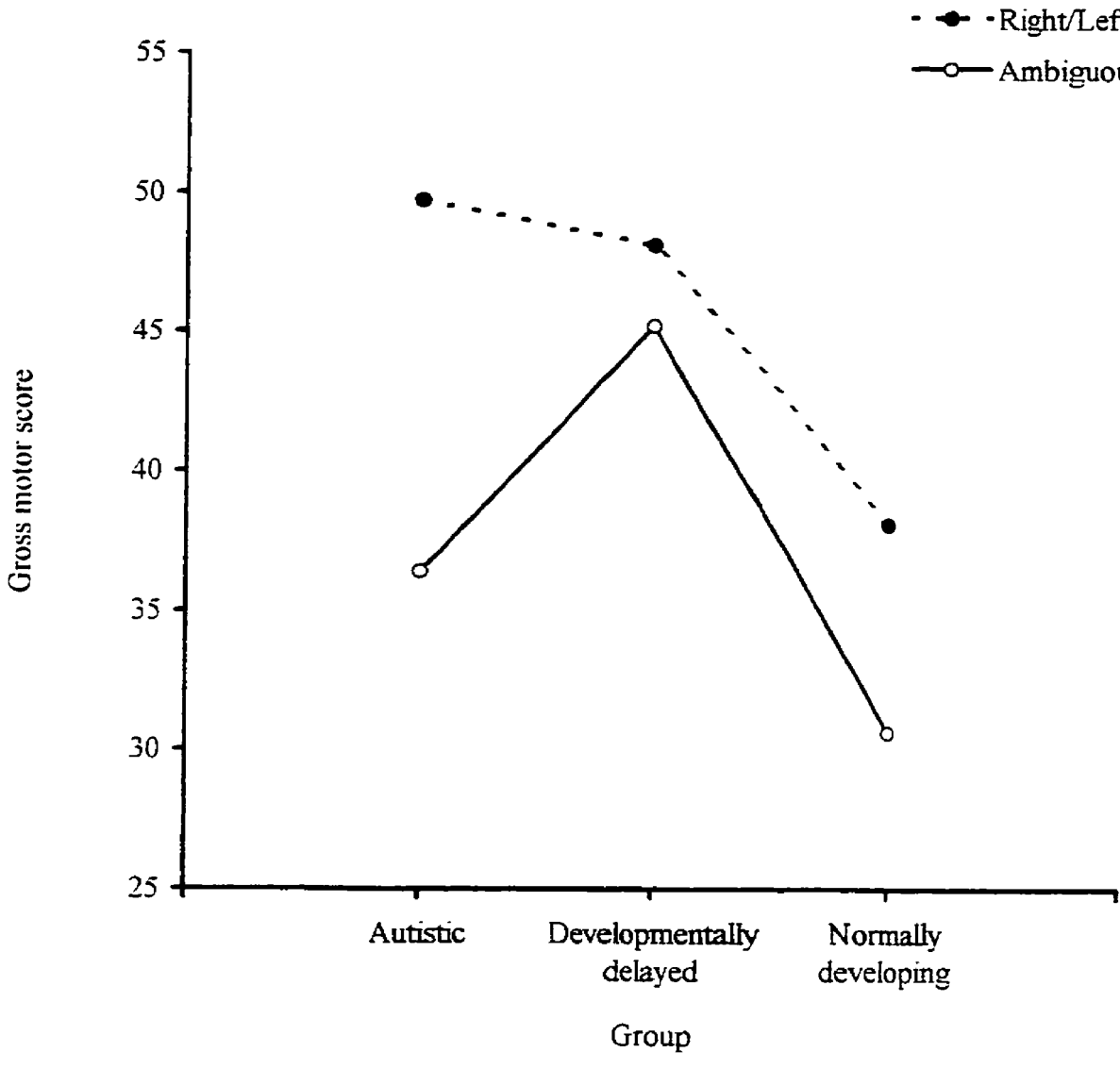


Figure 7. Group Means for Gross Motor Scores.

As expected, the MANOVA revealed a main effect of Group. These are essentially the same results as those discussed in the section "Group Comparison of Handedness, Verbal Ability and Motor Skills Across Groups", therefore, they will not be discussed further.

One of the hypotheses generated was that children with autism, who did not have a definite hand preference, would have lower verbal ability, cognitive and motor scores than those children with autism who had developed a definite hand preference. To test this hypothesis, t-tests were performed for the four variables of interest by hand preference grouping (definite hand preference(right or left) compared to no definite hand preference (ambiguous))(see Tables 17, 18, 19 & 20), with receptive verbal ability t (18) = -.573, $p < .05$, cognitive ability indicating a trend with t (18) = 2.08, $p = .052$, fine motor t (18) = 2.11, $p < .05$, and gross motor t (18) = 2.11, $p < .05$. The results revealed that the children with autism who had not developed a hand preference were functioning significantly lower in the areas of receptive verbal ability, and fine and gross motor skills, and showed a trend towards lower cognitive ability than children with autism with a definite hand preference. Independent samples t-tests were also performed for the children with developmental delays and normally developing children to see if the same pattern emerged as with the children with autism on the four measures of interest. The t-test of receptive verbal ability for the children with developmental delays indicated a trend, with t (18) = 2.06, $p = .054$. No other t-tests were significant, or indicated trends. Therefore, the relationship of hand preference to verbal, cognitive, and motor scores appears to be exclusive to the children with autism, although the pattern can be seen in

Table 17

Group Comparisons of Receptive Verbal Ability by Hand Preference

Group	M	SD	n	df	t
Autistic					
Left/Right	31.86	11.63	7	18	2.43*
Ambiguous	21.46	7.6	13		
Developmentally delayed					
Left/Right	37.06	8.24	16	18	2.06
Ambiguous	27.00	10.81	4		
Normally developing					
Left/Right	40.22	14.84	9	18	1.23
Ambiguous	34.18	6.19	11		

*$p < .05$.

Table 18

Group Comparisons of Cognitive Ability by Hand Preference

Group	M	SD	n	df	t
Autistic					
Left/Right	35.00	19.12	7	18	2.08
Ambiguous	23.38	5.44	13		
Developmentally delayed					
Left/Right	35.78	12.07	16	18	.99
Ambiguous	29.25	10.21	4		
Normally developing					
Left/Right	37.06	12.16	9	18	1.60
Ambiguous	30.64	4.95	11		

Table 19

Group Comparisons of Fine Motor Ability by Hand Preference

Group	M	SD	n	df	t
Autistic					
Left/Right	44.79	17.38	7	18	2.11*
Ambiguous	33.23	7.26	13		
Developmentally delayed					
Left/Right	43.31	8.28	16	18	.59
Ambiguous	40.25	13.23	4		
Normally developing					
Left/Right	36.83	13.64	9	18	1.36
Ambiguous	30.91	4.41	11		

*$p < .05$.

Table 20

Group Comparisons of Gross Motor Ability by Hand Preference

Group	M	SD	n	df	t
Autistic					
Left/Right	49.71	15.15	7	18	2.11*
Ambiguous	36.42	12.46	13		
Developmentally delayed					
Left/Right	48.13	13.35	16	18	.36
Ambiguous	45.25	18.72	4		
Normally developing					
Left/Right	38.11	16.54	9	18	1.49
Ambiguous	30.32	5.13	11		

*$p < .05$.

the children with developmental delays and normally developing children to a lesser extent (see Figures 4, 5, 6, and 7). These differences were masked in the omnibus multivariate analyses.

Pregnancy and Birth History

Group Differences in Pregnancy and Delivery Problems

The questions regarding pregnancy and delivery details on the Birth and Pregnancy questionnaire were analyzed individually using chi-square analyses. No significant group differences were found for the following variables using chi-square tests at an alpha level of .05: mother bleeding during first 3 months of pregnancy (χ^2 (2, $\underline{N}$ = 53) = 2.15), bleeding during fourth to sixth months (χ^2 (2, $\underline{N}$ =52) = 1.77), and bleeding during third trimester (χ^2 (2, $\underline{N}$ =53) = .08), mother contracting a cold or other virus during pregnancy (χ^2 (2, $\underline{N}$ = 50) =1.50), mother smoked one or more packs of cigarettes a day during the pregnancy (χ^2 (2, $\underline{N}$ = 54) = .18), mother developed toxemia (χ^2 (2, $\underline{N}$ = 53) = 3.43), labour being induced (χ^2 (2, $\underline{N}$ = 51) = 4.48), mother had a caesarian section (χ^2 (2, $\underline{N}$ = 54) = 2.28), difficult delivery (χ^2 (2, $\underline{N}$ = 52) = 2.73), and mother was put to sleep for delivery(χ^2 (2, $\underline{N}$ = 53) = .12). Mother having to take medications during the pregnancy with χ^2 (2, $\underline{N}$ = 53) = 5.85, $\underline{p}$ = .054 (N.B. medication taken during the delivery, for example, pain killers, were not included in this category) was the only variable in this section that approached significance.

Analyses of variance were used to examine group differences in mother's weight gain during the pregnancy, the number of days early or late from the due date that the baby was delivered, the age of the mother at birth, the number of pregnancies the mother had up to this particular pregnancy, and the birth weight of the baby (means and standard deviations for these variables are presented in Table 21). No significant differences were found: mother's weight gain $\underline{F}$ (2,46) = .61, $\underline{p} > .05$; delivery date accuracy $\underline{F}$ (2,49) = 1.25, $\underline{p} > .05$; age of mother at birth $\underline{F}$ (2,50) = .92, , $\underline{p} > .05$; the number of pregnancy this child was $\underline{F}$ (2,47) = 2.00, $\underline{p} > .05$; and birth weight $\underline{F}$ (2,50) = .10, $\underline{p} > .05$.

Group Differences in Newborn Problems

Problems with the newborn at birth were also analyzed using chi-square analyses. No significant group differences were found on any of the variables at an alpha level of .05: baby injured during birth χ^2 (2, $\underline{N}$ = 51) = 2.70; baby had trouble breathing χ^2 (2, $\underline{N}$ = 50) = 1.53; baby was jaundiced χ^2 (2, $\underline{N}$ = 53) = 1.80; mother had twins or triplets χ^2 (2, $\underline{N}$ = 55) = 1.93; baby had seizures χ^2 (2, $\underline{N}$ = 55) = 3.63; baby needed oxygen χ^2 (2, $\underline{N}$ = 49) = 3.06; baby had trouble sucking χ^2 (2, $\underline{N}$ =53) = .60; baby had to stay in hospital more than a week χ^2 (2, $\underline{N}$ = 54) = .76; baby was born with a heart defect χ^2 (2, $\underline{N}$ =54) =.05; baby was born with some other defect(s) χ^2 (2, $\underline{N}$ = 54) = 1.04; and whether the baby was breastfed χ^2 (2, $\underline{N}$ = 54) = 2.31. The variable baby turned blue (cyanosis) was the only one that approached significance (χ^2 (2, $\underline{N}$ = 50) = 5.14, $\underline{p}$ = .076).

Overall Comparison of Total Problems During Pregnancy and Total Newborn Problems

The number of problems reported in the pregnancy/delivery section of the

questionnaire, and in the newborn section were totaled for each section (see Table 21 for means and standard deviations of total pregnancy/birth and newborn problems) and a MANOVA was performed (see Table 22). No significant group differences were found in the total number of pregnancy and newborn problems reported (Wilks' lambda $F(2,23) = 1.10$, $p > .05$).

CARS Score and Relationships to Receptive Verbal Ability, Cognitive Ability, Motor Skills and Handedness

Severity of Autism Characteristics on a Continuum

Pearson product-moment correlations were performed to investigate the relationships between severity of autism characteristics as measured by the CARS and the test variables (receptive verbal ability, cognitive ability, fine and gross motor skills, consistency of hand preference and strength of hand preference). All correlations were insignificant, with probabilities ranging from .87 to .95 (see Table 23). Hence there appears to be no relationship between severity of autism characteristics and scores on any of the variables tested. An independent-samples t-test was performed to examine differences in CARS scores by hand preference classification indicated that CARS scores were not significantly different for right handed children with autism (no left handers in this study), versus autistic children with no hand preference ($t(18) = -.57$, $p > .05$). Means and standard deviations for CARS scores for each hand preference group are presented in Table 24.

Table 21

Group Means for Pregnancy and Newborn Details

	Group					
	Autistic		Developmentally delayed		Normally developing	
Measures	M	SD	M	SD	M	SD
Weight gain	33.41	11.25	35.54	17.06	30.21	13.17
Accuracy of delivery date	-.05	7.42	2.07	7.69	-3.67	14.48
Mother's age	30.25	3.95	28.68	5.44	31.68	8.45
Number of pregnancy	2.30	1.30	2.33	1.54	1.53	.83
Baby's weight	7.22	.77	7.39	1.58	7.24	1.03
Total number of pregnancy/birth problems	1.40	1.14	1.87	1.46	.95	.97
Total number of newborn problems	1.10	1.37	1.50	1.63	.95	1.54

Table 22

MANOVA for Reported Pregnancy and Birth Problems

Source	Mult. F[a]	Dependent variable	Univ. F[b]
Group	1.10	Total pregnancy problems	2.15
		Total newborn problems	.60

[a] For the multivariate ANOVA, df = 2,23. [b] For the univariate ANOVAs, df = 2,49.

Table 23

Correlations Between CARS Score, and Performance and Hand Preference Measures (Children with Autism)[a]

	Receptive verbal ability	Cognitive	Fine motor	Gross motor	Hand consistency	Strength of hand preference
CARS	.01	.03	.02	-.02	.03	-.04

[a] $\underline{n} = 20$.

Table 24

Hand Preference Groups Means on the CARS (Children With Autism)

	M	SD
Right or left hand preference	34.57	5.53
Ambiguous hand preference	35.92	4.76

Categorization of Autism Severity

A MANOVA was also performed to investigate whether children identified as displaying mild-moderate versus severe autistic characteristics, as defined by the authors of the CARS test (Schopler, Reichler, & Renner, 1986), differed on receptive verbal ability, cognitive ability, gross and fine motor skills, consistency and strength of hand preference (see Table 25). The main effect for the autism categories was not significant (Wilks' lambda F (1, 6) = .42, $p > .05$), and all reported univariate Fs were also not significant at the .05 alpha level. Means and standard deviations for the dependent measures are presented in Table 26.

Hand Preference in the Family

The means for mother's and father's degree of hand preference, number of left handed siblings, and relativity indexes for left handedness (including and excluding the child) are presented in Table 27. Analyses of variance (ANOVAs) were performed to investigate possible differences across groups for degree of handedness among the participant's family members. No significant group differences were found for the degree of handedness shown by mothers and fathers (Mother's handedness F (2,50) = .76, $p > .05$; Father's handedness F (2,46) = 1.80, $p > .05$. The number of siblings who were left handed (as reported by parents) was similar across the three groups, with F (2,37) = .00, $p > .05$.

Table 25

MANOVA for Performance and Hand Preference Measures According to CARS Score Classification

Source	Mult. F[a]	Dependent variable	Univ. F[b]
Autism Category	.42	Receptive verbal ability	1.28
		Cognitive	.67
		Fine motor	.76
		Gross motor	.90
		Hand consistency	.001
		Strength of hand preference	.14

[a] For the multivariate ANOVA, df = 1,6. [b] For the univariate ANOVAs, df = 1,18.

Table 26

Category of Autism Means for Performance and Hand Preference Measures

	Autism Category			
	Mild-moderate		Severe	
Dependent measures	M	SD	M	SD
Receptive verbal ability	23.00	10.68	28.25	9.33
Cognitive	25.50	9.58	30.38	17.05
Fine motor	35.25	10.78	40.31	15.36
Gross motor	38.54	14.94	44.88	14.13
Hand consistency	4.17	2.89	4.13	2.10
Strength of hand preference	16.00	7.07	14.88	5.72

Table 27

Groups Means for Parents' Degree of Handedness, Number of Left-handed Siblings, and Relativity Index for Left Handedness Including and Excluding the Child

	Group					
	Autistic		Developmentally delayed		Normally developing	
Measures	M	SD	M	SD	M	SD
Mother's degree of hand preference	36.45	3.20	35.93	5.97	34.16	7.97
Father's degree of hand preference	33.16	9.92	36.17	6.28	37.50	2.53
Number of left handed siblings	.20	.41	.20	.42	.20	.63
Relativity index including child	.27	.33	.37	.41	.33	.43
Relativity index excluding child	.27	.33	.30	.38	.33	.43

Indexes of left handedness within the family, immediate and extended, were calculated by assigning values corresponding to the immediacy of the relationship of the left handed person to the identified participant. A value of 1.0 was assigned if the identified participant was classified as left handed, 0.5 if a parent or sibling was reported to be left handed, 0.25 if a grandparent, aunt or uncle was the relative, 0.125 for a cousin, and 0.0625 for a second cousin. The left handed relativity index was calculated twice, including and excluding the identified participant. No significant differences were found across the groups for these two measures (index including child F (2,51) = .15, $p > .05$; index without child F (2,51) = .31, $p > .05$).

Fine and Gross Motor Questionnaire

Totals for the two sections of the motor questionnaire, fine and gross motor, were calculated. A MANOVA resulted in a significant effect for Group (Wilks' lambda F (2,24) = 2.71, $p < .05$) (see Table 28). Univariate F's indicated that there was a significant difference in gross motor skills across the three groups F (2,52) = 3.45, p = .039 (mean gross and fine motor scores and standard deviations are reported in Table 29). However, with a Bonferroni correction in place, the univariate F was not longer significant (i.e., .05/2 = .025). As a trend was indicated, post-hoc comparisons using Tukey's HSD were conducted. Results revealed that there were no significant differences among groups. From Table 29 it can be seen that there is a trend for the parent reported gross motor scores of the children with developmental delays to be higher than both the children with autism and the normally developing children, whose mean

Table 28

MANOVA for Fine and Gross Motor Questionnaire Scores

Source	Mult. F^a	Dependent variable	Univ. F^b
Group	2.71*	Fine motor	2.21
		Gross motor	3.45+

[a] For the multivariate ANOVA, df = 2,24. [b] For the univariate ANOVAs, df = 2,52.

*$p < .05$. +$p < .05$ is not considered significant when the Bonferroni correction is applied to the univariate F.

Table 29

Group Means on the Fine and Gross Motor Questionnaire

Group	Fine motor		Gross motor	
	M	SD	M	SD
Autistic[a]	89.50	36.61	112.95	19.61
Developmentally delayed[b]	94.56	29.92	130.75	25.66
Normally developing[c]	73.84	24.27	113.11	23.17

[a]n = 20. [b]n = 16. [c]n = 19.

scores are very similar. The reported fine motor score across groups did not differ significantly, with $\underline{F}$ (2,52) = 2.21, $\underline{p}$ > .05).

DISCUSSION

Group Differences in Hand Preference

Past research has found that approximately 35% of children with autism do not have a consistent hand preference within tasks, i.e., they have an ambiguous hand preference (Fein et al., 1985; Soper et al., 1986). The first hypothesis examined was that a greater percentage of children with autism would show ambiguous patterns of hand preference than the matched children with developmental delays, and normally developing children. The results did not support all components of this hypothesis. The children with autism and the normally developing children were found to have similar percentages of ambiguous handedness (65% for the autism group, and 55% for the normally developing group). Overall, the classifications of hand preference did not differ between the normally developing and autistic children. However, the children with developmental delays did not show the high levels of ambiguous handedness seen in the other two groups (only 20% ambiguous). Thus, their pattern of hand preference classification was significantly different from both the normally developing children and the children with autism, even though all three groups were matched for developmental level.

Given the young age of the normally developing children in this study, the finding that a high percentage of the group had not yet developed a hand preference is not surprising. Kaufman, Zalma and Kaufman (1978) in their sample of normally developing children found that 58% of the two-and-a-half year olds had developed a hand preference, which is similar to the 45% found in this study. As strength of hand

preference seen in normally developing children increases until approximately age seven (McManus et al., 1988), most of these children will likely develop a definite hand preference as they become older. Age of the children with autism in this current study may also be a factor in the difference in percentages of hand preference found, especially ambiguous handedness, when compared to other studies. For example, Fein et al. (1985) reported a rate of 29% ambiguous handedness, and Soper et al. (1986) found a rate of 36% ambiguous handedness in their sample. However, the participants in these studies were, on average, older (the age range of Fein et al.'s sample was 6 years 8 months to 11 years 7 months, and Soper et al.'s age range was from 4 years to 34 years of age) than the children who participated in the present study.

The distribution of hand preference in the children with autism was the same as that of the normally developing children of the same developmental level. This finding suggests that the hypothesis of a developmental lag in the lateralization of children with autism may be correct (Barry & James, 1978; Fein et al., 1984). However, the pattern of hand preference in children with autism is not the same as children of the same chronological and mental ages (children with developmental delays). There are several possibilities that may account for this finding. One is that years of experience have played more of a factor in the development of a hand preference in the children with developmentally delays, but not in the children with autism. However, the most likely explanation is that although the two groups are matched generally on mental age, there are still differences in cognitive abilities and disabilities between the groups, suggesting that different areas of cerebral dysfunction may contribute to the disproportionate amount

of ambiguous handedness in the group with autism compared to the group with developmental delays. Harris and Carlson (1988) noted that a finding of increased ambiguous handedness in individuals with autism "is more consistent with the full clinical picture of autism, which includes both linguistic and social-affective disorders, as well as attentional and arousal disorders. It is also consistent with the view that the etiology is more likely to involve bilateral cortical (and subcortical) than unilateral cortical dysfunction (Fein et al., 1984)", (p.304).

It is also possible that the developmental lag in children with autism is more severe given the same general level of cognitive abilities as the matched children with developmental delays at this young age. Because of maturation, we might expect the number of children with autism with definite hand preference will increase, as the strength of hand preference increases and levels off over the next few years. The stability of hand preference in all three of the groups in this study is an area that needs further research.

Few studies have directly compared children with autism and matched children with developmental delays to examine patterns of hand preference. Previous studies with non-autistic adults with mental retardation using the HPDT have reported a higher percentage of ambiguous handedness (Morris & Romski, 1993; Soper et al., 1987) than what was found in this study (32% in the Morris & Romski study, 45% in the Soper et al. study). However, there are some dissimilarities between the groups of individuals with developmental delays used in these studies and the group of children in the present study. Specifically, in the Soper et al. study, the adults with mental retardation were severely or

profoundly retarded with an average mental age of 24.3 months. In the Morris and Romski study, 76% of the participants were severely or profoundly retarded, and all were nonspeaking or minimal speakers. The children with developmental delays in this study had an average mental age of 34.5 months, and only one child had severe speech difficulties. Both Soper et al.'s, and Morris and Romski's groups contained participants with genetic or diagnosed syndromes, such as congenital hydrocephalus, brain lesions, and Down Syndrome. The current study excluded children with known origins of pathology in order to create a more homogeneous group.

Soper, Satz, Orsini, Van Gorp and Green's (1987) questioned whether the phenomenon of ambiguous handedness is specific to autism. Arnold and Askew's (1993) study of hand preference in a group of deaf children and young adults with severe learning difficulties also found a distribution of hand preference similar to Soper et al. (1986), with a significant percentage of ambiguous handedness. The results of the present study support Arnold and Askew's claim that ambiguous handedness is not specific to children with autism, but is also found in individuals with developmental delay. However, when direct matches were made for cognitive level and age in the present study, the children with autism and the children with developmental delays showed different proportions of ambiguous handedness. This matching has not been controlled for in any other study to date.

The second and third hypotheses of this study predicted that the percentages of left handedness in the children with autism, and children with developmental delays would be similar, and both groups would have a higher percentage of left hand

preference than the normally developing group. Both of these hypotheses were not supported. Using the 90% criterion suggested by Soper et al. (1986), none of the normally developing or children with autism met criteria for definite left hand preference, although there was one child in the normally developing group, and two children with autism that showed a trend towards left handedness. The children in this study who are developing normally were very young, and many were not yet showing a definite hand preference, which is consistent with the literature which states that hand preference continues to develop through the preschool years. The children with autism were also young, and showed a high degree of ambiguous handedness. It is likely that some of the children with autism, and the normally developing children who are currently not showing a hand preference, will develop a definite left hand preference similar to the percentages reported for older individuals. The percentage of children with developmental delays with a definite left hand preference was 10%, which supports the data of studies that have also used the HPDT with populations with developmental delays: Soper et al. (1987) found 9.6% of their adult sample were left handed, and Arnold and Askew (1993) found 14.4% of their participants were classified as left handed. Cornish and McManus (1996) using a different hand classification measure found a left hand preference rate of 11.5% in their group of children with a learning disability. Therefore, these results consistently show that the rate of left handedness in children and adults with a learning disability or developmental delay is approximately 10%, which is half the incidence originally reported in the literature (Hicks & Barton, 1975). This may be due, in part, to a more liberal classification criteria in the other

studies, and also the fact that many early studies did not use a classification of mixed handedness, and instead used a dichotomous classification of right or left handed, or right and non-right handed. Either way, individuals that would have been classified as ambiguously handed were probably placed in the left handed group, thus increasing the incidence of left handedness in those samples (Harris & Carlson, 1988).

The results of this study show that hand preference classification, left, right or ambiguous, was not related to the chronological age of the children within each group. Previous findings that autistic children with ambiguous hand preferences are younger than their definite preference counterparts (Barry & James, 1978; Tsai, 1983) are therefore not supported. The age range of the children with autism in this study was purposely kept small (two-and-a-half to seven years of age) so the cohort can be followed for further research without changing ability measures. The age range on the Barry and James study was from 4 years 11 months to 18 years 11 months. Similarly Tsai (1983) used a wide age range from 2 years 10 months to 13 years 6 months. It may be found in future research that the proportion of ambiguous handedness changes in the autism group involved in this study as they become older, which would explain why the previous studies have found more ambiguous handedness in younger children. Tsai (1983) noted that mixed handedness was most frequent in children with autism who were younger than five years of age, and suggested that consistency of hand preference is established in children with autism after age five. Fifty percent of the children with autism in this study are less than five years old. The reason for including children of such a young age was to examine differences in children who developed a hand preference at an earlier age,

and the relationship that the early development of hand preference may have to other abilities and long term prognosis.

Although the differences did not reach significance, there was a trend that indicated that the children with autism with an ambiguous hand preference were more likely to have pregnancy, birth and newborn infant problems than children with autism who had a definite hand preference. Given that this is retrospective reported data, caution should be taken when interpreting this data (Dewey, 1990). As Tsai pointed out, autistic individuals, in general, do experience a higher frequency of complications and problems; however, due to small sample sizes, these factors often do not reach statistical significance, and hence are not taken to be of clinical importance. Further large scale studies in this area should take birth history of the sample as necessary data, as there is no data to date on birth complications in previous studies looking at ambiguous handedness. The same trend for more pregnancy and birth problems, but not newborn problems, was seen for the ambiguously handed children with developmental delays. When hand preference classification is ignored, there were no significant differences in pregnancy, birth and newborn problems reported by the three groups.

Neither degree of handedness in parents, nor prevalence of left handedness in the extended family were found to be significantly different between groups. The lack of difference between groups provides support for the literature that states that there is no increase in left handedness in families of children with autism, compared to the general population. The lack of a difference does not support Pipe's (1990) review of the literature that states that there is an increased incidence of left handedness in the families

of individuals with developmental delays. However it should be noted that only 10% of the children with developmental delays in the present study were found to be left handed (approximately equivalent to the percentage of left handedness in the general population). Familial data was also missing in the present study from four of the children with developmental delays, one of which was one of the two children classified as being left handed.

The current study found that there was a trend for the children with developmental delays to have a more established hand preference than the children with autism. Barry and James (1978) also observed this phenomena in their study. The children with autism and normally developing children of the same chronological age showed a gradual increase of dominant handedness as a function of age. The children with developmental delays showed a much sharper incline in their dominant hand use with age. The Barry and James study, and the current study suggest that children with developmental delays show a different rate of hand preference development compared to children with autism and normally developing children.

There were no group differences found in the current study for consistency of hand preference. Cornish and McManus (1996) found that there was no difference in their study between children with autism and children with learning disabilities for consistency of handedness, however, similar to Barry and James (1978), Cornish and McManus found that the normally developing children (matched for chronological age but not developmental level) were more consistent in their hand preference than both the children with autism and children with developmental delays. The children with learning

disabilities showed a sharp increase in consistency of hand preference with age, to the point that their scores were similar to normally developing children at approximately 11 years old. The children with autism showed a slow but steady increase in consistency of handedness with age, but never reached the level of consistency demonstrated by the normally developing children at age 11. Given that the present study is looking at very young normally developing children at the same developmental level as the children with autism and the children with developmental delays, the strength and consistency of hand preference was not likely to differ by group if those variables increase with age in a normal population, as has been reported in the literature (McManus et al., 1988). The normally developing children are too young to have yet developed much consistency of hand use, as their mean age was two years and eight months. Further research is suggested to observe the consistency of hand preference in the children in the present study as they get older, to examine whether the rate of development of hand consistency changes according to group.

Soper et al. (1986) reported that in their sample of children and adults with autism, almost all of the individuals who demonstrated inconsistent responses on more than two tasks of the HPDT were in the ambiguous handedness group (93%). This inconsistency was essentially responses that differed within tasks, as opposed to across tasks, which would infer ambidextrous hand preference. Soper found similar results in his study of retarded adults (Soper et al., 1987). The results of the present study were consistent with Soper et al. (1987): 92% of children with autism with ambiguous handedness demonstrated inconsistency on more than two tasks, and 100% of both the

children with developmental delays with ambiguous handedness, and the normally developing children, with ambiguous handedness fell into this category. None of the children with autism that were right handed showed inconsistency on more than two items, but a third of both the children with developmental delays and normally developing children with a right hand preference did. As there are no other reports in the literature to compare this finding to, the implications of this finding are not known, and are hard to explain given that this is the first report of children of this age using this particular measure. It may be that the children with autism who have a right hand preference are more strongly lateralized than the right handed children in the two other groups.

The proportions of bimanual responses made by the children in this study were examined because of the young age of the sample, and the fact that HPDT does not factor bimanual responses into the laterality index. Soper et al. (1986) reported that 1.3% of the responses in his study were bimanual. Morris and Romski's (1993) study sample showed 3.9% bimanual responses. This current study had a bimanual response rate of almost double that of the Morris and Romski study (7.7%). Of those bimanual responses, the normally developing children were the highest contributors to that rate (42%), whereas the children with developmental delays and children with autism had approximately the same lower rate (30% and 28% respectively). Morris and Romski showed the breakdown of bimanual responses for the eight tasks involved in the HPDT to be fairly even across tasks. Their subject sample was an adult population. In the present study, the most bimanual responses were for tasks that are developmentally more appropriate for

bimanual hand use, i.e., drinking from a cup and throwing a ball. Given the younger age of the sample of this study, and that more of the normally developing children had bimanual responses than the other two groups, this finding does not seem surprising.

Comparison of Verbal, Cognitive, and Motor Skills Across Groups

The fine and gross motor scores of the children with developmental delays were significantly higher than the normally developing children. The fine and gross motor scores of the children with autism were positioned between the scores of the children with developmental delays and normally developing children, and were not significantly different from either group. These results were not unexpected when the differing ages of the groups and literature regarding motor skills are taken into consideration. The normally developing children would have lower motor scores as motor skills develop with age, and experience, and the majority of this group were only in the two year old age range. Jones and Prior (1995) reported that there is some evidence to suggest that children with autism have a delay in motor functioning in relation to their chronological age. In a study by Manjiviona and Prior (1995) they reported that 67% of children with autism in their sample had motor problems that were clinically significant, and were functioning motorically at a much lower level than would be expected for their age. Zittel (1994) reported that preschool children with developmental delays (the vast majority of the children with developmental delays in this study are preschoolers) often experience motor difficulties.

Children with autism had significantly lower receptive verbal ability scores than both the children with developmental delays and normally developing children. Again, this was not an unexpected result, given that language skills in children with autism are usually severely impaired, whereas, some cognitive skills may be spared. Hence, an overall cognitive score, consisting of many different cognitive abilities, is likely to be higher than a specific score relating to language (matching by general cognitive level therefore would most likely result in a group of children with autism that has lower verbal ability scores than the group of children with developmental delays). In the children with developmental delays, the age equivalent scores for cognitive and receptive verbal ability tests were, on average, comparable, and not significantly different from the normally developing children's scores.

Hand Preference Classification and its Relationship to Other Abilities

The fourth hypothesis to be tested in this study was that children with autism who have a definite hand preference (left or right) would show higher levels of functioning on receptive verbal ability, cognitive ability, and have better developed motor skills than children with autism who have ambiguous hand preferences. These results were generally supported, and are consistent with the literature, which has reported lower scores in the ambiguous hand preference group on a variety of cognitive tasks (Fein et al., 1984; Soper et al., 1986; Tsai, 1983). However, Fein et al. did not find any difference across hand preference groups on their motor measures, which were a peg-moving task, a measure of grip strength and a finger tapping task. Given that these measures are

inherently different to the motor measures in this study, the results may not be directly comparable. Most of the items in the BDI - motor domain are ecologically valid, and tasks that would be encountered regularly in the child's life, such as throwing and catching a ball, walking up and down stairs, opening a door knob, turning the pages of a book one at a time, manipulating a key, tying a knot, copying symbols and words, and so on. Hence, the motor measures in this study are believed to be more representative of actual skills in the gross and fine motor areas, and more informative than a measure of grip strength, for example.

Bishop (1990) has suggested that "poor motor functioning results in a failure to learn the types of motor skills for which hand preference is normally shown" (p. 113). Prior and Bradshaw (1979) also perceived mixed handedness in children with autism to be a result of an inability to do the tasks that are used on a handedness measure, rather than a real measure of hand preference per se. Given that the HPDT has been used successfully with adult populations with very similar results to this study, and that all the items on the test are demonstrated by children from a very young age, it seems unlikely that an ambiguous hand preference classification resulting from use of the HPDT could be associated with inability to do a task. Given an inability to do a task, it would be more likely that a bimanual or no-response be recorded. There was not a single no-response recorded in this study, and the bimanual responses were equivalent for both the delayed and autistic groups, and constituted a very low percentage of all responses.

A similar explanation as Bishop's (1990) concerning ambiguous handedness in children with autism has been put forward by Cornish and McManus (1996). They

posited that the lower consistency of hand preference seen in children with autism (and hence increase in ambiguous handedness) is a result of deficient motor skills. However, it was found in this study that the children with developmental delays and the children with autism did not differ significantly in their fine and gross motor skills. Therefore, if it was a question of poor motor functioning, we would have expected to find the same proportion of ambiguous handedness in the children with developmental delays as what was found in children with autism. Results showed that the two groups were very different in their hand preference distributions. These results question the idea that ambiguous handedness in children with autism is the result of deficits in motor skills. Another explanation for the increase in ambiguous handedness shown in children with autism is needed (see Group Differences in Hand Preference).

It is difficult to separate out causation from correlation in this area. There is a relationship shown in this study between ambiguous hand preference and lower functioning in motor skills; however, both could have been caused by the same phenomenon - extensive brain dysfunction (most likely bilateral). In order to investigate this area further, more research is required to examine the motor development of the children with autism who go on to develop a definite hand preference, and to see if there is a concomitant increase in motor skills.

Results for the children with developmental delays and normally developing children show that although there is a trend for lower skills in motor, cognitive and language functioning in the ambiguous hand preference groups, the results are not significantly different from the definite hand preference group scores. However, there

was a trend towards significance for the receptive language scores of the children with developmental delays when hand preference groups are compared. Given the small numbers of ambiguously handed children with developmental delays, an increase in the sample size may subsequently increase the statistical significance of this result. This is an area that deserves further research.

When all three groups are combined, the analyses of variance showed that there were significant differences by hand preference group for language and cognitive ability, and a trend towards significance for the motor skills scores. These results may be an artifact of the autism group's influence in increasing the score difference between the two hand preference categories.

The finding of a trend towards lower scores on ability tasks for ambiguously handed normally developing children is consistent with studies by Annett (1970) and Kaufman et al. (1976). The motor testing results found in the present study are discrepant from the series of studies by Gabbard and Hart (Gabbard, Hart & Gentry, 1995b; Gabbard, Hart & Kanipe, 1993), which used finger tapping tasks. However, their study that involved a global motor performance measure (Gabbard, Hart & Gentry, 1995a) showed results that were consistent with this study in that the right handed children had higher scores than the mixed handed children. The motor skills example provides an illustration of the difficulties inherent in the area of hand preference research when classifications and measures differ across studies, and differing conclusions can be made that are not necessarily justified. The area of motor functioning warrants further investigation, and follow-up studies of children would indicate whether the snapshot of

abilities taken at a specific point in time is predictive of later abilities in any of the three groups, given that children are still developing, and their hand preferences may change.

Severity of Autism

Contrary to predictions made by Kinsbourne (1988) ambiguous hand preference in children with autism is not related to severity of autism, either when looked at on a continuum or by discrete categories. Moreover, correlations between CARS scores and ability and hand preference measures, such as receptive verbal ability, cognitive ability, motor skills, strength of hand preference and consistency were all insignificant, indicating that severity of autism has no relationship at all to a child's abilities in a number of areas. This finding is surprising, in that one might expect that severity of autistic characteristics might imply a lower level of functioning. The results of this study dispute the fifth and final hypothesis of this study. A lack of relationship between severity of autism and hand preference might suggest that it is the very presence of autistic characteristics, sufficient to meet DSM-IV criteria, that is important to the development of handedness, as opposed to the particular degree of manifestation of autism characteristics. The behavioural presentation of each individual with autism is unique, and therefore, it seems increasingly likely that it is the constellation of characteristics, implicating specific but also variable patterns of cerebral dysfunction, that sets this group of individuals apart from groups of individuals with developmental delays.

Comparison of Questionnaire Data

One of the questions asked in the sociodemographic questionnaire which showed no significant difference between groups, was a comparison of siblings diagnosed with a chronic illness, learning disability, language disorder, attention problem and so on. There are several reports in the literature that have documented an increase in speech, language, cognitive or reading disorders in siblings of children with autism (for example, Bolton & Rutter, 1990), as well as a 50 times greater prevalence of autism in siblings than that found in the normal population. It is possible that the question used in the present study was not specific enough, and that the social and language abnormalities reported to be prevalent in the broader familial phenotype of autism, suggested by Rutter and colleagues, were missed. Further, a sample size of twenty children in each group may not have been large enough to pick up potential differences.

Analyses of individual questions regarding birth and pregnancy problems were generally unremarkable across groups. There was a trend for group differences on the question of mother taking medication during pregnancy, with mothers of delayed children having the most "yes" answers of the three groups, and the least "no" answers. This data should be interpreted with caution, because the group with the least data available was the children with developmental delays. The only other variable where there was a trend towards group differences was cyanosis in the newborn baby. There were no incidences of cyanosis in the normally developing children, one in the children with autism, and three in the children with developmental delays. The above cautions

apply to interpreting the cyanosis variable, as a similar lack of data for the children with developmental delays applies.

Limitations of the Study and Suggestions for Future Research

Autism is a relatively rare disorder in the general population, and hence the availability of possible participants is restricted. Given the devastating impact a diagnosis of autism can have on a family, many parents experience a high level of stress and workload, hence involvement in a research study is far from their top priority. However, despite the obstacles, the sample size used in this study is of comparable size to those reported in the published literature. In order to have a larger sample size a multi-site study would be required, or there would need to be collection of data over a longer period of time. That was not possible for this particular study.

A major limitation of the current study was the relatively small size of the hand preference groups when split by participant group. When comparisons were made according to definite hand preference versus no hand preference, the smallest group was the ambiguous handedness group of children with developmental delays (four children). It is possible that with larger groups of participants additional significant differences would have been found, and trends would have become statistically significant. Given the matching requirements, however, it was sometimes difficult to identify appropriate children with developmental delays, especially as the gap between mental and chronological age widened.

A second limitation of this study is that IQ scores could not be reported for the children with autism, and children with developmental delays. This was due to the difficulties of finding an appropriate instrument for the range of abilities shown by these groups. The instrument used for the majority of cognitive testing, the Bayley Scales of Infant Development - MDI, is frequently used with children with autism, and with children with significant developmental delays, but is not designed for the age range for which it is used (i.e., the Bayley only goes up to 36 months of age), hence there are no norms available to compute a standard score, although an age equivalent score can be determined. Age equivalent scores on cognitive tests have been used by Soper et al. (1987). Therefore, the use of age equivalent scores is not unheard of. The same situation arose for the PPVT-R scores, as many of the children with autism, and some of the children with developmental delays were scoring below the first percentile, and not achieving a standard score. With hindsight, the PLS-3 should have been used as the instrument of choice, but as the PLS-3 only has norms available up to 6 years and 11 months of age, the PPVT-R would have had to have been used for the older children.

A third limitation of this study was the uneven gender ratios in the groups. There were very few girls in both the groups of children with autism, and children with developmental delays, and few boys in the normally developing group of children. Previous research on hand preference has suggested that there may be sex differences in the development of hand preference. This was not able to be explored in the present study. A larger sample size would be required in order to look for reliable differences in hand preference and related abilities in respect to gender.

Additional studies were suggested by this research. Given the ages of the sample groups in this study, it would be of great research interest to follow these groups as their hand preference becomes more established, and examine whether verbal, cognitive and motor abilities change accordingly. If the children in the ambiguous handedness group move into the definite handedness group, it would be interesting to see if they are still behind in their verbal, cognitive, and motor abilities in comparison to the children that were already showing a definite hand preference. It has been noted in the literature that the early development of a hand preference may be a predictor of functioning later in life. To date no-one has followed a study group to explore this hypothesis. It would be important to early interventionists who work with children with autism in particular, to have an additional predictor of future functioning, and to also have a better conception of which children are more in need of physiotherapy and occupational therapy in order to increase the skills associated with the development of a hand preference. Whether it is possible to speed up the process of hand preference development, or intervene to turn an ambiguous handed child to a definite hander is unknown. Cornish and McManus (1996) hypothesized that ambiguous handedness is due to a lack of skill in that area, or lack of co-ordination. This suggests that it is possible to change an ambiguous hand preference to a definite hand preference given sufficient amount of practice to improve the consistency of responses made with one hand. That would constitute another area of research. Whether the change in hand preference classification through mechanical practice would improve language, cognitive, and global motor skills is also a suggested area for research.

A replication of this study is suggested, given that this is the first study to compare all three matched groups, looking at a variety of variables, measures and their interactions. An expansion of this study is also called for, using an expressive measure of language ability in addition to the receptive measure. Further exploration of the ambiguous groups would be especially informative, given that the acknowledgment of this group in the literature is a relatively new occurrence. The finding that the delayed children with ambiguous handedness showed a trend towards lower receptive ability warrants closer investigation.

Future research on hand preference in children with autism may try to separate the characteristics of autism, to examine their association with hand groups. Repetitive behaviours, and self abusive behaviour have been linked to degree of cognitive deficit. Given that bilateral brain dysfunction is implicated in autistic children with ambiguous handedness, and studies are increasingly pointing to lower cognitive functioning in this group of children, it might be expected that the children with ambiguous handedness would show increases in the repetitive autistic behaviours.

Studies that continue in this area of ambiguous handedness should collect detailed pregnancy and birth histories for the children, to strengthen or dispute the findings of increased complications surrounding the birth and early lives of these children.

Concluding Remarks

The results of this study support the hypothesis that children with autism who have not developed a definite hand preference have lower cognitive, receptive language,

and motor skills than children with autism who have developed a hand preference. The children with developmental delays and normally developing children also showed a tendency for lower scores in the ambiguous hand preference groups, but the difference was not as pronounced as seen in the children with autism. The lower levels of functioning in the ambiguous handed children with autism suggested a greater degree of brain dysfunction in these children. Hence, the literature that postulates bilateral insult, as opposed to unilateral insult, in children with autism with ambiguous handedness is supported. Severity of autism was not a factor associated with ambiguous handedness.

While further research is needed to explore additional deficits that may be associated with ambiguous handedness, and to replicate the results found here, this study has important implications. This research has suggested that children with autism who have a definite hand preference are functioning higher in a number of important areas than the group of children with autism who have not developed a hand preference. Further research which investigates whether early intervention can impact the development of hand preference, and if there is an associated increase in other abilities is needed. The results of this study also suggest that it is not a lower level of motor skills per se, that is causing ambiguous handedness in children with autism, as matched children with developmental delays, who did not differ from the children with autism in their level of fine and gross motor skills, show a much higher degree of definite hand preference.

REFERENCES

American Psychiatric Association. (1994). Diagnostic and statistical manual of mental disorders (4th ed.). Washington, DC: Author.

Annett, M. (1970). The growth of manual preference and speed. British Journal of Psychology, 61, 545-588.

Annett, M., & Turner, A. (1974). Laterality and the growth of intellectual abilities. British Journal of Educational Psychology, 44, 37-46.

Arnold, P., & Askew, S. (1993). Handedness distribution and figure drawing ability in a deaf school population, with severe learning difficulties: A research note. Journal of Child Psychology and Psychiatry, 34, 255-261.

Bailey, A., Phillips, W., & Rutter, M. (1996). Autism: Towards an integration of clinical, genetic, neuropsychological, and neurobiological perspectives. Journal of Child Psychology and Psychiatry, 37, 89-126.

Barry, R. J., & James, A. L. (1978). Handedness in autistics, retardates, and normals of a wide age range. Journal of Autism and Childhood Schizophrenia, 8, 315-321.

Batheja, M., & McManus, I. C. (1985). Handedness in the mentally handicapped. Developmental Medicine and Child Neurology, 27, 63-68.

Bayley, N. (1993). The Bayley Scales of Infant Development - Second Edition. San Antonio, TX: Psychological Corporation.

Beaumont, J. G. (1983). Introduction to neuropsychology. New York: Guilford Press.

Dewey, D. (1996). Manual asymmetries in children with developmental disabilities. In D. Eliot and E. R. Roy (Eds.), Manual asymmetries in motor performance (pp. 197-213).

Doll, E. A. (1965). Vineland Social Maturity Scale. Circle Pines, MN: American Guidance Service.

Douglas, J. W. B., Ross, J. M., & Cooper, J. E. (1967). The relationship between handedness, attainment, and adjustment in a national sample of school children. Educational Research, 9, 223-232.

DuBose, R. F., & Langley, M. B. (1977). Developmental Activities Screening Inventory (DASI). Hingham, MA: Teaching Resources Corporation.

Dunn, L. M., & Dunn, L. M. (1981). The Peabody Picture Vocabulary Test - Revised. Circle Pines, MN: American Guidance Service.

Fein, D., Humes, M., Kaplan, E., Lucci, D., & Waterhouse, L. (1984). The question of left-hemisphere dysfunction in infantile autism. Psychological Bulletin, 95, 258-281.

Fein, D., Pennington, B., Markowitz, P., Braverman, M., & Waterhouse, L. (1986). Towards a neuropsychological model of infantile autism: Are the social deficits primary? Journal of the American Academy of Child Psychiatry, 25, 198-212.

Fein, D., Waterhouse, L., Lucci, D., Pennington, B., & Humes, M. (1985). Handedness and cognitive functions in pervasive developmental disorders. Journal of Autism and Developmental Disorders, 15, 77-95.

Gabbard, C., Hart, S., & Gentry, V. (1995a). General motor proficiency and handedness in children. Journal of Genetic Psychology, 156, 411-416.

Gabbard, C., Hart, S., & Gentry, V. (1995b). A note on trichotomous classification of handedness and fine-motor performance in children. Journal of Genetic Psychology, 156, 97-104.

Gabbard, C., Hart, S., & Kanipe, D. (1993). Hand preference consistency and fine motor performance in young children. Cortex, 29, 746-753.

Gesell, A., & Ames, L. B. (1947). The development of handedness. Journal of Genetic Psychology, 70, 155-175.

Gillberg, C. (1983). Autistic children's hand preference: Results form an epidemiological study of infantile autism. Psychiatry Research, 10, 21-30.

Hardyck, C., & Petrinovich, L. F. (1977). Left handedness. Psychological Bulletin, 84, 385-404.

Harris L. J., & Carlson, D. F. (1988). Pathological left-handedness: An analysis of theories and evidence. In D. C. Molfese & S. J. Segalowitz (Eds.), Brain lateralization in children: Developmental implications (pp. 289-372). New York: Guilford Press.

Hauser, S. L., DeLong, G. R., & Rosman, N. P. (1975). Pneumographic findings in the infantile autism syndrome. Brain, 98, 667-688.

Henderson, S. E., & Sugden, D. A. (1992). The Movement Assessment Battery for Children Checklist. San Antonio, TX: Psychological Corporation.

Hepper, P. G., Shahidullah, S., & White, R. (1991). Handedness in the human fetus. Neuropsychologia, 29, 1107-1111.

Hicks, R. E., & Barton, A. K. (1975). A note on left-handedness and severity of mental retardation. Journal of Genetic Psychology, 127, 323-324.

Hicks, R. E., & Kinsbourne, M. (1976). On the genesis of human handedness: a review. Journal of Motor Behavior, 8, 257-266.

Hobson, R. P. (1991). Methodological issues for experiments on autistic individual's perception and understanding of emotion. Journal of Child Psychology and Psychiatry, 32, 1135-1158.

Hobson, R. P., & Lee, A. (1989). Emotion-related and abstract concepts in autistic people: Evidence from the British Picture Vocabulary Scale. Journal of Autism and Developmental Disorders, 19, 601-623.

Kaufman, A. S., Zalma, R., & Kaufman, N. L. (1978). The relationship of hand dominance to the motor coordination, mental ability, and right-left awareness of young normal children. Child Development, 49, 885-888.

Kinsbourne, M. (1987). Cerebral-brainstem relations in infantile autism. In E. Schopler & G. B. Mesibov (Eds.), Neurobiological issues in autism (pp. 107-125). New York: Plenum.

Kinsbourne, M. (1988). Sinistrality, brain organization, and cognitive deficits. In D. L. Molfese, & S. J. Segalowitz (Eds.), Brain lateralization in children (pp. 259-279). New York: Guilford Press.

Klinger, L. G., & Dawson, G. (1996). Autistic Disorder. In E. J. Mash & R. A. Barkley (Eds.), Child Psychopathology (pp. 311-339). New York: Guilford.

Kolb, B., & Whishaw, I. Q. (1985) Fundamentals of human neuropsychology (2nd ed.). New York: W. H. Freeman and Company.

Leboyer, M., Osherson, D. N., Nosten, M., & Roubertoux, P. (1988). Is autism associated with anomalous dominance? Journal of Autism and Developmental Disorders. 18, 539-551.

Levine, M. D. (1980). The Anser System Parent Questionnaire, Form 2P. Cambridge: Education Publishing Service.

Lord, C., Schopler, E., & Revicki, D. (1982). Intellectual and developmental assessment of autistic children from pre-school to school age. In E. Schopler & G. Mesibov (Eds.), Diagnosis and assessment in autism (pp. 167-181). New York: Plenum Press.

Lucas, J. A., Rosenstein, L. D., & Bigler, E. D. (1989). Handedness and language among the mentally retarded: Implications for the model of pathological left-handedness and gender differences in hemispheric specialization. Neuropsychologia, 27, 713-723.

McCarthy, D. (1972). Manual for the McCarthy Scales of Children's Abilities. San Antonio, TX: Psychological Corporation.

McManus, I. C., Sik, G., Cole, D. R., Mellon, A. F., Wong, J., & Kloss, J. (1988). The development of handedness in children. British Journal of Developmental Psychology, 6, 257-273.

Manjiviona, J., & Prior, M. (1995). Comparison of Asperger Syndrome and high-functioning autistic children on a test of motor impairment. Journal of Autism and

Developmental Disorders, 25, 23-39.

Morris, R. D., & Romski, M. A. (1993). Handedness distribution in a nonspeaking population with mental retardation. American Journal on Mental Retardation, 97, 443-448.

Newborg, J., Stock, J. R., Wnek, L., Guidubaldi, J., & Svinicki, J. (1984). The Battelle Development Inventory. Chicago: Riverside Publishing.

Newcombe, F. G., Ratcliff, G. G., Carrivick, P. J., Hiorns, R. W., Harrison, G. A. & Gibson, J. B. (1975). Hand preference and IQ in a group of Oxfordshire villages. Annals of Human Biology, 2, 235-242.

Obrzut, J. E. (1988). Deficient lateralization in learning-disabled children: Developmental lag or abnormal cerebral organization? In D. C. Molfese & S. J. Segalowitz (Eds.), Brain lateralization in children: Developmental implications (pp. 567-590). New York: Guilford Press.

Pipe, M-E. (1990). Mental retardation and left-handedness: Evidence and theories. In S. Coren (Ed.), Left handedness (pp. 293-318). Amsterdam: Elsevier Science Publishers B.V.

Rasmussen, T., & Milner, B. (1977). The role of early left-brain injury in determining lateralization of cerebral speech functions. In S. Dimond, & D. Blizard (Eds.), Evolution and lateralization of the brain (pp. 355-369). New York: New York Academy of Sciences.

Rimland, B. (1964). Infantile autism. New York: Appleton-Century-Crofts.

Ritvo, E., & Freeman, B. (1978). National Society for Autistic Children definition of the syndrome of autism. Journal of Autism and Childhood Schizophrenia, 8, 162-167.

Ross, G., Lipper, E.G., & Auld, P. A. M. (1987). Hand preference in four-year-old children: Its relationship in premature birth and neurodevelopmental outcome. Developmental Medicine and Child Neurology, 29, 613-622.

Sattler, J. M. (1992). Assessment of children (Rev. 3rd ed.). San Diego, CA: Jerome M. Sattler, Publisher, Inc.

Satz, P., Soper, H. V., & Orsini, D. L. (1988). Human hand preference: Three nondextral subtypes. In D. C. Molfese & S. J. Segalowitz (Eds.), Brain lateralization in children: Developmental implications (pp. 281-287). New York: Guilford Press.

Satz, P., Soper, H. V., Orsisni, D. L., Henry, R. R., & Zvi, J. C. (1985). Handedness subtypes in autism. Psychiatric Annals, 15, 447-450.

Schopler, E., Reichler, R. J., & Renner, B. R. (1986). The Childhood Autism Rating Scale (CARS). New York: Irvington.

Semel, E., Wiig, E. S., & Secord, W. A. (1987). Clinical Evaluation of Language Fundamental - Revised (CELF-R). San Antonio, TX: Psychological Corporation.

Smalley, S., Asarnow, R., & Spence, M. (1989). Autism and genetics: A decade of research. Archives of General Psychiatry, 45, 953-961.

Soper, H. V., Satz, P., Orsini, D. L., Henry, R. R., Zvi, J. C., & Schulman, M. (1986). Handedness patterns in autism suggest subtypes. Journal of Autism and Developmental Disorders, 16, 155-167.

Soper, H. V., Satz, P., Orsini, D. L., Van Gorp, W. G., & Green, M. F. (1987). Handedness distribution on a residential population with severe or profound mental retardation. American Journal of Mental Deficiency, 92, 94-102.

Sparrow, S. S., Balla, D. A., & Cicchetti, D. V. (1984). Vineland Adaptive Behavior Scales. Circle Pines, MN: American Guidance Service.

Tager-Flusberg, H. (1985). Basic level and superordinate level categorization by autistic, mentally retarded and normal children. Journal of Experimental Child Psychology, 40, 450-469.

Thorndike, R. L., Hagen, E. P., & Sattler, J. M. (1986). Guide for administering and scoring, the Stanford-Binet Intelligence Scale: Fourth Edition (SB:FE). Chicago: Riverside Publishing.

Tsai, L. Y. (1982). A brief report: Handedness in autistic children and their families. Journal of Autism and Developmental Disorders, 12, 421-423.

Tsai, L. Y. (1983). The relationship of handedness to the cognitive, language and visuo-spatial skills of autistic patients. British Journal of Psychiatry, 142, 156-162.

Tsai, L. Y. (1987). Pre-, peri-, and neonatal factors in autism. In E. Schopler & G. B. Mesibov (Eds.), Neurobiological issues in autism (pp. 107-125). New York: Plenum.

Wing, L., & Gould, J. (1979). Severe impairments of social interaction and associated abnormalities in children: Epidemiology and classification. Journal of Autism and Developmental Disorders, 9, 11-29.

Zimmerman, I. L., Steiner, V. G., & Pond, R. E. (1992). The Preschool Language Scale - 3 (PLS-3). San Antonio, TX: Psychological Corporation.

Zittel, L. L. (1994). Gross motor assessment of pre-school children with special needs: Instrument selection considerations. Adapted Physical Activity Quarterly, 11, 245-260.

APPENDIX A: Letter to Parents in the Autism Calgary Association

December 1996

Programme in Clinical Psychology
Ed B 292
University of Calgary

Dear Parents,

We would like to invite you and your child to participate in a study that we are conducting through the University of Calgary and the Alberta Children's Hospital. Researchers at the University of Calgary and the Children's Hospital are conducting a study examining hand preference, ability to understand spoken language, intelligence and motor skills of children with autism. Past research has indicated that there is a group of children with autism who do not develop a hand preference as they get older. This study aims to identify how hand preference (i.e., right, left or no hand preference) may be related to intellectual, verbal and motor skills in children with autism, in comparison to delayed and normally developing children.

The researchers are looking for children, and their parents to be part of this study.

What would we ask of your child? For the study, each child will be observed on simple activities to determine hand preference. Intellectual, verbal and motor skills will also be assessed. However, if there has been recent testing of your child through their program, this data can be taken from their file. Therefore, where current data is already available, there will be little conducted in the way of assessment of your child. If there is no information available that is being looked at in this study, testing and observation of your child will take approximately 2 hours in total, which will be spread out over several occasions where required by the needs of the child. Your child can be assessed at The Society for Treatment of Autism, the Alberta Children's Hospital, the University of Calgary or a suitable location that is more convenient for you (also at home if that is more convenient).

What would we ask of you? One parent in the family will be asked to complete questionnaires about their child's motor skills, any pregnancy or birth complications, hand preference within the family, and general socio-demographic information. The questionnaires should take between 30 to 60 minutes to complete.

If you are willing for your child to take part in the study, please complete the enclosed consent form. After you have returned the form, the questionnaires will be sent to you to complete and return. Participation in this study is entirely voluntary. If you have further questions or concerns please contact Dr. Deborah Dewey or Joy Hauck at

229-7365.

Thank you for your time and co-operation.

Joy Hauck, B.Sc.(Hons)
Clinical Psychology Graduate Student
University of Calgary

Deborah Dewey, Ph.D.
Assistant Professor
University of Calgary

APPENDIX B: Consent Form for the Children with Autism recruited through the Autism Calgary Association

CONSENT FORM

RESEARCH PROJECT: Hand preference, receptive verbal ability, intelligence and motor functioning in children with autism.

INVESTIGATORS: Joy Hauck, B.Sc. (Hons), and Deborah Dewey, Ph.D.
University of Calgary and Alberta Children's Hospital

This consent form is only part of the process of informed consent. A copy of this form has been provided for you to keep, and a photocopy of this completed form will also be given to the agency your child attends, in order for them to release pertinent information from your child's file to the researchers. This form should give you the basic idea of what the research project is about and what your participation will involve. If you would like more details about something that is mentioned here, or information not included, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

This research is being conducted to meet the thesis requirements of the principal investigator (Joy Hauck) for an M.Sc. degree at the University of Calgary. Supervision will be provided by Deborah Dewey, PhD, Chartered Psychologist in the Department of Pediatrics, University of Calgary. The main purpose of this project is to examine the relationship between hand preference, intelligence, verbal ability and motor skills in children with autism, in comparison to children who are developmentally delayed, and to children who are developing normally.

Your child will be given a Hand Preference Demonstration Test, where the child's hand preference on several simple activities will be observed. Your child will also be assessed regarding their intelligence level, receptive verbal ability and motor skills. However, if any elements of this testing have been performed recently, the results will be obtained from you in order to keep assessment and possible disruption to your child's routine to a minimum. Therefore, we also ask your permission to have access to your child's file at their current place of education or agency where they were tested. Where there are no current test results available, testing will take approximately 2 hours, split into shorter sessions over several days. Parents will also be asked to complete questionnaires about their child's motor skills, possible pregnancy and birth complications, hand preferences within the family, and general socio-demographic information questions. Completion of these questionnaires should take approximately 30 to 60 minutes of your time in total.

Your child and family may benefit from participating in this study, as any information gathered during the project regarding your child may be made available to their agency if you desire, and thus may be used in regards to program planning. Separate written consent to release test results to the child's agency is required from you, should you wish them to receive the information. Feedback regarding your child's abilities noted during

the testing process will be made available to parents. Also by serving as a subject, you may contribute new information which may provide future benefit to children with autism.

All information collected during this study will be completely confidential and will be used for *research* purposes only by the principal investigators. The results of the research will be reported as group data so that no individual identities will be revealed. Neither your name nor identity will be used for publication or publicity purposes. Information will be kept in a locked filing cabinet and will be destroyed after five years of completion of the research project. A summary of the study's results will be mailed to you upon completion of the study.

Your signature on this form indicates that you have understood to your satisfaction the information regarding taking part in this study, and agree to your child's participation. In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw your child from the study at any time without jeopardizing your child's services and care. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout the study. If you have further questions concerning matters related to this research, please contact Joy Hauck at (403) 279-7574.

If you have any questions about your child's rights or your rights as a possible participant in this research, please contact the Office of Medical Bioethics, Faculty of Medicine, The University of Calgary, at 220-7990.

_____	_____
(Name of Child)	(Date)
_____	_____
(Name of Parent or Legal Guardian)	(Signature of Parent or Legal Guardian)
_____	_____
(Name of Witness)	(Signature of Witness)
Joy Hauck	_____
Name of Investigator	(Signature of Investigator)

A copy of this consent form is provided for you. Please keep it for your records and

future reference.

The investigator will, as appropriate, explain to your child his or her involvement, and will seek his or her ongoing co-operation throughout the project. If your child is able to sign or mark their assent to their involvement in this project, please have them complete the line below:

_____

(Signature of Child)

Please note that the principal investigator will ensure that breaks during testing will be provided for your child when needed (based on the child's behavioural presentation).

APPENDIX C: Letter to Parents of Children who Previously Attended the Society for Treatment of Autism

September 1996

Programme in Clinical Psychology
Ed B 292
University of Calgary

Dear Parents,

The Society for Treatment of Autism has been kind enough to send this to you, so that we may invite you and your child to participate in a study that we are conducting through the University of Calgary and the Alberta Children's Hospital. Researchers at the University of Calgary and the Children's Hospital are conducting a study examining hand preference, ability to understand spoken language, intelligence and motor skills of children with autism. Past research has indicated that there is a group of children with autism who do not develop a hand preference as they get older. This study aims to identify how hand preference (i.e., right, left or no hand preference) may be related to intellectual, verbal and motor skills in children with autism, in comparison to delayed and normally developing children.

The researchers are looking for children, and their parents to be part of this study.

What would we ask of your child? For the study, each child will be observed on simple activities to determine hand preference. Intellectual, verbal and motor skills will also be assessed. However, if there has been recent testing of your child through their program, this data can be taken from their file. Therefore, where current data is already available, there will be little conducted in the way of assessment of your child. If there is no information available that is being looked at in this study, testing and observation of your child will take approximately 2 hours in total, which will be spread out over several occasions where required by the needs of the child. Your child will be assessed at The Society for Treatment of Autism, the Alberta Children's Hospital, or the University of Calgary or a suitable location that is more convenient for you. The principal researcher of this project - Joy Hauck - previously worked in the Early Intervention Program before being accepted into graduate school, therefore some of the children who have been in EIP will be familiar with Joy.

What would we ask of you? One parent in the family will be asked to complete questionnaires about their child's motor skills, any pregnancy or birth complications, hand preference within the family, and general socio-demographic information. The questionnaires should take between 30 to 60 minutes to complete.

If you are willing for your child to take part in the study, please complete the

enclosed consent form. After you have returned the form, the questionnaires will be sent to you to complete and return. Participation in this study is entirely voluntary. If you have further questions or concerns please contact Dr. Deborah Dewey or Joy Hauck at 229-7365.

Thank you for your time and co-operation.

Joy Hauck, B.Sc.(Hons)
Clinical Psychology Graduate Student
University of Calgary

Deborah Dewey, Ph.D.
Assistant Professor
University of Calgary

APPENDIX D: Consent form for Children who Previously Attended the Society for Treatment of Autism

CONSENT FORM

RESEARCH PROJECT: Hand preference, receptive verbal ability, intelligence and motor functioning in children with autism.

INVESTIGATORS: Joy Hauck, B.Sc. (Hons), and Deborah Dewey, Ph.D.
University of Calgary and Alberta Children's Hospital

This consent form is only part of the process of informed consent. A copy of this form has been provided for you to keep, and a photocopy of this completed form will also be given to the agency your child attends, in order for them to release pertinent information from your child's file to the researchers. This form should give you the basic idea of what the research project is about and what your participation will involve. If you would like more details about something that is mentioned here, or information not included, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

This research is being conducted to meet the thesis requirements of the principal investigator (Joy Hauck) for an M.Sc. degree at the University of Calgary. Supervision will be provided by Deborah Dewey, PhD, Chartered Psychologist in the Department of Pediatrics, University of Calgary. The main purpose of this project is to examine the relationship between hand preference, intelligence, verbal ability and motor skills in children with autism, in comparison to children who are developmentally delayed, and to children who are developing normally.

Your child will be given a Hand Preference Demonstration Test, where the child's hand preference on several simple activities will be observed. Your child will also be assessed regarding their intelligence level, receptive verbal ability and motor skills. However, if any elements of this testing have been performed recently, the results will be obtained from your child's file in order to keep assessment and possible disruption to your child's routine to a minimum. Therefore, we also ask your permission to have access to your child's file at The Society for Treatment of Autism, or their current place of education. Where there are no current test results available from your child's agency, testing will take approximately 2 hours, split into shorter sessions over several days. Parents will also be asked to complete questionnaires about their child's motor skills, possible pregnancy and birth complications, hand preferences within the family, and general socio-demographic information questions. Completion of these questionnaires should take approximately 30 to 60 minutes of your time in total.

Your child and family may benefit from participating in this study, as any information gathered during the project regarding your child may be made available to their agency if you desire, and thus may be used in regards to program planning. Separate written consent to release test results to the child's agency is required from you, should you wish

them to receive the information. Feedback regarding your child's abilities noted during the testing process will be made available to parents. Also by serving as a subject, you may contribute new information which may provide future benefit to children with autism.

All information collected during this study will be completely confidential and will be used for *research* purposes only by the principal investigators. The results of the research will be reported as group data so that no individual identities will be revealed. Neither your name nor identity will be used for publication or publicity purposes. Information will be kept in a locked filing cabinet and will be destroyed after five years of completion of the research project. A summary of the study's results will be mailed to you upon completion of the study.

Your signature on this form indicates that you have understood to your satisfaction the information regarding taking part in this study, and agree to your child's participation. In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw your child from the study at any time without jeopardizing your child's services and care. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout the study. If you have further questions concerning matters related to this research, please contact Joy Hauck at (403) 279-7574.

If you have any questions about your child's rights or your rights as a possible participant in this research, please contact the Office of Medical Bioethics, Faculty of Medicine, The University of Calgary, at 220-7990.

_____	_____
(Name of Child)	(Date)
_____	_____
(Name of Parent or Legal Guardian)	(Signature of Parent or Legal Guardian)
_____	_____
(Name of Witness)	(Signature of Witness)
Joy Hauck	_____
Name of Investigator	(Signature of Investigator)

A copy of this consent form is provided for you. Please keep it for your records and future reference.

The investigator will, as appropriate, explain to your child his or her involvement, and will seek his or her ongoing co-operation throughout the project. If your child is able to sign or mark their assent to their involvement in this project, please have them complete the line below:

_____

(Signature of Child)

Please note that the principal investigator will ensure that breaks during testing will be provided for your child when needed (based on the child's behavioural presentation).

APPENDIX E: Letter to Parents with Children in the Early Intervention Program, at the Society for the Treatment of Autism

September 1996

Programme in Clinical Psychology
Ed B 292
University of Calgary

Dear Parents,

The Society for Treatment of Autism has been kind enough to send this to you, so that we may invite you and your child to participate in a study that we are conducting through the University of Calgary and the Alberta Children's Hospital. Researchers at the University of Calgary and the Children's Hospital are conducting a study examining hand preference, ability to understand spoken language, intelligence and motor skills of children with autism. Past research has indicated that there is a group of children with autism who do not develop a hand preference as they get older. This study aims to identify how hand preference (i.e., right, left or no hand preference) may be related to intellectual, verbal and motor skills in children with autism, in comparison to delayed and normally developing children.

The researchers are looking for children, and their parents to be part of this study.

What would we ask of your child? For the study, each child will be observed on simple activities to determine hand preference. Intellectual, verbal and motor skills will also be assessed. However, if there has been recent testing of your child through their program, this data can be taken from their file. Therefore, where current data is already available, there will be little conducted in the way of assessment of your child. If there is no information available that is being looked at in this study, testing and observation of your child will take approximately 2 hours in total, which will be spread out over several occasions so that your child's routine has a minimum of disruption. Your child will be assessed at The Society for Treatment of Autism, and you will be notified in advance of when your child will be tested. The principal researcher of this project - Joy Hauck - previously worked in the Early Intervention Program before being accepted into graduate school, therefore some of the children in EIP will be familiar with Joy.

What would we ask of you? One parent in the family will be asked to complete questionnaires about their child's motor skills, any pregnancy or birth complications, hand preference within the family, and general socio-demographic information. The questionnaires should take between 30 to 60 minutes to complete.

If you are willing for your child to take part in the study, please complete the enclosed consent form. After you have returned the form, the questionnaires will be sent

to you to complete and return. Participation in this study is entirely voluntary. If you have further questions or concerns please contact Dr. Deborah Dewey or Joy Hauck at 229-7365.

Thank you for your time and co-operation.

Joy Hauck, B.Sc.(Hons)
Clinical Psychology Graduate Student
University of Calgary

Deborah Dewey, Ph.D.
Assistant Professor
University of Calgary

APPENDIX F: Consent Form for Children with Autism in the Early Intervention Program, at the Society for the Treatment of Autism

CONSENT FORM

RESEARCH PROJECT: Hand preference, receptive verbal ability, intelligence and motor functioning in children with autism.

INVESTIGATORS: Joy Hauck, B.Sc. (Hons), and Deborah Dewey, Ph.D.
University of Calgary and Alberta Children's Hospital

This consent form is only part of the process of informed consent. A copy of this form has been provided for you to keep, and a photocopy of this completed form will also be given to the agency your child attends, in order for them to release pertinent information from your child's file to the researchers. This form should give you the basic idea of what the research project is about and what your participation will involve. If you would like more details about something that is mentioned here, or information not included, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

This research is being conducted to meet the thesis requirements of the principal investigator (Joy Hauck) for an M.Sc. degree at the University of Calgary. Supervision will be provided by Deborah Dewey, PhD, Chartered Psychologist in the Department of Pediatrics, University of Calgary. The main purpose of this project is to examine the relationship between hand preference, intelligence, verbal ability and motor skills in children with autism, in comparison to children who are developmentally delayed, and to children who are developing normally.

Your child will be given a Hand Preference Demonstration Test, where the child's hand preference on several simple activities will be observed. Your child will also be assessed regarding their intelligence level, receptive verbal ability and motor skills. However, if any elements of this testing have been performed recently, the results will be obtained from your child's file in order to keep assessment and possible disruption to your child's routine to a minimum. Therefore, we also ask your permission to have access to your child's file at The Society for Treatment of Autism. Where there are no current test results available from your child's agency, testing will take approximately 2 hours, split into shorter sessions over several days. Parents will also be asked to complete questionnaires about their child's motor skills, possible pregnancy and birth complications, hand preferences within the family, and general socio-demographic information questions. Completion of these questionnaires should take approximately 30 to 60 minutes of your time in total.

Your child and family may benefit from participating in this study, as any information gathered during the project regarding your child may be made available to their agency if you desire, and thus may be used in regards to program planning. Separate written consent to release test results to the child's agency is required from you, should you wish

them to receive the information. Feedback regarding your child's abilities noted during the testing process will be made available to parents. Also by serving as a subject, you may contribute new information which may provide future benefit to children with autism.

All information collected during this study will be completely confidential and will be used for *research* purposes only by the principal investigators. The results of the research will be reported as group data so that no individual identities will be revealed. Neither your name nor identity will be used for publication or publicity purposes. Information will be kept in a locked filing cabinet and will be destroyed after five years of completion of the research project. A summary of the study's results will be mailed to you upon completion of the study.

Your signature on this form indicates that you have understood to your satisfaction the information regarding taking part in this study, and agree to your child's participation. In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw your child from the study at any time without jeopardizing your child's services and care. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout the study. If you have further questions concerning matters related to this research, please contact Joy Hauck at (403) 279-7574.

If you have any questions about your child's rights or your rights as a possible participant in this research, please contact the Office of Medical Bioethics, Faculty of Medicine, The University of Calgary, at 220-7990.

_____	_____
(Name of Child)	(Date)
_____	_____
(Name of Parent or Legal Guardian)	(Signature of Parent or Legal Guardian)
_____	_____
(Name of Witness)	(Signature of Witness)
Joy Hauck	_____
Name of Investigator	(Signature of Investigator)

A copy of this consent form is provided for you. Please keep it for your records and future reference.

The investigator will, as appropriate, explain to your child his or her involvement, and will seek his or her ongoing co-operation throughout the project. If your child is able to sign or mark their assent to their involvement in this project, please have them complete the line below:

_____

(Signature of Child)

Please note that the principal investigator will ensure that breaks during testing will be provided for your child when needed (based on the child's behavioural presentation).

APPENDIX G: Letter to Parents of Children with Developmental Delays at Providence Children's Centre

September 1996

Programme in Clinical Psychology
Ed B 292
University of Calgary

Dear Parents,

Providence Children's Centre has been kind enough to send this to you, so that we may invite you and your child to participate in a study that we are conducting through the University of Calgary and the Alberta Children's Hospital. Researchers at the University of Calgary and the Children's Hospital are conducting a study examining hand preference, ability to understand spoken language, intelligence and motor skills of children with autism. Past research has indicated that there is a group of children with autism who do not develop a hand preference as they get older. This study aims to identify how hand preference (i.e., right, left or no hand preference) may be related to intellectual, verbal and motor skills in children with autism, in comparison to developmentally delayed and normally developing children.

The researchers are looking for children, and their parents to be part of this study.

What would we ask of your child? For the study, each child will be observed on simple activities to determine hand preference. Intellectual, verbal and motor skills will also be assessed. However, if there has been recent testing of your child through their program, this data can be taken from their file. Therefore, where current data is already available, there will be little conducted in the way of assessment of your child. If there is no information available that is being looked at in this study, testing and observation of your child will take approximately 2 hours in total, which will be spread out over several occasions so that your child's routine has a minimum of disruption. Your child will be assessed at the Providence Children's Centre, and you will be notified in advance of when your child will be assessed.

What would we ask of you? One parent in the family will be asked to complete questionnaires about their child's motor skills, any pregnancy or birth complications, hand preference within the family, and general socio-demographic information. The questionnaires should take between 30 to 60 minutes to complete.

If you are willing for your child to take part in the study, and would like more

information, please complete the information overpage and return it to Providence. You will then be contacted regarding consent forms and the questionnaires will be sent to you.

You may withdraw your participation in the study *at any time*. Participation in this study is entirely voluntary. If you have further questions or concerns please contact Dr. Deborah Dewey or Joy Hauck at 229-7365.

Thank you for your time and co-operation.

Joy Hauck, B.Sc.(Hons)
Clinical Psychology Graduate Student
University of Calgary

Deborah Dewey, Ph.D.
Assistant Professor
University of Calgary

I am interested in receiving more information about the research study on hand preference and other skills.

Child's name_____

Parent's name_____

Daytime telephone # _____

Evening telephone # _____

APPENDIX H: Consent Form for Children with Developmental Delays at Providence Children's Centre

CONSENT FORM

RESEARCH PROJECT: Hand preference, receptive verbal ability, intelligence and motor functioning in children with autism.

INVESTIGATORS: Joy Hauck, B.Sc. (Hons), and Deborah Dewey, Ph.D.
University of Calgary and Alberta Children's Hospital

This consent form is only part of the process of informed consent. A copy of this form has been provided for you to keep, and a photocopy of this completed form will also be given to the agency your child attends, in order for them to release pertinent information from your child's file to the researchers. This form should give you the basic idea of what the research project is about and what your participation will involve. If you would like more details about something that is mentioned here, or information not included, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

This research is being conducted to meet the thesis requirements of the principal investigator (Joy Hauck) for an M.Sc. degree at the University of Calgary. Supervision will be provided by Deborah Dewey, PhD, Chartered Psychologist in the Department of Pediatrics, University of Calgary. The main purpose of this project is to examine the relationship between hand preference, intelligence, verbal ability and motor skills in children with autism, in comparison to children who are developmentally delayed, and to children who are developing normally.

Your child will be given a Hand Preference Demonstration Test, where the child's hand preference on several simple activities will be observed. Your child will also be assessed regarding their intelligence level, receptive verbal ability and motor skills. However, if any elements of this testing have been performed recently, the results will be obtained from your child's file in order to keep assessment and possible disruption to your child's routine to a minimum. Therefore, we also ask your permission to have access to your child's file at Providence Children's Centre or the agency where they were tested. Where there are no current test results available, testing will take approximately 2 hours, split into shorter sessions over several days. All testing will take place at the Providence Children's Centre. Parents will also be asked to complete questionnaires about their child's motor skills, possible pregnancy and birth complications, hand preferences within the family, and general socio-demographic information questions. Completion of these questionnaires should take approximately 30 to 60 minutes of your time in total.

Your child and family may benefit from participating in this study, as any information gathered during the project regarding your child may be made available to their agency if you desire, and thus may be used in regards to program planning. Separate written consent to release test results to the child's agency is required from you, should you wish

them to receive the information. Feedback regarding your child's abilities noted during the testing process will be made available to parents.

All information collected during this study will be completely confidential and will be used for *research* purposes only by the principal investigators. The results of the research will be reported as group data so that no individual identities will be revealed. Neither your name nor identity will be used for publication or publicity purposes. Information will be kept in a locked filing cabinet and will be destroyed after five years of completion of the research project. A summary of the study's results will be mailed to you upon completion of the study.

Your signature on this form indicates that you have understood to your satisfaction the information regarding taking part in this study, and agree to your child's participation. In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw your child from the study at any time without jeopardizing your child's services and care. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout the study. If you have further questions concerning matters related to this research, please contact Joy Hauck at (403) 279-7574.

If you have any questions about your child's rights or your rights as a possible participant in this research, please contact the Office of Medical Bioethics, Faculty of Medicine, The University of Calgary, at 220-7990.

_____	_____
(Name of Child)	(Date)
_____	_____
(Name of Parent or Legal Guardian)	(Signature of Parent or Legal Guardian)
_____	_____
(Name of Witness)	(Signature of Witness)
Joy Hauck	_____
Name of Investigator	(Signature of Investigator)

A copy of this consent form is provided for you. Please keep it for your records and future reference.

The investigator will, as appropriate, explain to your child his or her involvement, and will seek his or her ongoing co-operation throughout the project. If your child is able to sign or mark their assent to their involvement in this project, please have them complete the line below:

_____

(Signature of Child)

Please note that the principal investigator will ensure that breaks during testing will be provided for your child when needed (based on the child's behavioural presentation).

APPENDIX I: Letter to Parents of Children with Developmental Delays Recruited Through the Alberta Children's Hospital

March 1997

Programme in Clinical Psychology
Ed B 292
University of Calgary

Dear Parents,

Thank you for provisionally agreeing to participate in a study that we are conducting through the University of Calgary and the Alberta Children's Hospital. Researchers at the University of Calgary and the Children's Hospital are conducting a study examining hand preference, ability to understand spoken language, intelligence and motor skills of children with autism. Past research has indicated that there is a group of children with autism who do not develop a hand preference as they get older. This study aims to identify how hand preference (i.e., right, left or no hand preference) may be related to intellectual, verbal and motor skills in children with autism, in comparison to children who have been identified with delays in certain areas, and to normally developing children.

What would we ask of your child? For the study, each child will be observed on simple activities to determine hand preference. Intellectual, verbal and motor skills will also be assessed. However, if there has been recent testing of your child through the Children's Hospital or their place of education, this data can be taken from their file. Therefore, where current data is already available, there will be little conducted in the way of assessment of your child. If there is no information available that is being looked at in this study, testing and observation of your child will take approximately 2 hours in total, which will be divided into two sessions. Your child can be assessed at a suitable location that is convenient for you and your child, such as their place of education/agency (also at home if that is more convenient).

What would we ask of you? One parent in the family will be asked to complete questionnaires about their child's motor skills, any pregnancy or birth complications, hand preference within the family, and general socio-demographic information. The questionnaires should take between 30 and 60 minutes to complete.

If you are still willing for your child to take part in the study, please complete the enclosed consent form and the three questionnaires. You will be contacted by telephone by Joy within the next week to 10 days, regarding setting up a time to meet with your child, and collecting the consent form and questionnaires. Participation in this study is

entirely voluntary. If you have further questions or concerns please contact Dr. Deborah Dewey at 229-7365, or Joy Hauck at 279-7574.

Thank you for your time and co-operation.

Joy Hauck, B.Sc.(Hons)
Clinical Psychology Graduate Student
University of Calgary

Deborah Dewey, Ph.D.
Assistant Professor, University of Calgary
Behaviour Research Unit, ACH

APPENDIX J: Consent Form for Children with Developmental Delays Recruited Through the Alberta Children's Hospital

CONSENT FORM

RESEARCH PROJECT: Hand preference, receptive verbal ability, intelligence and motor functioning in children with autism.

INVESTIGATORS: Joy Hauck, B.Sc. (Hons), and Deborah Dewey, Ph.D.
University of Calgary and Alberta Children's Hospital

This consent form is only part of the process of informed consent. A copy of this form has been provided for you to keep. This form should give you the basic idea of what the research project is about and what your participation will involve. If you would like more details about something that is mentioned here, or information not included, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

This research is being conducted to meet the thesis requirements of the principal investigator (Joy Hauck) for an M.Sc. degree at the University of Calgary. Supervision will be provided by Deborah Dewey, Ph.D., Chartered Psychologist in the Department of Pediatrics, University of Calgary. The main purpose of this project is the examine the relationship between hand preference, intelligence, verbal ability and motor skills in children with autism, in comparison to children who are developmentally delayed, and to children who are developing normally.

Your child will be given a Hand Preference Demonstration Test, where the child's hand preference on several simple activities will be observed. Your child will also be assessed regarding their intelligence level, receptive verbal ability and motor skills. However, if any elements of this testing have been performed recently, the results can be obtained from your child's file at their place of education/agency, or from you, in order to keep assessment and possible disruption to your child's routine to a minimum. Therefore, we also ask your permission to have access to this information if it is available. Where there are no current test results available, testing will take approximately 2 hours in total, divided into two sessions. Testing will take place at a location most convenient for you and your child, for example, at your child's place of education/agency, or at home. Parents will also be asked to complete questionnaires about their child's motor skills, possible pregnancy and birth complications, hand preferences within the family, and general socio-demographic information questions. Completion of these questionnaires should take approximately 30 to 60 minutes of your time in total.

Your child and family may not personally benefit from participating in this study, but by serving as a subject, you and your child may contribute new information regarding hand preference in relation to intellectual, verbal, and motor skills. Testing results will be made available to parents of their child's performance, and if parents request, the results can also be made available to your child's place of education for use in program

planning.

All information collected during this study will be completely confidential and will be used for research purposes only by the principal investigators. The results of the research will be reported as group data so that no individual identities will be revealed. Neither your name nor identity will be used for publication or publicity purposes. Information will be kept in a locked filing cabinet and will be destroyed after five years of completion of the research project. A summary of the study's results will be mailed to you upon completion of the study. Should you wish that any individual or agency be informed of any test results, your written permission for release of information will be required.

Your signature on this form indicates that you have understood to your satisfaction the information regarding taking part in this study, and agree to your child's participation. In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw your child from the study at any time. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout the study. If you have further questions concerning matters related to this research, please contact Joy Hauck at (403) 279-7574.

If you have any questions about your child's rights or your rights as a possible participant in this research, please contact the Office of Medical Bioethics, Faculty of Medicine, The University of Calgary, at 220-7990.

_____	_____
(Name of Child)	(Date)
_____	_____
(Name of Parent or Legal Guardian)	(Signature of Parent or Legal Guardian)
_____	_____
(Name of Witness)	(Signature of Witness)
Joy Hauck	_____
(Name of Investigator)	(Signature of Investigator)

A copy of this consent form is provided for you. Please keep it for your records and future reference.

The principal investigator will, as appropriate, explain to your child his or her involvement, and will seek his or her ongoing co-operation throughout the project. If your child is of appropriate age to sign or mark their assent to involvement in this project, please have them complete the line below:

_____

(Signature of Child)

The investigator will be alert at all times to any gestures, and verbal or non-verbal signs from your child that they do not wish to be involved in a testing procedure, and they will be given a break or be withdrawn from testing at that time, and retested at a later occasion.

APPENDIX K: Letter to Parents of Normally Developing Children at Providence Children's Centre

April 1997

Programme in Clinical Psychology
Ed B 292
University of Calgary

Dear Parents,

Providence Children's Centre has been kind enough to send this to you, so that we may invite you and your child to participate in a study that we are conducting through the University of Calgary and the Alberta Children's Hospital. Researchers at the University of Calgary and the Children's Hospital are conducting a study examining hand preference, ability to understand spoken language, intelligence and motor skills of children with autism. Past research has indicated that there is a group of children with autism who do not develop a hand preference as they get older. This study aims to identify how hand preference (i.e., right, left or no hand preference) may be related to intellectual, verbal and motor skills in children with autism, in comparison to developmentally delayed and normally developing children. Your child would be part of the **normal comparison group.**

The researchers are looking for children, and their parents to be part of this study.

What would we ask of your child? For the study, each child will be observed on simple activities to determine hand preference. Intellectual, verbal and motor skills will also be assessed. However, if there has been recent testing of your child through their program, this data can be taken from their file. If there is no information available that is being looked at in this study, testing and observation of your child will take approximately 2 hours in total, which will be spread out over several occasions so that your child's routine has a minimum of disruption. Your child will be assessed at the Providence Children's Centre.

What would we ask of you? One parent in the family will be asked to complete questionnaires about their child's motor skills, any pregnancy or birth complications, hand preference within the family, and general socio-demographic information. The questionnaires should take between 30 and 60 minutes to complete.

If you are willing for your child to take part in the study, please complete **one** of the enclosed consent forms and return it to Providence. Please keep the other copy for your reference. The questionnaires for you to complete will be sent to you once the consent forms have been received. Please note that you may withdraw your child's participation in the study *at any time*. Participation in this study is entirely voluntary. If

you have further questions or concerns please contact Dr. Deborah Dewey or Joy Hauck at 229-7365.

Thank you for your time and co-operation.

Joy Hauck, B.Sc.(Hons)
Clinical Psychology Graduate Student
University of Calgary

Deborah Dewey, Ph.D.
Assistant Professor
University of Calgary

APPENDIX L: Consent Form for Normally Developing Children at Providence Children's Centre

CONSENT FORM

RESEARCH PROJECT: Hand preference, receptive verbal ability, intelligence and motor functioning in children with autism.

INVESTIGATORS: Joy Hauck, B.Sc. (Hons), and Deborah Dewey, Ph.D.
University of Calgary and Alberta Children's Hospital

This consent form is only part of the process of informed consent. A copy of this form has been provided for you to keep. This form should give you the basic idea of what the research project is about and what your participation will involve. If you would like more details about something that is mentioned here, or information not included, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

This research is being conducted to meet the thesis requirements of the principal investigator (Joy Hauck) for an M.Sc. degree at the University of Calgary. Supervision will be provided by Deborah Dewey, Ph.D., Chartered Psychologist in the Department of Pediatrics, University of Calgary. The main purpose of this project is the examine the relationship between hand preference, intelligence, verbal ability and motor skills in children with autism, in comparison to children who are developmentally delayed, and to children who are developing normally. Your child will be part of the **normal comparison group** of children.

Your child will be given a Hand Preference Demonstration Test, where the child's hand preference on several simple activities will be observed. Your child will also be assessed regarding their intelligence level, receptive verbal ability and motor skills. However, if any elements of this testing have been performed recently, the results can be obtained from you in order to keep assessment and possible disruption to your child's routine to a minimum. Therefore, we also ask your permission to have access to this information if it is available. Testing will take approximately 2 hours in total, spread out over several shorter sessions. **All testing will take place at the Providence Children's Centre.** Parents will also be asked to complete questionnaires about their child's motor skills, possible pregnancy and birth complications, hand preferences within the family, and general socio-demographic information questions. Completion of these questionnaires should take approximately 30 to 60 minutes of your time in total.

Your child and family may not personally benefit from participating in this study, but by serving as a subject, you and your child may contribute new information regarding hand preference in relation to intellectual, verbal, and motor skills. Testing results will be made available to parents of their child's performance.

All information collected during this study will be completely confidential and will be

used for research purposes only by the principal investigators. The results of the research will be reported as group data so that no individual identities will be revealed. Neither your name nor identity will be used for publication or publicity purposes. Information will be kept in a locked filing cabinet and will be destroyed after five years of completion of the research project. A summary of the study's results will be mailed to you upon completion of the study. Should you wish that any individual or agency be informed of any test results, your written permission for release of information will be required.

Your signature on this form indicates that you have understood to your satisfaction the information regarding taking part in this study, and agree to your child's participation. In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw your child from the study at any time. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout the study. If you have further questions concerning matters related to this research, please contact Joy Hauck at (403) 279-7574.

If you have any questions about your child's rights or your rights as a possible participant in this research, please contact the Office of Medical Bioethics, Faculty of Medicine, The University of Calgary, at 220-7990.

_____	_____
(Name of Child)	(Date)
_____	_____
(Name of Parent or Legal Guardian)	(Signature of Parent or Legal Guardian)
_____	_____
(Name of Witness)	(Signature of Witness)
Joy Hauck	_____
(Name of Investigator)	(Signature of Investigator)

A copy of this consent form is provided for you. Please keep it for your records and future reference.

The principal investigator will, as appropriate, explain to your child his or her

involvement, and will seek his or her ongoing co-operation throughout the project. If your child is of appropriate age to sign or mark their assent to involvement in this project, please have them complete the line below:

_____

(Signature of Child)

The investigator will be alert at all times to any gestures, and verbal or non-verbal signs from your child that they do not wish to be involved in a testing procedure, and they will be given a break or be withdrawn from testing at that time, and retested at a later occasion.

APPENDIX M: Letter to Parents of Normally Developing Children at the University Child Care Centre

November 1996

Programme in Clinical Psychology
Ed B 292
University of Calgary

Dear Parents,

The University Child Care Centre has been kind enough to send this to you, so that we may invite you and your child to participate in a study that we are conducting through the University of Calgary and the Alberta Children's Hospital. Researchers at the University of Calgary and the Children's Hospital are conducting a study examining hand preference, ability to understand spoken language, intelligence and motor skills of children with autism. Past research has indicated that there is a group of children with autism who do not develop a hand preference as they get older. This study aims to identify how hand preference (i.e., right, left or no hand preference) may be related to intellectual, verbal and motor skills in children with autism, in comparison to delayed and normally developing children. **YOUR CHILD WOULD BE PART OF THE COMPARISON GROUP OF NORMAL CHILDREN.**

The researchers are looking for children, and their parents to be part of this study.

What would we ask of your child? For the study, each child will be observed on simple activities to determine hand preference. Intellectual, verbal and motor skills will also be assessed. However, if there has been recent testing of your child on the tests to be used, the researchers will not repeat those tests. Therefore, where current data is already available, there will be little conducted in the way of assessment of your child. If there is no information available that is being looked at in this study, testing and observation of your child will take approximately 2 hours in total, which will be spread out over several occasions so that your child's routine has a minimum of disruption. Your child will be assessed at the Child Care Centre.

What would we ask of you? One parent in the family will be asked to complete questionnaires about their child's motor skills, any pregnancy or birth complications, hand preference within the family, and general socio-demographic information. The questionnaires should take between 30 and 60 minutes to complete.

If you are willing for your child to take part in the study, please complete the enclosed consent form. After you have returned the form, the questionnaires will be sent for you to complete and return. Participation in this study is entirely voluntary. If you have further questions or concerns please contact Dr. Deborah Dewey or Joy Hauck at

229-7365.

Thank you for your time and co-operation.

Joy Hauck, B.Sc.(Hons)
Clinical Psychology Graduate Student
University of Calgary

Deborah Dewey, Ph.D.
Assistant Professor
University of Calgary

APPENDIX N: Consent Forms for Normally Developing Children at the University Child Care Centre

CONSENT FORM

RESEARCH PROJECT: Hand preference, receptive verbal ability, intelligence and motor functioning in children with autism.

INVESTIGATORS: Joy Hauck, B.Sc. (Hons), and Deborah Dewey, Ph.D.
University of Calgary and Alberta Children's Hospital

This consent form is only part of the process of informed consent. A copy of this form has been provided for you to keep, and a photocopy of this completed form will be given to the agency involved with your child, in order for them to release any information that is relevant to this study. This form should give you the basic idea of what the research project is about and what your participation will involve. If you would like more details about something that is mentioned here, or information not included, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

This research is being conducted to meet the thesis requirements of the principal investigator (Joy Hauck) for an M.Sc. degree at the University of Calgary. Supervision will be provided by Deborah Dewey, PhD, Chartered Psychologist in the Department of Pediatrics, University of Calgary. The main purpose of this project is the examine the relationship between hand preference, intelligence, verbal ability and motor skills in children with autism, in comparison to children who are developmentally delayed, and to children who are developing normally. Your child will be part of the **normal comparison group** of children.

Your child will be given a Hand Preference Demonstration Test, where the child's hand preference on several simple activities will be observed. Your child will also be assessed regarding their intelligence level, receptive verbal ability and motor skills. However, if any elements of this testing have been performed recently, the results can be obtained from you in order to keep assessment and possible disruption to your child's routine to a minimum. Therefore, we also ask your permission to have access to this information if it is available. Testing will take approximately 2 hours in total, spread out over several shorter sessions. Testing will take place in the University Child Care Centre. Parents will also be asked to complete questionnaires about their child's motor skills, possible pregnancy and birth complications, hand preferences within the family, and general socio-demographic information questions. Completion of these questionnaires should take approximately 30 to 60 minutes of your time in total.

Your child and family may not personally benefit from participating in this study, but by serving as a subject, you and your child may contribute new information regarding hand preference in relation to intellectual, verbal, and motor skills. Testing results will be

made available to parents of their child's performance.

All information collected during this study will be completely confidential and will be used for research purposes only by the principal investigators. The results of the research will be reported as group data so that no individual identities will be revealed. Neither your name nor identity will be used for publication or publicity purposes. Information will be kept in a locked filing cabinet and will be destroyed after five years of completion of the research project. A summary of the study's results will be mailed to you upon completion of the study. Should you wish that any individual or agency be informed of any test results, your written permission for release of information will be required.

Your signature on this form indicates that you have understood to your satisfaction the information regarding taking part in this study, and agree to your child's participation. In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw your child from the study at any time without jeopardizing your child's services and care. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout the study. If you have further questions concerning matters related to this research, please contact Joy Hauck at (403) 279-7574.

If you have any questions about your child's rights or your rights as a possible participant in this research, please contact the Office of Medical Bioethics, Faculty of Medicine, The University of Calgary, at 220-7990.

_____	_____
(Name of Child)	(Date)
_____	_____
(Name of Parent or Legal Guardian)	(Signature of Parent or Legal Guardian)
_____	_____
(Name of Witness)	(Signature of Witness)
Joy Hauck	_____
(Name of Investigator)	(Signature of Investigator)

A copy of this consent form is provided for you. Please keep it for your records and future reference.

The principal investigator will, as appropriate, explain to your child his or her involvement, and will seek his or her ongoing co-operation throughout the project. If your child is of appropriate age to sign or mark their assent to involvement in this project, please have them complete the line below:

_____

(Signature of Child)

The investigator will be alert at all times to any gestures, and verbal or non-verbal signs from your child that they do not wish to be involved in a testing procedure, and they will be given a break or be withdrawn from testing at that time, and retested at a later occasion.

APPENDIX O: Consent Form for Parents of Normally Developing Children (non-agency)

CONSENT FORM

RESEARCH PROJECT: Hand preference, receptive verbal ability, intelligence and motor functioning in children with autism.

INVESTIGATORS: Joy Hauck, B.Sc. (Hons), and Deborah Dewey, Ph.D.
University of Calgary and Alberta Children's Hospital

This consent form is only part of the process of informed consent. A copy of this form has been provided for you to keep. This form should give you the basic idea of what the research project is about and what your participation will involve. If you would like more details about something that is mentioned here, or information not included, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

This research is being conducted to meet the thesis requirements of the principal investigator (Joy Hauck) for an M.Sc. degree at the University of Calgary. Supervision will be provided by Deborah Dewey, Ph.D., Chartered Psychologist in the Department of Pediatrics, University of Calgary. The main purpose of this project is the examine the relationship between hand preference, intelligence, verbal ability and motor skills in children with autism, in comparison to children who are developmentally delayed, and to children who are developing normally. Your child will be part of the **normal comparison group** of children.

Your child will be given a Hand Preference Demonstration Test, where the child's hand preference on several simple activities will be observed. Your child will also be assessed regarding their intelligence level, receptive verbal ability and motor skills. However, if any elements of this testing have been performed recently, the results can be obtained from you in order to keep assessment and possible disruption to your child's routine to a minimum. Therefore, we also ask your permission to have access to this information if it is available. Testing will take approximately 2 hours in total, spread out over several shorter sessions. Parents will also be asked to complete questionnaires about their child's motor skills, possible pregnancy and birth complications, hand preferences within the family, and general socio-demographic information questions. Completion of these questionnaires should take approximately 30 to 60 minutes of your time in total.

Your child and family may not personally benefit from participating in this study, but by serving as a subject, you and your child may contribute new information regarding hand preference in relation to intellectual, verbal, and motor skills. Testing results will be made available to parents of their child's performance.

All information collected during this study will be completely confidential and will be used for research purposes only by the principal investigators. The results of the research

will be reported as group data so that no individual identities will be revealed. Neither your name nor identity will be used for publication or publicity purposes. Information will be kept in a locked filing cabinet and will be destroyed after five years of completion of the research project. A summary of the study's results will be mailed to you upon completion of the study. Should you wish that any individual or agency be informed of any test results, your written permission for release of information will be required.

Your signature on this form indicates that you have understood to your satisfaction the information regarding taking part in this study, and agree to your child's participation. In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw your child from the study at any time. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout the study. If you have further questions concerning matters related to this research, please contact Joy Hauck at (403) 279-7574.

If you have any questions about your child's rights or your rights as a possible participant in this research, please contact the Office of Medical Bioethics, Faculty of Medicine, The University of Calgary, at 220-7990.

_____	_____
(Name of Child)	(Date)
_____	_____
(Name of Parent or Legal Guardian)	(Signature of Parent or Legal Guardian)
_____	_____
(Name of Witness)	(Signature of Witness)
Joy Hauck	_____
(Name of Investigator)	(Signature of Investigator)

A copy of this consent form is provided for you. Please keep it for your records and future reference.

The principal investigator will, as appropriate, explain to your child his or her involvement, and will seek his or her ongoing co-operation throughout the project. If

your child is of appropriate age to sign or mark their assent to involvement in this project, please have them complete the line below:

_____

(Signature of Child)

The investigator will be alert at all times to any gestures, and verbal or non-verbal signs from your child that they do not wish to be involved in a testing procedure, and they will be given a break or be withdrawn from testing at that time, and retested at a later occasion.

APPENDIX P: Hand Preference Demonstration Test (HPDT; Soper et al., 1986)

Hand Preference Demonstration Test

Name of Child:

Date A:

Date B:

	Time A			Time B		
	1	2	3	1	2	3
1. Eat with a spoon						
2. Drink from a cup						
3. Brush teeth						
4. Write with pen/draw with crayon						
5. Throw a ball						
6. Hammer a nail						
7. Pick up a raisin						
8. Pick up a dime						

L = Left
R = right
B = Bimanual
N = No response

APPENDIX Q: Hand Preference Questionnaire, and Pregnancy and Birth Complications Questionnaire

SELF-ADMINISTERED QUESTIONNAIRE

for (Name of Child). _____

Name of Person(s) answering the questionnaire: _____

Relationship to child: _____ Date: _____

HAND PREFERENCE

First, we would like to ask a few questions about your family's hand preference.

1. **Please indicate hand preference for the child's BIOLOGICAL MOTHER on the following tasks, by putting a circle around your answer. If you don't know her preferred hand to complete these tasks and cannot find out, please go on to question #3, on page 2.**

	PREFERRED HAND TO COMPLETE TASK (Circle your answer)				
To eat with a spoon	ALWAYS LEFT	USUALLY LEFT	EITHER HAND	USUALLY RIGHT	ALWAYS RIGHT
To throw a ball	ALWAYS LEFT	USUALLY LEFT	EITHER HAND	USUALLY RIGHT	ALWAYS RIGHT
To drink from a cup	ALWAYS LEFT	USUALLY LEFT	EITHER HAND	USUALLY RIGHT	ALWAYS RIGHT
To write	ALWAYS LEFT	USUALLY LEFT	EITHER HAND	USUALLY RIGHT	ALWAYS RIGHT
To brush your teeth	ALWAYS LEFT	USUALLY LEFT	EITHER HAND	USUALLY RIGHT	ALWAYS RIGHT
To hammer a nail	ALWAYS LEFT	USUALLY LEFT	EITHER HAND	USUALLY RIGHT	ALWAYS RIGHT
To pick up a raisin	ALWAYS LEFT	USUALLY LEFT	EITHER HAND	USUALLY RIGHT	ALWAYS RIGHT
To pick up a dime	ALWAYS LEFT	USUALLY LEFT	EITHER HAND	USUALLY RIGHT	ALWAYS RIGHT

2. **Please indicate hand preference for the child's <u>BIOLOGICAL FATHER</u> on the following tasks, by putting a circle around your answer. If you don't know his preferred hand to complete these tasks and cannot find out, please go on to question #4, below.**

	PREFERRED HAND TO COMPLETE TASK (Circle your answer)				
To eat with a spoon	ALWAYS LEFT	USUALLY LEFT	EITHER HAND	USUALLY RIGHT	ALWAYS RIGHT
To throw a ball	ALWAYS LEFT	USUALLY LEFT	EITHER HAND	USUALLY RIGHT	ALWAYS RIGHT
To drink from a cup	ALWAYS LEFT	USUALLY LEFT	EITHER HAND	USUALLY RIGHT	ALWAYS RIGHT
To write	ALWAYS LEFT	USUALLY LEFT	EITHER HAND	USUALLY RIGHT	ALWAYS RIGHT
To brush your teeth	ALWAYS LEFT	USUALLY LEFT	EITHER HAND	USUALLY RIGHT	ALWAYS RIGHT
To hammer a nail	ALWAYS LEFT	USUALLY LEFT	EITHER HAND	USUALLY RIGHT	ALWAYS RIGHT
To pick up a raisin	ALWAYS LEFT	USUALLY LEFT	EITHER HAND	USUALLY RIGHT	ALWAYS RIGHT
To pick up a dime	ALWAYS LEFT	USUALLY LEFT	EITHER HAND	USUALLY RIGHT	ALWAYS RIGHT

3a. How many <u>biological</u> brothers and sisters does this child have?

NUMBER OF BROTHERS_____

NUMBER OF SISTERS_____

3b. How many of this child's <u>biological</u> brothers and sisters are left-handed (particularly for writing)?

NUMBER OF LEFT-HANDED BROTHERS_____

NUMBER OF LEFT-HANDED SISTERS_____

4. Do you know of any other left-handed <u>biological</u> relatives of this child?

NO___ YES_____

If YES, please state the relationship of the relative to the child; for example, paternal grandfather, father's sister, mother's brother's son.

_____

_____

PREGNANCY AND BIRTH OF YOUR CHILD

5. Please indicate the characteristics of the pregnancy with your child, by circling your answers.

	CHARACTERISTICS OF PREGNANCY (Please circle your answer)		
Mother had bleeding during first 3 months.	TRUE	NOT TRUE	CANNOT SAY
Mother had bleeding during second 3 months.	TRUE	NOT TRUE	CANNOT SAY
Mother had bleeding during last 3 months.	TRUE	NOT TRUE	CANNOT SAY
Mother had toxaemia (Pregnancy-induced high blood pressure)	TRUE	NOT TRUE	CANNOT SAY
Mother smoked 1 or more packs of cigarettes per day.	TRUE	NOT TRUE	CANNOT SAY
Labour was induced.	TRUE	NOT TRUE	CANNOT SAY
Had a caesarean section.	TRUE	NOT TRUE	CANNOT SAY
Had a difficult delivery.	TRUE	NOT TRUE	CANNOT SAY
Was put to sleep for delivery.	TRUE	NOT TRUE	CANNOT SAY

Mother had to take medications.*** TRUE NOT TRUE CANNOT SAY

***Specify any medications given for pregnancy, if applicable:_____

6. Please specify other pregnancy problems:_____

_____

7. Did the mother have a virus or bacterial infection (colds, flu, or any other virus)?

and what month of pregnancy did it occur in?_____

8. How many pounds or kilograms did the mother gain during this pregnancy?

_____ lbs. or _____ kg. (Please mark the weight as pounds or kilograms.)

9. When was this child due? ___/___/_____
Month/Day/Year

10. When was this child born? ___/___/_____
Month/Day/Year

11. How old was the mother when this child was born? ____years _____months

12. How many pregnancies (including miscarriages and abortions) has the mother had?_____

Which pregnancy was this child?_____

Thank you. We would now like to ask you a few questions about this child at birth.

13. Please indicate below whether there were any problems with this child AS A NEWBORN AT THE TIME OF BIRTH. Please put a circle around your answer in the appropriate column.

	NEWBORN INFANT PROBLEMS AT BIRTH (Please circle your answer)		
Injured during birth.	TRUE	NOT TRUE	CANNOT SAY
Had trouble breathing.	TRUE	NOT TRUE	CANNOT SAY
Got yellow (jaundice).	TRUE	NOT TRUE	CANNOT SAY

Turned blue (cyanosis).	TRUE	NOT TRUE	CANNOT SAY
Was a twin or a triplet.	TRUE	NOT TRUE	CANNOT SAY
Had seizures (fits, convulsions).	TRUE	NOT TRUE	CANNOT SAY
Needed oxygen.	TRUE	NOT TRUE	CANNOT SAY
Had trouble sucking.	TRUE	NOT TRUE	CANNOT SAY
Was in hospital more than 7 days.	TRUE	NOT TRUE	CANNOT SAY
Born with heart defect.	TRUE	NOT TRUE	CANNOT SAY
Born with other defect(s).**	TRUE	NOT TRUE	CANNOT SAY

** Please specify other defect(s), if applicable:_____

How much did this child weigh at birth? _____ lbs. or _____ kg.
(Please mark the weight as pounds or kilograms.)

14. Was this child <u>breastfed</u>? NO___ YES_____

If YES, Number of months fed solely with breast milk ___ months

Month of life when non-breast milk introduced ___ months

Month of life when all breastfeeding stopped ___ months

Thank you very much for taking the time to complete this questionnaire. Your contribution to this study is greatly appreciated.

APPENDIX R: Fine and Gross Motor Questionnaire

FINE AND GROSS MOTOR QUESTIONNAIRE

Please circle one of the following as it applies to this child:

2 = Yes, usually **1 = Sometimes, partially** **0 = No, never**

GROSS MOTOR SKILLS

1. Standing, Walking and Sitting

Maintains a sitting position in chair	2	1	0
Sits down in chair	2	1	0
Gets out of chair by self	2	1	0
Stands unsupported	2	1	0
Walks with two-hand support	2	1	0
Walks with one-hand support	2	1	0
Walks without any support	2	1	0
Walks alone with good co-ordination	2	1	0
Pulls self up to standing position	2	1	0
Stands up by self from sitting position	2	1	0
Stands on tiptoes momentarily	2	1	0
Walks around rooms avoiding stationary objects/ persons	2	1	0
Carries objects avoiding collision with stationary objects/persons	2	1	0
Walks around rooms avoiding moving persons	2	1	0

2. Stairs and Climbing

Walks up stairs, with both hands held	2	1	0
Walks down stairs, with both hands held	2	1	0
Walks up stairs, with one hand held	2	1	0
Walks down stairs, with one hand held	2	1	0
Walks up stairs putting both feet on each step (no help)	2	1	0
Walks down stairs forward, putting both feet on each			

step	2	1	0
Walks up stairs with alternating feet	2	1	0
Walks down stairs with alternating feet	2	1	0
Gets up and down from low structure	2	1	0
Climbs up and down stationary play equipment	2	1	0
Uses non-stationary playground equipment, such as swings, unassisted	2	1	0
3. Running			
Walks fast	2	1	0
Runs stiffly, with some falling	2	1	0
Runs smoothly, with changes in speed and direction	2	1	0
4. Jumping			
Attempts jump with one hand held	2	1	0
Attempts jump without hand held	2	1	0
Jumps off floor with both feet	2	1	0
Jumps from low structure (bottom step)	2	1	0
Jumps over small object, such as chalkboard eraser	2	1	0
Broad-jumps (both feet together) a distance of 2 inches (5cm)	2	1	0
Broad-jumps over an object or string 2 inches (5cm) high	2	1	0
Jumps forward 5 times	2	1	0
Jumps backward once	2	1	0
Jumps backward 5 times	2	1	0
5. Hopping			
Hops once with one hand held for balancing support	2	1	0
Hops on spot without support	2	1	0
Hops a distance of 10 feet (3m) with ease	2	1	0
6. Kicking/Hitting			

Rolls large ball by pushing foot against it without losing balance (no backward swing)	2	1	0
Kicks flexing lower leg on backward swing and with very little movement	2	1	0
Walks up and kicks a stationary large ball	2	1	0
Kicks a large ball with a definite backward and forward leg swing and with definite arm movement	2	1	0
Does a co-ordinated kick with a good backward and forward leg swing, arm movement and follow-through	2	1	0
Takes two or more co-ordinated steps and kicks a playground ball	2	1	0
Kicks an approaching ball using the foot, while standing still	2	1	0
Runs forward and kicks a rolled large ball	2	1	0
Runs to kick an approaching ball	2	1	0
Hits a moving ball using a bat/racket or stick	2	1	0
7. Balance Beam			
Stands on beam with hands held	2	1	0
Stands on beam alone	2	1	0
Walks balance beam with both hands held	2	1	0
Stands with both feet on balance beam without assistance	2	1	0
Walks forward using arms to aid balance	2	1	0
Walks balance beam with arms at side	2	1	0
Walks balance beam heel-to-toe	2	1	0

8. Catching

Intercept and stops a moving object (car, ball) as it comes into reach	2	1	0
Catches a *bounced* large ball with both hands, arms away from body	2	1	0
Catches a *bounced* tennis ball with both hands	2	1	0
Catches a *thrown* large ball by "hugging" it to the body	2	1	0
Catches a *thrown* large ball with both hands, arms away from body	2	1	0
Catches a *thrown* tennis ball with both hands	2	1	0
Catches a *thrown* tennis ball with one hand	2	1	0
Runs to catch an approaching ball	2	1	0

9. Rolling and Throwing

Rolls a large ball back and forth, with another person, while in a sitting position	2	1	0
Hurls a tennis ball, or similar size ball with one hand	2	1	0
Throws a ball with both hands from an overhead position	2	1	0
Throws an object (ball, beanbag) into a container using an underarm action	2	1	0
Throws an object (ball, beanbag) into a container using an overarm action	2	1	0
Throws a large ball by holding the ball above the shoulders, using almost exclusive arm movement, with no change in feet position and with little or no body rotation	2	1	0
Throws a tennis ball a distance of 10 feet (3m)	2	1	0
Throws a ball from a position in back of the head, with horizontal rotation of the body and with a step forward	2	1	0
Throws a tennis ball a distance of 20 feet (6m)	2	1	0
Throws a ball/bean bag for a moving child to catch	2	1	0

10. Pedalling and Steering Objects

Pushes wheeled vehicles, wagons, etc.	2	1	0
Pulls wheeled vehicles, wagons, etc.	2	1	0
Sits on riding toy while adult pushes	2	1	0
Pushes riding toy with feet without steering	2	1	0
Pushes riding toy with feet while steering	2	1	0
Pedals and steers tricycle	2	1	0
Pedals and steers 2-wheeled bicycle with training wheels	2	1	0
Rides and steers a 2-wheeled bicycle	2	1	0

11. Other

Continually bounce a large ball while standing still	2	1	0
Moves around keeping control of a bouncing ball	2	1	0
Turns a rope with sufficient force and accuracy to allow another child to jump or skip	2	1	0
Keep time to musical beat by clapping hands or tapping foot	2	1	0
Skips rope	2	1	0
May have difficulty learning new motor skills, although may perform them well once they are learned (e.g. swimming, skiing, skating)	2	1	0

FINE MOTOR SKILLS

1. General Eye/Finger/Hand Manipulative Skills

Grasps hand sized objects with whole hand	2	1	0
Picks up small objects (raisins) with thumb and index finger	2	1	0
Takes objects such as blocks out of a container	2	1	0
Assembles toys/objects that require putting pieces			

together	2	1	0
Fits shapes into corresponding space	2	1	0
Completes non-inset puzzle of at least 6 pieces	2	1	0
Uses hand to activate objects	2	1	0
Uses index finger to activate objects (pushing buttons)	2	1	0
Turns the pages of a book in order	2	1	0
Opens doors by turning and pulling doorknobs	2	1	0
Screws and unscrews lids of jars	2	1	0
Uses one hand consistently in most activities	2	1	0
Unlocks key locks	2	1	0
Puts a paper clip on paper	2	1	0
Creases paper with fingers	2	1	0
2. Block Tower Building			
Attempts to build a tower	2	1	0
Builds a 2 block tower	2	1	0
Builds a 4 block tower	2	1	0
Builds a 6 block tower	2	1	0
Builds a 10 block tower	2	1	0
Builds a 12 block tower	2	1	0
3. Prehandwriting			
Marks with pencil, crayon, or chalk on appropriate writing surface	2	1	0
Imitates scribble	2	1	0
Scribbles, seldom going off page	2	1	0
Holds pencil/crayon with fingers, perhaps incorrectly, with hand not fisted	2	1	0
Draws somewhat recognisable picture	2	1	0
Grasps pencil correctly	2	1	0
Traces easier uppercase letters such as **H A T**	2	1	0

Copies easier uppercase letters such as **H A T**	2	1	0
Copies first name	2	1	0
Prints first name	2	1	0
Colours within lines	2	1	0
Traces more difficult lowercase letters	2	1	0
Copies more difficult lowercase letters	2	1	0
Uses appropriate tension or effort when printing or writing	2	1	0

4. Draw a Person

Can the child draw a person? If so, does the picture include:

head	2	1	0
legs?	2	1	0
ears	2	1	0
feet?	2	1	0
arms	2	1	0
shoulders?	2	1	0
trunk	2	1	0
eyes?	2	1	0
nose	2	1	0
hair?	2	1	0
neck	2	1	0
hands?	2	1	0
mouth?	2	1	0

5. Forms

Copies:	Vertical line	2	1	0
	Square	2	1	0
	Horizontal line	2	1	0

Rectangle	2	1	0
Circle	2	1	0
+ (cross or plus)	2	1	0
diamond	2	1	0
X	2	1	0

6. Cutting with Scissors

Opens and closes scissors	2	1	0
Snips or makes small cuts in paper	2	1	0
Holds paper for cutting	2	1	0
Cuts paper in half	2	1	0
Moves paper while cutting	2	1	0
Cuts out circles close to lines	2	1	0
Cuts out circles on lines	2	1	0
Cuts out shapes with straight lines (triangle, rectangle, square)	2	1	0
Cuts out items such as pictures from magazines	2	1	0

7. Self Help Skills

Drinks from cup without spilling	2	1	0
Eats with a spoon	2	1	0
Eats with a fork	2	1	0
Uses a knife to spread with	2	1	0
Cuts with a Knife	2	1	0
Brushes teeth unassisted	2	1	0
Brushes hair	2	1	0
Puts on long pants	2	1	0
Puts on front-opening garment	2	1	0
Puts on pullover garment	2	1	0
Puts on shoes	2	1	0
Differentiate between left and right feet when putting			

on shoes	2	1	0
Puts on underwear	2	1	0
Dresses and undresses self without assistance	2	1	0
Stands stable on one leg to put on pants, etc.	2	1	0
Pulls up zipper	2	1	0
Fastens buttons	2	1	0
Threads zipper (and pulls up)	2	1	0
Ties shoe laces	2	1	0

APPENDIX S: Sociodemographic Questionnaire

General Questionnaire for Parents

First, we would like to ask you some questions about your family.

1. Please complete the following information about all members in your household.

	Name	Sex	Date of Birth
Father			
Mother			
Child			
Child			
Child			
Child			

2. Have any children in your family been diagnosed with a chronic illness, language disorder, learning disability, developmental problem or attention problems?

   Yes_____ No_____

3. IF YES, what specific illness or type of problem and which child is affected:

_____

FOR MOTHER:

4. What is your present marital status?

_____	Married	_____	Separated
_____	Living with someone	_____	Never married and not living with someone
_____	Divorced	_____	Widowed

5. From the list below, please indicate the highest level of education that you

completed (please circle).

a) No high school
b) Some high school, didn't graduate
c) High school diploma
d) Some post-secondary, but no diploma or degree
e) Post-secondary diploma (e.g. technical)
f) University degree

6. What is your occupation?_____

FOR FATHER:

7. What is your present marital status?

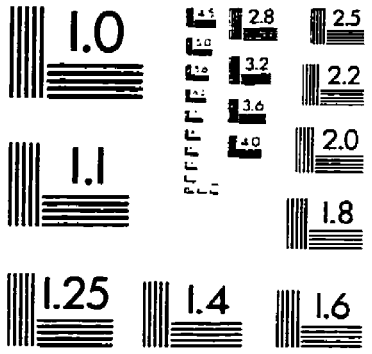
_____	Married	_____	Separated
_____	Living with someone	_____	Never married and not living with someone
_____	Divorced	_____	Widowed

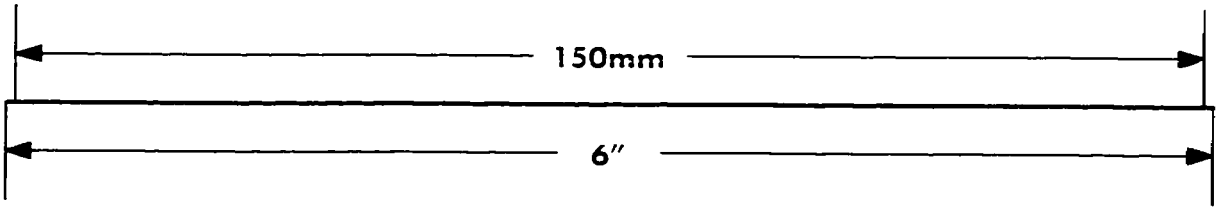
8. From the list below, please indicate the highest level of education that you completed (please circle).

a) No high school
b) Some high school, didn't graduate
c) High school diploma
d) Some post-secondary, but no diploma or degree
e) Post-secondary diploma (e.g. technical)
f) University degree

9. What is your occupation?_____

IMAGE EVALUATION TEST TARGET (QA-3)





APPLIED IMAGE . Inc
1653 East Main Street
Rochester, NY 14609 USA
Phone: 716/482-0300
Fax: 716/288-5989