Impact of sensory responses and motor skills on functional skills in activities of daily living of pre-school children with autism spectrum disorders

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ABSTRACT

BACKGROUND: In children with autism spectrum disorders (ASD), sensori-motor development and functional skills in activities of daily living (ADL) remain little explored in comparison to the other domains of development. **OBJECTIVES:** To determine the impact of sensori-motor skills on functional skills in ADL of pre-school children with ASD, and to examine their type of sensory responses, their motor skills and their functional skills in ADL. **METHODS:** This project is a pilot and cross-sectional study. Thirty-five children with ASD, three to four years of age, have been recruited and assessed. Control groups are also included: eight children with developmental delay (DD) and five children with typical development (TD). A battery of diagnostic and clinical tests was used. **RESULTS:** ASD and DD groups have significantly more atypical sensory responses than the TD group as measured by the Sensory Profile. The ASD group has significantly poorer motor skills than controls (TD and DD) based on the Peabody Developmental Motor Scales – 2nd edition (PDMS-2). Self-care skills of the ASD group fall below 2 standard deviations (SD) on the Functional Independence Measure for Children (WeeFIM). Daily living skills (DLS) of the ASD group are significantly poorer than controls on the Vineland Adaptive Behavior Scales – Second Edition (VABS-II). The largest percentage of variability in self-care skills, as measured by the WeeFIM, is explained by cognitive functioning and auditory processing, while personal skills, as measured by the VABS-II, are predicted by fine motor skills and sensory avoiding. **CONCLUSION:** Pre-school children with ASD, but also children with DD, react differently to sensory stimuli than typically developing children. Also, children with ASD have significantly poorer motor skills than DD and TD children. These sensory and motor difficulties affect the functional skills in ADL. Therefore, it will be important clinically to individually assess and consider sensori-motor and functional skills in ADL of children with ASD. Future interventions may then aim at

improving and supporting the development and autonomy of these children. In turn this may assist caregivers by reducing their care load.

Keywords: autism spectrum disorders, sensory responses, motor skills, functional skills, activities of daily living

RÉSUMÉ

Recension des écrits : Chez les enfants présentant un trouble envahissant du développement (TED), le développement sensori-moteur ainsi que le niveau d'indépendance fonctionnelle dans les activités de la vie quotidienne (AVQ) ont été peu étudiés comparativement aux autres domaines de développement. **Objectifs :** Déterminer l'impact des habiletés sensori-motrices sur les habiletés fonctionnelles dans les AVQ des enfants préscolaires présentant un TED, et examiner leur type de réponses sensorielles, leurs habiletés motrices et leurs habiletés fonctionnelles dans les AVQ. **Méthodologie :** Ce projet est une étude pilote et transversale. Trente-cinq enfants présentant un TED, de trois à quatre ans, ont été recrutés et évalués. Deux groupes de contrôle sont également inclus : huit enfants présentant un retard de développement (RD) et cinq enfants suivant un développement typique (DT). Une batterie de tests diagnostiques et cliniques a été utilisée. **Résultats :** Au *Sensory Profile*, les groupes TED et RD ont significativement plus de réponses sensorielles atypiques que le groupe DT. Selon le *Peabody Developmental Motor Scales – 2nd edition* (*PDMS-2*), le groupe TED a des habiletés motrices significativement plus faibles que les groupes de contrôle (RD et DT). À la *Functional Independence Measure for Children* (*WeeFIM*), les habiletés dans les soins personnels du groupe TED sont inférieures à 2 écart-types (ÉT). D'après le *Vineland Adaptive Behavior Scales – Second Edition* (*VABS-II*), les habiletés de la vie quotidienne du groupe TED sont significativement plus faibles que celles des groupes de contrôle. Le plus grand pourcentage de variabilité dans les habiletés de soins personnels de la *WeeFIM* est expliqué par le fonctionnement cognitif et le traitement de l'information auditive alors que les habiletés personnelles du VABS-II sont prédites par les habiletés de motricité fine et l'évitement sensoriel. **Conclusion :** Les enfants pré-scolaires présentant un TED, mais également les enfants présentant un RD, réagissent différemment aux stimuli sensoriels que les enfants suivant un développement typique. Aussi, les enfants présentant un TED ont des habiletés motrices significativement plus pauvres que les enfants présentant un RD ou suivant un DT. Ces difficultés sensorielles et motrices affectent les habiletés fonctionnelles dans les AVQ des enfants présentant un TED. Par conséquent, il est important d'évaluer individuellement et de considérer les habiletés sensori-motrices et fonctionnelles dans les AVQ des enfants présentant un TED. De futures interventions pourront ainsi améliorer et supporter le développement et l'autonomie de ces enfants. En retour, cela pourra aider leurs proches en réduisant leur charge de soins.

Mots-clés : trouble envahissant du développement, réponses sensorielles, habiletés motrices, habiletés fonctionnelles, activités de la vie quotidienne

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LIST OF ABREVIATIONS

ADI-R	Autism Diagnostic Interview-Revised
ADOS-G	Autism Diagnostic Observation Schedule-Generic
ADL	Activities of daily living
APA	American Psychiatric Association
ASD	Autism spectrum disorders
ASQ	Autism Screening Questionnaire
DBPC	Developmental and Behavioral Pediatrics Clinic
DISCO	Diagnostic Interview for Social and Communication Disorders
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders – 4th edition
DD	Developmental delay
GDD	Global developmental delay
ICF	International Classification of Functioning, Disability and Health
IQ	Intellectual quotient
MA	Mental age
MABC	Movement Assessment Battery for Children
MCH	Montreal Children's Hospital
MRI	Magnetic resonance imaging
PDMS-2	Peabody Developmental Motor Scales – 2nd Edition
PLS-4	Preschool Language Scale – 4th edition
PPVT-3	Peabody Picture Vocabulary Test – 3rd Edition
SLI	Speech Language Impairment
SRS	Social Responsiveness Scale
VABS-II	Vineland Adaptive Behavior Scales – 2nd Edition
WeeFIM	Functional Independence Measure for Children
WHO	World Health Organization

GLOSSARY*

Activities of daily living: "Activities that are oriented toward taking care of one's own body" (e.g.: eating, grooming, bathing, dressing, toileting; Mulligan, 2003).

Asperger syndrome: Qualitative impairment in social interaction and stereotyped patterns of behavior, interests and activities. There is no clinically significant general delay in language and cognitive development (APA, 2000).

Atypical sensory responses: Unusual reactions to sensory stimuli, generally reported as hypo- and hyper-responsiveness (Baranek, 2006).

Autistic disorder: Qualitative impairment in social interaction and communication, and restricted repetitive and stereotyped patterns of behavior, interests and activities (APA, 2000).

Dyspraxia: "A developmental condition in which the ability to plan unfamiliar motor tasks is impaired" (Bundy et al. 2002).

Fine motor skills: Motor abilities using the small muscle systems, such as grasping and visual-motor integration (Folio and Fewell, 2000).

Gross motor skills: Motor abilities requiring the large muscle systems (e.g.; body control, walking, running, manipulating a ball; Folio and Fewell, 2000).

Hyper-responsiveness: Exaggerated reaction to sensory stimuli (Baranek, 2006).

Hypo-responsiveness: Lack or insufficient intensity of reaction to sensory stimuli (Baranek, 2006).

Mirror neurons: Neurons, identified in the ventral pre-motor cortex and anterior parietal regions, that are activated by the perception of an action or when the same action is executed (Williams et al. 2006).

Motor skills: "Skills in moving and interacting with tasks, objects and environment" (Mulligan, 2003).

Pervasive developmental disorder not otherwise specified (PDD-NOS): Severe and pervasive impairment in the development of social interaction or communication, or stereotyped patterns of behavior, interests and activities. The criteria for a specific PDD are not met in this category (APA, 2000).

Praxis or motor planning: Ability that involves both a motor component (physical execution) and a cognitive component (ideation, planning, and sequencing; Mulligan, 2003)

Proprioception: "Sensations derived from movement (i.e., speed, rate, sequencing, timing, and force) and joint position. Derived from stimulation to muscle and, to a lesser extent, joint receptors, especially from resistance to movement" (Bundy et al. 2002).

Sensory modulation: "The ability to regulate and organize reactions to sensory input in a graded and adaptive manner (behavioral). The balancing of excitatory and inhibitory inputs and adapting to environmental changes (neurophysiological)" (Bundy et al. 2002).

Sensory processing: "Functions related to sensation occurring in the central nervous system; includes reception, modulation, integration, and organization of sensory stimuli; also includes the behavioural responses to sensory input" (Bundy et al. 2002).

Sensory responses: Reactions following sensory processing of the basic sensory systems (auditory, visual, vestibular, touch, proprioception, taste and smell; Dunn, 1999).

Vestibular: "Sensation derived from stimulation to the vestibular mechanism in the inner ear that occurs through movement and position of the head; contributes to posture and the maintenance of a stable visual field" (Bundy et al. 2002).

* Quotation marks indicate that definitions are quoted verbatim from the original source. The other definitions are inspired by the reported source.

Chapter 1: INTRODUCTION

In the behavioral domain of the autism spectrum disorders (ASD) much research focuses on problems of communication, socialization and cognition. However, sensori-motor development remains little explored in comparison to the other areas of development. In addition, functional skills to perform activities of daily living (ADL) are little documented in the scientific literature on ASD. ADL, defined here as activities that are oriented toward taking care of one's own body (e.g.: washing, dressing, grooming, eating, etc.; Mulligan 2003), are influenced by cognitive, motor and sensory skills.

As sensori-motor development supports and interacts with perceptual learning and social-cognitive development in children (Piaget, 1952; Gibson, 2000; Diamond, 2000), it remains to be characterized in order to target interventions that will meet children's specific and global needs, in an integrated and coherent manner. Level of independence (or assistance needed) in ADL is one of the main concerns of caregivers and therapists because it is perceived as facilitating the integration of the child into the social environment, such as daycare and school. Hence, it will be important to examine the sensory responses and motor skills of children with ASD, as well as their functional skills in ADL, in order to determine their interaction and in the long-term support caregivers.

1.1. Objectives

The main objective of this study is to determine the impact of sensory responses and motor skills on functional skills in ADL (e.g.: eating, grooming, dressing, toileting) of children with ASD, three to four years of age. More specifically, we examined sensory responses, motor skills and functional skills in ADL of children with ASD when compared to norms and controls.

1.2. Sections of the thesis

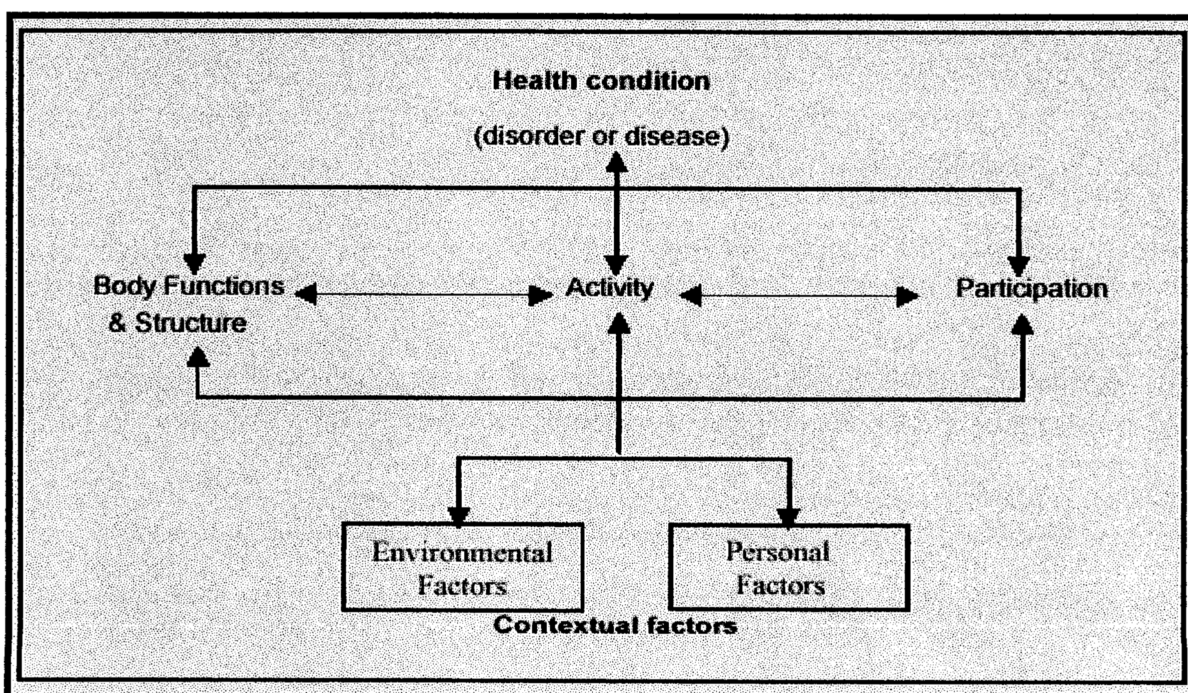
The present thesis is divided into four main sections: literature review, methods, results, and discussion. The literature review focuses on the following subjects: model; clinical characteristics; epidemiology; screening and diagnosis; history; genetics; neurobiology; neuropsychology; socialization; communication; stereoptyped behaviors, interests and activities; sensory responses; motor skills; and functional skills in ADL. The rationale and the hypotheses follow the literature review. The methodology includes the design, the participants, the clinical measures, the procedures and the statistical analyses. Results are reported from the more specific objectives to the main objective in the following order: sensory responses, motor skills, functional skills in ADL, correlations between sensory responses, motor skills and functional skills in ADL, and predictions of functional skills from sensori-motor performances. The discussion presents the interpretation of results and a comparison of results in the context of the scientific literature. Finally, limitations, summary and conclusion, including clinical contribution to rehabilitation and future directions, complete this thesis.

Chapter 2: LITERATURE REVIEW

2.1. Model

We used the International Classification of Functioning, Disability and Health (ICF) of the World Health Organization (WHO, 2001) to embed this study in a rehabilitation framework. This conceptual framework proposes a terminology and a classification of the consequences of health disorders or diseases on function. The ICF includes the following main categories: health condition (disorder or disease); body functions and structures; activities and participation; as well as environmental and personal factors (Figure 1).

Figure 1. Model of International Classification of Functioning, Disability and Health (ICF) of the World Health Organization (WHO, 2001)



The health conditions, in the present study, are the ASD. The targeted functions are the sensory functions (sensory responses) and the functions related to movement (motor skills). In the literature review, we will describe that other functions are also influenced by the ASD (e.g.: mental functions, voice and speech functions). In addition, the ASD are recognized as a neuro-developmental disorder. The main structures affected are those related to the nervous system with an underlying complex genetic basis. The associated genes are not completely identified. In terms of activities and participation, although this study focuses on the functional skills in self care (ADL), ASD may also interfere with learning and applied learning (cognition), communication, and interpersonal interactions and relationships (socialization). Environmental factors in the ASD may be described as barriers or facilitators, such as products and technology; natural environment; support and relationships; attitudes; systems, services, and policies (e.g.: legal, social, health, education). Moreover, the socio-economic situation, interventions and medication may be considered as environmental factors. Lastly, personal factors include chronological age, intelligence quotient (IQ), gender, severity of the symptoms, temperament, personality and language.

2.2. Clinical characteristics

One body of literature suggests that ASD are neuro-developmental disorders where the etiology is related to genetic factors. According to the Diagnostic and Statistical Manual of Mental Disorders – 4^{th} edition (DSM-IV; APA, 2000), the Pervasive Developmental Disorders (PDD), comprising the ASD, are characterized by severe and pervasive impairments in the spheres of development such as social interactions and communication, or by stereotyped behaviors, interests and activities. Among the PDD, five categories are included: autistic disorder, Rett's syndrome, childhood disintegrative disorder, Asperger syndrome and pervasive developmental disorder not otherwise specified (PDD-NOS).

However, in this study, only ASD are included and described, i.e. autistic disorder, Asperger syndrome, and PDD-NOS.

The autistic disorder emerges before the age of three years, and is defined by qualitative deficits in the social interactions and the communication as well as repetitive and stereotyped behaviors, interests and activities. The Asperger syndrome is similar to the autistic disorder regarding social interactions and behaviors, interests and activities. However, the individual with Asperger syndrome does not present significant clinical delays in language and cognitive development. Finally, the diagnosis of PDD-NOS is given when there are severe and pervasive impairments in one of the two spheres of development (social interactions or communication) or the presence of stereotyped behaviors, interests and activities when the criteria of any of the other specific PDD are not met. The severity of the deficits is very variable among individuals with ASD; however, it remains that these impairments hinder the daily functioning of these individuals.

2.3. Epidemiology

According to a recent review of epidemiological studies by Fombonne (2005), the prevalence of all PDD is about 60 to 65/10 000. More specifically, the prevalence of the autistic disorder and Asperger syndrome are estimated to be 13/10 000 and 3/10 000 respectively. Therefore, there are approximately four times more individuals diagnosed with the autistic disorder than with Asperger syndrome. In addition, the prevalence of PDD-NOS corresponds to 15/10 000 (Fombonne, 2003). Regarding the gender distribution, known only for the autistic disorder, it is approximately four boys to one girl. When mental retardation is present with autism, the difference between boys and girls decreases. This suggests a strong association between gender distribution and mental retardation. In fact, 70% of the cases with autism also present with mental retardation; approximately 30% have a mild to moderate and 40%, a severe to profound delay. However, according to

Bryson and Smith (1998), the majority of ASD, including Asperger syndrome and PDD-NOS, do not present mental retardation on intellectual assessment.

2.4. Screening and diagnosis

As the biological markers in ASD are not yet known, screening must be done through observation of specific behaviors. Screening for ASD may begin from the age of 12 months, by observing impairments in four behaviors: visual contact, orientation when the child's name is called, pointing and demonstration (Filipek et al. 1999). A diagnosis may now be accurately given from two years of age onward (Volkmar et al. 2004). However, the evaluation requires a multidisciplinary approach, including the collection of data from questionnaires obtained from the caregiver, observations of the child, interactions with the child, as well as clinical judgment (Filipek et al. 1999). Indeed, the evaluation must be conducted by professionals specialized in ASD and the use of valid and reliable diagnostic tests, such as the Autism Diagnostic Interview-Revised (ADI-R; Le Couteur, Lord and Rutter, 2003) for the interview and the Autism Diagnostic Observation Schedule-Generic (ADOS; Lord et al. 2000) for the observation. Moreover, the assessment process must include the following information: medical and neurological data, communication skills, cognitive functioning, adaptive behavior, sensori-motor skills, functional skills in ADL, family resources, etc. Finally, towards the age of 24 months, children with ASD are easier to differentiate from children with other developmental disorders, if the diagnostic evaluation is carried out by professionals in a clinical setting and not just based on the information reported by caregivers (Trillingsgaard et al. 2005).

2.5. Historical perspective

The historic article by Kanner (1943) marks the beginning of descriptions of autism in children. At the end of the 1940's, autism was regarded as an early and unusual manifestation of schizophrenia in which the etiology included lack of emotional responsiveness in a familiar social environment (Rutter, 1999). Between the years 1950 and 1960, three behavioral criteria emerged for the characterization of autism: 1) general failure in the development of social relationships; 2) delay of language, with impairments of comprehension, echolalia and pronominal reversal; and 3) ritualistic and compulsive behaviors associated with repetitive and stereotyped play. During this period, clinicians started to replace the concept of psychosis with a neuro-developmental disorder. Consequently, research began to focus on medical etiologies and cerebral mechanisms to explain the development of autism. Between 1970 and 1980, standardized tests were developed to build toward a consensus for diagnosis and the differentiation among all categories of PDD. Moreover, extensive research on language development indicated that there was not only a language delay, but mainly an anomaly of the quality and use of language that characterized children with PDD. The investigations on the medical causes also highlighted that genetic factors play an important role in autism. In addition, despite the evidence of general cognitive impairments, there was a need to explain more specifically the cognitive deficits of individuals with autism. New assumptions and theories attempted to explain the cognitive deficits associated with autism such as perceptual inconstancy (Ornitz and Ritvo, 1968), delay in sensori-motor integration (Ornitz, 1971), over-selective attention (Lovaas, Koegel and Schreibman, 1979), socio-emotional deficit (Hobson, 1982) and the theory of mind (Baron-Cohen, Leslie and Frith, 1985). During the period of 1980 to 1990, research indicated that autism was not only due to one gene, but to an interaction of more than ten genes. During these same years, neuropsychological studies continued to evolve. However, none of the proposed theories adequately explain the cognitive impairments associated with autism. Lastly, as genes have been found to be strongly implicated in the expression of ASD (Volkmar et al. 2004), research began focusing more and more on genetics. With new discoveries in genetics, researchers hope to improve the definition and identification of autism as well as the comprehension of the implied neurological processes.

2.6. Genetics

The epidemiological data on twins and their families suggest that the majority of individuals with ASD have a complex genetic predisposition for the condition (Volkmar et al. 2004). Moreover, as mentioned in the historical review, studies indicate that autism is not caused by only one gene, but by a combination of several genes. The identification of the gene combination would help researchers to better understand the biochemical and physiological processes implicated in ASD as well as the environmental factors that influence the expression of the phenotype. Recently, The Autism Genome Project Consortium discovered chromosomal anomalies that contribute to ASD, including: a) an area of chromosome 11, containing a gene implicated in ASD; and b) an anomaly on chromosome 2 where a part of the gene for neurexin is removed (i.e. a protein implicated in the functioning of neuronal connections is missing; Szatmari et al. 2007). However, despite the fact that discoveries in genetics appear promising, the enigma of the genetic combination of autism remains difficult to solve, because of the heterogeneity of the phenotype, the number of genes implicated (Wassink et al. 2004) and the epigenetic factors (Schanen, 2006).

2.7. Neurobiology

In studies on the developmental neurobiology of ASD, several researchers reported anomalies in the growth of the brain as well as neuronal functioning (DiCicco-Bloom et al. 2006). During early childhood, children with ASD show an abnormally high cerebral volume. However, this abnormal cerebral volume decreases during childhood or adolescence. In addition, studies showed anomalies in the growth of the cerebellum, the cerebral cortex, the amygdala and possibly, the hippocampus. However, only the anomalies of the cerebellum and the cerebral cortex are based on rigorous methodology. Moreover, neuronal abnormalities of individuals with ASD are now thought to be due to a dysfunction of mirror neurons, activated by the perception of an action or performance of said action (Dapretto et al. 2005). In addition, the dysfunctional activity of mirror neurons may explain why these individuals have difficulty showing empathy. Finally, impairments of the prefrontal lobes and the amygdala have been observed when executing tasks that require a theory of mind construct (Castelli et al. 2002).

2.8. Neuropsychology

Although biological factors are accepted among the causes of autism, neuropsychological theories also try to explain the signs and symptoms of autism (Hill and Frith, 2003). The three main neuro-cognitive theories are: theory-of-mind deficit, weak central coherence and executive dysfunction.

First, according to the theory of mind, individuals with autism have difficulty to intuitively understand the mental states of others. More specifically, individuals with autism would show deficits in the comprehension of pretence, irony, non-literal language and disappointment. In the theory of central coherence, it is suggested that individuals with autism have connective impairments between the basic perceptual and modulating processes within the brain that cause difficulties in integrating information into a coherent whole at a higher level of thought. This theory describes the tendency of these individuals to put emphasis on specific aspects of an object of interest instead of on the global view. Thus, the weak central coherence explains their uneven profile of performance in tests of intelligence. Finally, the theory of executive dysfunction addresses problems of rigidity and perseveration of individuals with autism. These problems are explained by difficulties in initiating new actions and switching to a subsequent task. Although these theories were studied separately, they are neither rivals or exclusive.

2.9. Socialization

The first studies on social development of children with autism were based predominantly on information reported by caregivers rather than on clinical observation (Volkmar et al. 1987). In addition, initial references in infantile psychiatry generally reported difficulties with the acquisition of speech or the possibility of deafness. Experimental and clinical data showed that demonstrations of social deviance appeared from the first month of life of a child with autism. More specifically, social deviance may be observed by the absence of reciprocal eye contact as well as the social smile. Consequently, these children are little motivated and influenced by socio-emotional factors, such as seeking affection, sharing interests or, participating in interactive plays. Lastly, specific social processes associated with autism include difficulties with social orientation (e.g.: eye contact, joint attention), imitation, symbolic play, social attachment, emotional development (e.g.: empathy) and pragmatic skills (Volkmar et al. 1987).

2.10. Communication

Caregivers of children with ASD often notice the first problematic signs during the second year of life because of the absence of speech or the loss of developed speech (Tager-Flusberg, 2001). Individuals with autism may show a variety of difficulties of communication: echolalia, perseveration, atypical prosody (intonation, volume, rhythm) and reversed pronouns (Wilkinson, 1998). While the majority of research has stressed the expression of language, the comprehension has been less studied (Tager-Flusberg, 2001). However, research suggests that impairments of comprehension are more severe than the impairments of expression. It should be noted that language acquisition requires the integration of development of conceptual (lexical and semantic), linguistic (phonology and syntax) and social (pragmatic) domains. Finally, the most important characteristic concerning the language of individuals with ASD is the heterogeneity of their language skills: a person may present with mutism and/or a low level of communication while another may show relatively functional speech (Wilkinson, 1998).

2.11. Stereotyped behaviors, interests and activities

Stereotyped behaviors, interests and activities of individuals with ASD may include dyskinesias, tics, stereotyped movements, repetitive manipulation of objects, repetitive behaviors of self-mutilation, object attachments, obsessions, repetitive language, as well as restricted interests (Turner, 1999). There are several explanations for these repetitive behaviors implying impairments in the following functions: homeostatic mechanism, operant behavior and mentalizing ability, weak central coherence, or symptoms of executive dysfunction.

First, the homeostatic mechanism is defined as the mechanism that modulates levels of arousal and maintains homeostasis (Hutt et al. 1964). Operant behavior refers to behaviors that are reinforced by providing sensory consequences (Lovaas, Newsom, and Hickman, 1987). Therefore, repetitive behaviors might be seen as a way in which the homeostatic mechanism operates in children with ASD. Also, repetitive behaviors may provide sensory reinforcement necessary for an impaired ability to modulate behavior. As well, these repetitive behaviors might serve to reduce anxiety due to impairments in the comprehension of the social world (i.e. mentalizing ability) that may be perceived as unpredictable and scary. In addition, repetitive behaviors are proposed to be a consequence of weak coherence, as discussed in section 2.8. Finally, executive dysfunctions may explain repetitive behaviors, since individuals with autism have difficulties to initiate, plan and control their behaviors (Ridley, 1994). As with neuropsychological processes, these assumptions are complementary and not mutually exclusive.

2.12. Sensory responses

Ayres (1972), the founder of sensory integration theory, defined sensory integration as "the neurological process that organizes sensation from one's own body and from the environment and makes it possible to use the body effectively within the environment". Since that time, the field of sensory integration has evolved, through the refinement of both theory and practice. The sensory integration approach is used frequently by occupational therapists. From a more neurophysiological perspective, sensory processing refers to the functions related to sensations that occur in the central nervous system (Anzalone and Williamson, 2000). These functions include reception, modulation, integration, and organization of sensory stimuli from sensory input. Sensory responses are defined as the child's reactions following sensory processing by the basic sensory systems (auditory, visual, vestibular, touch, smell and taste; Dunn, 1999) and are based on daily observations from a functional point of view. Atypical sensory responses are the unusual reactions to sensory stimuli (Baranek, 2006), generally reported as hypo- and hyper-responsiveness. Hypo-responsiveness means a lack of response, or insufficient intensity of response to sensory stimuli. Conversely, hyper-responsiveness is an exaggerated behavioral response to sensory stimuli.

2.12.1. History of atypical sensory responses

In his first paper on autism, Kanner (1943) described behaviors in individuals with autism that may be interpreted as atypical sensory responses (Rogers and Ozonoff, 2005). These behaviors included fascination with falling objects, unwarranted excited jumping, exaggerated fear of noises and age inappropriate mouthing of objects. Kanner (1943), Ayres (1971) and Ornitz (1989) suggested that the stereotyped and repetitive movements of children with autism were related to their difficulty with modulating sensory input, as observed by an exaggeration or a lack of reaction to sensory input (Kientz and Dunn, 1997). More recently, however, Leekam et al. (2007) and Baranek et al. (2006) stated that atypical sensory responses are very frequent in children with ASD but not unique to them.

2.12.2. Sensory theories

Bergman and Escalona (1949) proposed the first sensory hypothesis of autism: they suggested that children with autism started life with a high level of sensitivity that caused sensory defensiveness, developmental distortions and subsequent, atypical sensory responses. Various sensory theories on autism have emerged since this time and include: over-arousal theories, under-arousal theories, inconstancy theories, and impaired cross-modal processing theories (Rogers and Ozonoff, 2005).

First, over-arousal theories suggest that children with autism are more sensitive or reactive to sensory stimuli than other children. Consequently, they present more difficulties in habituating to stimuli in the environment as compared to their peers. In under-arousal theories, impairments in the activation of the limbic system, resulting in a privation of sensory and emotional information, explain the lack of initiative and social interests of these children. Perceptual inconstancy theories attribute the fluctuation of arousal states (hyper- and hypo-arousal) to the dysfunctions in the brainstem that lead to distortion of sensory information. Finally, cross-modal impairment theories suggest that the main cause of atypical sensory responses in children with autism consists of cross-modal difficulties with sensory information that interfere with the ability to integrate all the sensory information experienced in the same spatio-temporal situation. In general, these theories have tried to explain causes of the maladapted behaviors: anomalies of the level of general awareness, and level of awareness in response to a stimulus and habituation to stimuli. Two common sensory patterns emerge from these interpretations: hyper- and hypo-responsiveness (Baranek et al. 2006; Baranek 2002; O'Neill and Jones 1997).

Moreover, Anzalone and Williamson (2000) defined four interrelated behaviors, the 4 A's of behavior, to explain difficulties of sensory processing and modulation of children with ASD. These four behaviors include: 1) arousal, 2) attention, 3) affect, and 4) action. For the first behavior, arousal, the authors suggest that sensory responses of children with ASD vary according to their own state of arousal and that sensory information changes their own state of arousal. Secondly, by attention, they mean that a child with ASD may have difficulty with attention to a specific sensory modality and may have sensory preferences. Affect is based on the observation that a hyper-sensitive child may express strong and frequent emotional reactions while a hypo-sensitive child may show a paucity of emotion. Finally, in the fourth behavior, action, they report that difficulties of motor planning and poor sensori-motor awareness of their own body may lead children with ASD to have difficulties engaging in action.

2.12.3. Sensory responses and neurophysiology

The two common patterns, hyper- and hypo-responsiveness, have been supported by some psycho-physiological studies in children with ASD and children with other developmental disabilities, such as malfunction of the autonomic nervous system (Hirstein et al. 2001), physiologically based enhancement of reactions to sensations (McAlonan et al. 2002), abnormalities in the fronto-striatal systems and the cerebellum, and impaired sensori-motor gating (Miller et al. 2001). In addition, some authors proposed that atypical sensory responses may be explained by abnormalities in arousal level and habituation to stimuli (Rogers & Ozonoff, 2005). However, other studies failed to show physiological indicators supporting theses theories (Hobson, Ouston and Lee, 1988; Ozonoff, Pennington and Rogers, 1990; Goldberg et al. 2000). Since anatomical abnormalities in the cerebellum have been reported consistently (Allen, 2006), Liss et al. (2006) suggested that cerebellar dysfunctions may cause attention abnormalities in ASD. In addition, it has been hypothesized that abnormal neurotransmitter activity, such as dopaminergic activity, may be related to inattention and stereotyped behaviors (Liss et al. 2006).

2.12.4. Sensory measures

Atypical sensory responses are mainly assessed by occupational therapists because they may interfere with functional skills in ADL (Watling et al. 2000). To evaluate sensory responses, occupational therapists have used different measures, including clinical observations, informal questionnaires and caregiver interviews. With these non-standardized or non-normative approaches, data may not get consistently recorded, analyzed and compared. However, standardized tests do exist. For example, the Sensory Integration and Praxis Test (Ayres, 1989) and the DeGangi-Berk Test of Sensory Integration (Berk and DeGangi, 1983) are used to assess sensory processing, but these tests measure more sensori-motor skills (e.g.: postural control, bilateral motor coordination and praxis) than sensory responses. Therefore, they may not reflect the sensory responses of the child on a daily basis (Dunn, 1994). To remedy this problem, questionnaires and interviews may be conducted with caregivers, but without norms and cutoff points for typical responses, the interpretation of such data will remain unclear. The Sensory Profile is the first clinical instrument that focuses on sensory responses and provides norms based on functional performance in daily life (Watling et al. 2000; Dunn, 1999). Before the publication of the Sensory Profile in 1999, sensory responses were more difficult to measure (Dunn, 1999). Therefore, the absence of normative and standardized measures, such as the Sensory Profile, may explain the methodological weaknesses and the limited focus of research on sensory processing in children with ASD.

2.12.5. Specificity

Research has increasingly shown that individuals with autism have difficulties with processing and modulation of sensory input. However, the specificity and the extent of these sensory symptoms are not yet established (O' Neill and Jones, 1997).

Recently, Kern et al. (2007) found significant differences in the four quadrants (low registration, sensation seeking, sensation sensitivity, and sensation avoidance) of the Sensory Profile compared to controls. With the exception of sensation avoidance, however, they (Kern et al. 2007) did observe improvement with age in three quadrants of the Sensory Profile (low registration, sensation seeking and sensation sensitivity), suggesting children with ASD become more similar to controls over time. An age effect and differences in auditory, visual, oral, and touch processing abnormalities, but no significant change in low threshold touch, has similarly been reported (Kern et al. 2006). Significant differences in responses to vestibular sensory events have been found in three to four-year-olds with autism, compared to controls (Kern et al. 2007). In addition, differences between three to six-year-old children with autism and children with mental retardation have been demonstrated by Watling et al. (2000) using the Sensory Profile based on eight factors. Rogers et al. (2003) stated that the most common atypical sensory responses in autism were taste/smell sensitivity, tactile sensitivity, and auditory filtering. Previously, most common atypical sensory responses were noted in auditory processing (Baranek et al. 1997, Gillberg et al. 1990, Dahlgren and Gillberg 1989). O'Riordan and Passetti (2006) confirmed this hypothesis by comparing tactile and auditory discrimination in children with autism and children with typical development. They noted greater auditory discrimination in the children with autism, but no difference in tactile discrimination. In contrast, other investigators found differences in touch responses (Baranek, Foster and Berkson, 1997; Kientz and Dunn, 1997, Rogers et al. 2003). These results led O'Riordan and Passetti (2006) to suggest that the atypical tactile responses in individuals with autism may be due to the fact that they pay more attention to touch to compensate for their atypical sensory performance in the other domains, such as vision and hearing. However, these studies are limited as they focused only on the discrimination of pressure; the perception of touch also includes pain, temperature and vibration, modalities that were not investigated. In addition, Roger et al. (2003) did not find that the degree of atypical responses was correlated with mental age and IQ, suggesting that mental retardation does not increase atypical sensory responses. Finally, Leekam et al. (2006) and Baranek et al. (2006) stated that atypical sensory responses are very frequent but not unique to children with ASD.

2.12.6. Impact of atypical sensory responses

Atypical sensory responses may reveal that a child presents sensory processing dysfunctions, i.e. difficulty with processing and organizing sensations in the central nervous system. Sensory integration theory (Bundy et al. 2002) predicts that if processing and organization of sensations is atypical, there will be a concomitant distortion of the perceptions of one's own body with respect to internal and external environments. This distortion may lead to subsequent difficulties in performance of tasks important in daily living as it will impact on perceptual learning. Indeed, based on Gibson's theory (2000), perceptual learning requires both perception and action, mainly provided by exploratory activities. Exploration, which is a sensori-motor process, gives information to children about the environment and the consequences of their own actions on the environment. Therefore, in exploratory activities, the child improves the planning of actions and the resolution of problems. As perceptions are crucial for the appropriate development of action plans, a better understanding of sensory responses in children with ASD is important in order to appreciate their needs and learning processes.

Recently, Hilton et al. (2007) showed moderate to strong correlations between the Social Responsiveness Scale (SRS; Constantino and Gruber, 2005) and the quadrants of the Sensory Profile. The strongest relationships were with sensory sensitivity and sensory avoiding. In addition, Liss et al. (2006) found that the hyper-reactivity of children with ASD was significantly correlated with their deficit in socialization, their stereotyped behaviors and their perseveration. As functional skills in ADL require sensory interaction, sensory sensitivity, sensory avoiding and hyper-reactivity to sensation are expected to interfere with functional skills. However, relations between sensory responses and functional skills in ADL remain to be explored.

2.13. Motor skills

Studies on motor skills in children with ASD are limited. However, atypical sensory responses in children with ASD are becoming more and more recognized and motor performance depends on sensory integrity. As mentioned before, research in the past has focused on difficulties with communication, socialization and cognition. However, during infancy and early childhood, children use their motor skills to explore the environment, engage in physical play, initiate social interactions, and develop basic academic skills (National Research Council, 2001; Gibson, 2000). Given the major role of motor development in infancy and early childhood, one might ask why motor skills have been neglected in the scientific literature on ASD. The limited focus on motor skills in children with ASD may be due to the fact that their mobility is considered functional while their communication, socialization and cognition show more difficulties and atypical functioning. In addition, avoidance and refusal to co-operate on the part of children with ASD makes it difficult to evaluate motor skills (Mandelbaum et al. 2006).

However, motor difficulties in individuals with ASD start to be more reported in the literature. Provost et al. (2007), using the Peabody Developmental Motor

Scales – 2nd edition (PDMS-2; Folio and Fewell, 2000), showed significant motor impairments in children with ASD, aged 21 to 41 months, and no differences compared to children with developmental delay (DD). In addition, Vanvuchelen et al. (2007) found that school-aged boys with autism, including children with high-functioning and low functioning autism performed significantly poorer than controls on the PDMS-2 or the Movement Assessment Battery for Children (MABC; Henderson and Sugden, 1992). Children with high-functioning autism did not perform more poorly than children with typical development on imitation tasks, except for non-meaningful gestures. Therefore, their findings suggest that difficulties of imitation in autism are mainly due to perceptual-motor impairments. Noterdaeme et al. (2002) also found that children with autism and children with a language disorder have significant gross and fine motor difficulties when compared to controls. Although clumsiness was proposed to characterize Asperger syndrome, one of the ASD, Smith (2004) concluded that motor difficulties are common in all individuals regardless of the category of ASD. Moreover, impairments in imitation of body movements in ASD are now recognized (Williams et al. 2006). Mostofsky et al. (2006) reported that children with ASD present not only impaired imitation, but also generalized praxis impairment. Praxis or motor planning involves both a motor component (physical execution) and a cognitive component (ideation, planning, and sequencing; Mulligan 2003). Impairments in praxis or motor planning may be observed by the difficulties to perform unfamiliar motor activities. Weimer et al. (2001) explained clumsiness in children with Asperger Syndrome by proprioceptive deficits, interfering with praxis.

2.13.1. Gross motor skills

Gross motor skills are defined as the motor abilities requiring the large muscle systems (e.g.: body control, walking, running, manipulating a ball; Folio and Fewell, 2000) and include both postural and movement abilities. A pilot study by

Kohen-Raz et al. (1992) found postural abnormalities in children with autism. These findings are supported by Minshew et al. (2004) who showed that individuals with high-functioning autism, between the ages 5 and 52 years, present under-developed postural control. Newell and Bodfish (2007), in a study on the relation between postural movements during sitting and stereotyped movement during body rocking, proposed that body rocking may be caused by impairments of motor control and/or postural control.

Vernazza-Martin et al. (2005) found that children with autism, aged 3- to 6 years, have two types of deficits in goal-directed locomotion. First, their locomotion was irregular due to disturbance of regular, rhythmic and automatic locomotor pattern maintenance. Secondly, they showed difficulties with motor planning due to difficulties or lack of motivation to determine and maintain the goal and the plan of the trajectory. Thus both static and dynamic equilibrium are compromised in these children.

2.13.2. Fine motor skills

Fine motor skills refer to the motor abilities using the small muscle systems, such as in grasping and visual-motor integration (Folio and Fewell, 2000), and are related to gross motor skills. Mari el al. (2003) observed differences in reach-to-grasp patterning in school-aged children with autism compared to typical children. Their results confirmed that individuals with autism present difficulties to initiate, switch, efficiently perform or continue an ongoing activity. These results are supported by Vernazza-Martin et al. (2005) who showed difficulties with goal directed motor performance during locomotion. As reach-to-grasp movement is one of the major motor milestones in child development, Mari et al. (2003) suggested that movement analysis may be used for early screening of autism. In addition, they proposed that the differences observed in the reach-to-grasp movements may be extended to actions required in communication, social interactions and daily living skills. Hauck and Dewey (2001) found that children with autism show more ambiguous handedness than children with developmental delays, as well as an association between inconsistent hand preference and fine motor difficulties, supporting a bilateral brain dysfunction hypothesis.

2.13.3. Neurophysiology of motor difficulties

Motor learning requires the input from many cortical and sub-cortical regions. Based on their findings of postural control abnormalities, Kohen-Raz (1992) proposed that these abnormalities in children with autism come from the mesocortex or the cerebellum. However, the findings of Minshew et al. (2004) on postural control did not support cerebellar dysfunctions, but rather abnormalities in neural connectivity at a higher level of brain organization. In addition, Müller et al. (2004), using magnetic resonance imaging (MRI), showed differences in visuo-motor learning processes between individuals with autism and controls. They suggested that individuals with autism do not recruit cortical regions that support the optimization of simple visuo-motor activities. As well, dysfunctions of mirror neurons are now known to constitute a core deficit in ASD (Dapretto et al. 2006). Mirror neurons, identified in the ventral pre-motor cortex and anterior parietal regions are activated by the perception of an action or when the same action is executed (Williams et al. 2006). Therefore, mirror neurons play a role in imitation, a crucial form of learning during development, including motor development. Williams et al. (2006) showed differences between individuals with ASD and controls in the patterns of brain activation during imitation.

2.13.4. Impact of motor difficulties

Motor skills, especially fine motor skills, are needed to perform ADL, such as eating, grooming, bathing and dressing. In addition, impairments in imitation of body movements, as needed for learning, may contribute to difficulties to perform

ADL. Therefore, children with ASD may have difficulty learning how to perform their ADL. Motor skills, as pointed out above, are not limited to imitation and motor planning. Difficulties with postural control, balance, motor coordination, grasping and visual-motor integration also influence functional skills and thereby may affect eating, grooming, bathing and dressing. For example, postural control and balance are required to sit up properly and free the hands from supporting the trunk in order to reach, grasp and manipulate objects in an appropriate way, as needed for eating. Anzalone and Williamson (2000) pointed out the need to study the influence of sensori-motor difficulties in ASD in all functional domains. Moreover, as perceptions and actions interact and influence a plan of action (Gibson, 2000), it is important to assess sensory responses and motor skills in parallel. Therefore, the purpose of our study was to examine the influence of sensori-motor difficulties on functional skills in ADL of children with ASD.

2.14. Functional skills in ADL

The achievement of functional skills in ADL of children with ASD may be compromised because of the reported sensory and motor difficulties. In the past, only the intellectual quotient (IQ) was used to predict level of function of children with autism (Freeman et al. 1985). However, Freeman et al. (1991), in a 12 year follow-up study, noted that the presence of maladapted behaviors was not related to IQ. With the development of the Vineland Adaptive Behavior Scales (VABS, 1984), a better measure than IQ became available to determine the pragmatic day-to-day functioning of a child. According to Freeman et al. (1988), the VABS, frequently used in the diagnostic process, give a more adequate functional profile of a child than cognitive tests and may be a better predictor of social adaptation, as well as long-term outcome. Previous studies by Volkmar et al. (1987), Burack and Volkmar (1992), and Stone et al. (1999) found, by using the VABS, that children with autism under three years of age, presented an uneven pattern of adaptive behaviors while children with developmental delay/language impairment were more evenly distributed across the four domains. This uneven pattern in the autistic group was illustrated by their significant lower communication and socialization skills compared to the group with developmental delay/language impairment. In addition, the comparison of adaptive behaviors with mental age (MA) showed that communication and socialization skills were lower than MA while daily living and motor skills were higher than MA. However, they did not report their scores in comparison to the norms.

Finally, Kottorp et al. (2003) reported that individuals with autism, including children and adults, may learn specific tasks that are taught in a specific environment. However, these skills were not generalized to other tasks or other environments, including ADL. The lack of generalization may also interfere with functional skills in ADL. Therefore, to improve the autonomy of individuals with ASD, and to promote coping with complex tasks, it may be necessary to use an approach that emphasizes variation in the three domains: sensory input, motor skill acquisition, and functional skill training.

Chapter 3: RATIONALE AND HYPOTHESES

3.1. Rationale

Before the conception and publication of the Sensory Profile (Dunn, 1994), there were no reliable and valid clinical tests to measure the sensory responses in daily life, explaining the methodological weaknesses and limited focus of research on sensory responses in children with ASD. Since then, research on the sensory responses of children with ASD has emerged, but the nature and extent of their sensory responses remains unspecified (O'Neill & Jones, 1997). In addition, the processing and modulation of sensory information influences the acquisition of motor skills, but studies on motor skills in children with ASD are limited in comparison to the other spheres of development. Recent studies have shown that difficulties of coordination are common in all individuals with ASD (Smith, 2004). Moreover, deficits in the imitation of body movements, due to a dysfunction of mirror neurons, are now recognized as being specific to ASD (Williams and al. 2006). Beyond imitation, difficulties of motor planning (Mostofsky et al. 2006; Vernazza et al. 2005; Mari et al. 2003; Weimer et al. 2001), as well as perceptual-motor impairments (Vanvuchelen et al. 2007; Müller et al. 2004) are now more frequently reported. With the exception of Weimer et al. (2001), who related proprioceptive deficits with apraxia in the Asperger Syndrome, sensory responses and motor skills have not been studied in connection with ASD. In addition, the impact of the sensori-motor difficulties on functional skills in ADL has not been investigated in children with ASD. In order to better understand the global and specific needs of pre-school children with ASD, as well as to target interventions and facilitate their integration in the social environment, it is important to document the relationship between sensori-motor and functional skills in children with ASD.

Therefore, the goal of the present study was to assess the association of sensory responses and motor skills with the functional skills in ADL of children with

ASD, 3 to 4 years of age. We hypothesize that children with ASD will have more atypical sensory responses, poorer motor skills and lower functional independence than children with developmental delay and children with typical development and that the lower functional independence will be related to atypical sensory responses and poorer motor skills.

3.2. Hypotheses

3.2.1. General hypothesis

Children with ASD have less functional independence in ADL than children with developmental delay and children with typical development because of their atypical sensory responses and motor difficulties.

3.2.2. Specific hypotheses

3.2.2.1. Sensory responses

Children with ASD have more atypical sensory responses, such as sensory sensitivity, registration, and emotional responses, than children with developmental delay and children with typical development.

3.2.2.2. Motor skills

Children with ASD have more motor difficulties, such as difficulties of visual-motor integration, dexterity, coordination, balance, and postural control, than children with developmental delay and children with typical development.

3.2.2.3. Functional skills in ADL

Children with ASD have less functional independence in ADL, such as difficulties with eating, grooming, dressing, and toileting, than children with developmental delay and children with typical development.

Chapter 4: METHODS

4.1. Design

The present project is a pilot, cross-sectional and comparative study that is integrated within a larger study. The larger study, cross-sectional and prospective, has as its objective the determination of the developmental and functional profile of children with ASD from the age of three to ten years. In the current study, the group of interest is pre-school children aged three and four years.

4.2. Participants

4.2.1. Children with ASD

A total of 39 children with ASD were identified and approached as candidates for the current study. Four children did not participate: three caregivers refused to participate and one child was functioning at a lower level than was required for this study. Therefore, 35 children (90% participation) with ASD, three to four years of age, were recruited from the ASD program at the Montreal Children's Hospital (MCH). Among these children, thirty-four were also enrolled in a long-term study examining the developmental trajectory of children with ASD and/or molecular genetics, and one child was referred from the ASD clinic. Children were excluded if they had childhood disintegrative disorder, Rhett syndrome, visual, hearing or physical disabilities, medically diagnosed genetic disorders, such as fragile X, or tuberous sclerosis.

The diagnosis was made by a child psychiatrist, and was based on the Autism Diagnostic Interview (ADI-R; Le Couteur et al. 2003), the Autism Diagnostic Observation Schedule-Generic (ADOS-G; Lord et al. 2000), diagnostic criteria for ASD based on the DSM-IV (APA, 2000) and finally, clinical judgment. Twenty-five children had a diagnosis of autistic disorder and ten children had a diagnosis of PDD-NOS. There were no children with Asperger Syndrome. Cognitive functioning was assessed by a psychologist with the Merrill-Palmer-Revised (Merrill-Palmer-R; Roid and Sampers, 2004) and language skills by a speech-language pathologist (SLP) with the Preschool Language Scale – 4^{th} edition (PLS-4; Zimmerman et al. 2002) and the Peabody Picture Vocabulary Test – 3^{rd} edition (PPVT-3; Dunn and Dunn, 1997). All tests have adequate psychometric properties. Table 1 illustrates participants' characteristics. Cognitive functioning and language skills are indicated by using the mean of their standard scores (SS). Six children with ASD did not receive a formal speech language assessment and only fourteen passed the PPVT-4. Family background information (FBI) was not completed in four children with ASD. Thus, data regarding maternal education, primary language and ethnicity are not complete.

4.2.2. Controls

Limited data are available for the control group because subject recruitment was delayed. This group consists of 13 children of the same age range with either typical development (TD, n=5) or developmental delay (DD, n=8). Children with developmental delay were diagnosed with global developmental delay (GDD, n=3) or speech-language impairment (SLI, n=5). Children with typical development were recruited from colleagues and daycare centers, and children with GDD and SLI were recruited from the Developmental and Behavioral Pediatrics Clinic (DBPC) at MCH. To rule out the diagnosis of ASD, caregivers were asked to complete the Autism Screening Questionnaire (ASQ; Kazak Berument et al. 1999). Their cognitive functioning and language skills were assessed with the same tests as the ASD group. A standard score below 78 (1.5 SD below the norm) in the cognitive scale of the Merrill-Palmer-R or in the PSL-4 was required to be included in the DD group. Table 1 also shows characteristics of control children. The FBI was missing for 3 children with SLI because questionnaires were not returned.

Table 1. Participant characteristics

	ASD[1] (*n = 35*)	*DD*[2] (*n = 8*)	*TD*[3] (*n = 5*)	*p*[4]
Gender				
Boys, % (n)	91.4 (32)	50.0 (4)	80.0 (4)	.041
Chronological age[5]				
Mean (SD)	44.1 (5.9)	50.0 (5.4)	43.8 (7.1)	.052
Range	36 – 56	36 – 58	39 – 57	
Cognitive functioning				
Mean (SD)	61.3[a] (26.1)	77.6[b] (31.1)	96.6[b] (19.1)	.012
Range	12 – 130	12 – 122	75 – 122	
Language skills				
1) Receptive				
Mean (SD)	63.1[a] (18.7)	82.4[b] (21.2)	112.0[c] (8.1)	<.0001
Range	50 – 113	50 – 112	106 – 125	
2) Expressive				
Mean (SD)	71.6[a] (17.3)	73.0[a] (18.2)	113.2[b] (10.3)	.003
Range	50 – 112	50 – 102	103 – 127	
3) PPVT-4				
Mean (SD)	74.6 (31.2)	73.9 (20.1)	100.4 (13.5)	.076
Range	40 – 117	40 – 110	79 – 115	
Maternal education[5]				
Mean(SD)	11.6 (1.0)	12.2 (1.3)	12.2 (2.2)	.197
Range	10 – 14	10 – 13	8 – 13	
Primary language				
English, % (n)	67.7 (21)	60.0 (3)	60.0 (3)	.908
French, % (n)	12.9 (4)	20.0 (1)	40.0 (2)	
Other, % (n)	19.4 (6)	20.0 (1)	0 (0)	
Ethnicity				
Caucasian, % (n)	67.8 (21)	80.0 (4)	60.0 (3)	.180

[1]ASD: Autism Spectrum Disorder.
[2]DD: Developmental Delay. Cognitive functioning and language skills are indicated in standard scores (see text for definition). Homogeneity of variance was tested for the ASD and DD groups.
[3]TD: Typical Development.
[4]Chi-Square and Kruskall-Wallis Tests were used respectively to determine differences between groups. Different letters (a, b, c) denote significant differences between groups using the Mann-Whitney-U, p<.05).
[5]Chronological age in months; maternal education in years.

4.3. Clinical Measures

4.3.1. Sensory responses

The Sensory Profile (Dunn, 1999), a caregiver questionnaire of 125-items for children aged 3 to 10 years, was administered. It measures children's sensory processing, modulation, behavioral and emotional responses. The 125-items are grouped into fourteen sections and nine factors. Results may also be presented in the form of four quadrants: sensory seeking; poor registration; sensory avoiding and sensory sensitivity. Frequency of responses is scored on a 5-point Likert scale (i.e. always, frequently, occasionally, seldom, or never). The normative data of the Sensory Profile are based on more than 1000 children with typical development and on 150 children with disabilities (Dunn, 1999). Reliabilities include internal consistency estimates (0.47 - 0.91) and standard error of measurement (range 1.0 – 2.8; Dunn, 1999). In addition, results are reported in short form, using the Short Sensory Profile, of 38 items, to obtain a total score.

4.3.2. Motor skills

Motor skills were assessed using the Peabody Developmental Motor Scales – 2nd Edition (PDMS-2; Folio and Fewell, 2000), a task-observation test for children from birth through 5 years of age. It was administered following standardized instructions. The PDMS-2 includes gross and fine motor tasks with subtests. The gross motor tasks are grouped into four subtests: reflexes (birth to 11 months); stationary (i.e. static balance and body control); locomotion (e.g.: crawling, walking, running, hopping, jumping); and object manipulation (e.g.: catching, throwing and kicking a ball). Two remaining subtests measure fine motor skills: grasping and visual-motor integration. Normative scores are based on a sample of 2003 children from birth to 5 years of age from 46 states in the United States and British Columbia, Canada. For items in the fine-motor scale, inter-rater reliability ranges from 0.90-0.97 (Gebhard, Ottenbacher and Lane, 1994), or from 0.84 to 0.99 (van Hartingsveldt, Cup and Oostendorp 2005).

4.3.3. Functional skills in ADL

The Functional Independence Measure for children (WeeFIM; Braun et al. 1994) and the Survey Interview Form of the Vineland Adaptive Behavior Scales – Second Edition (VABS-II) were used to determine functional skills in ADL. The WeeFIM, a semi-structured interview, is a pediatric Functional Independence Measure developed for children with physical and/or mental disabilities aged six months to eight years (Msall et al. 1994). This test, based on caregiver report, consists of 18 items grouped into three domains: self-care, mobility and cognition. The self-care domain comprises eating, grooming, bathing, dressing, and toileting. The mobility domain covers locomotion (walking, stairs) and transfers (chair, toilet, bath tub). The cognition domain includes communication (comprehension, expression), social interaction and cognitive skills (problem solving, memory). Scores are rated on a 7-point ordinal scale from total assistance (1) to complete independence (7). Results are computed as quotients. Inter-rater reliability for all subscales ranges from 0.85 to 1.00 (Ottenbacher et al. 1996) and stability of the items over 7 and 14 days ranges from 0.90 to 0.99 (Ottenbacher et al. 1997). Ottenbacher (2000) obtained a correlation of 0.89 for the WeeFIM with the VABS. Only the self-care results are used as outcome measures in this study.

The VABS-II assesses the adaptive behavior of individuals from birth to adulthood. It covers the following domains: communication, daily living skills (DLS), socialization, and motor skills; the higher the score, the better the skill. The VABS-II is a standardized instrument representing a sample of 3000 subjects from the United States. Reliability is well established and above the .80 level for all domains (Sparrow, Cicchetti and Balla, 2005).

4.4. Procedures

Assessment of sensory responses, motor skills and daily living skills were conducted by two occupational therapists trained in the administration of these tests. Motor skills were assessed in a quiet observation room at the MCH. Caregivers were present for support, but were asked not to intervene during testing. During the same visit, the Sensory Profile was completed by the caregiver and the WeeFIM was completed in a short interview with the caregiver. A typical assessment session lasted between 60 and 90 minutes. The VABS-II was administered by telephone interview by a psychologist, a research assistant or an occupational therapist, previously trained to administer this test.

4.5. Statistical analyses

In the WeeFIM and the VABS-II, analyses focused on self-care and daily living skills (DLS) respectively, including personal, domestic and community skills. The motor subscale of the VABS-II was also used to confirm findings from observational testing with the PDMS-2. Differences in frequencies of atypical sensory responses on the Short Sensory Profile were analyzed with Chi-Square tests. Because of the small number of controls, non-parametric tests (Kruskal-Wallis H and Mann-Whitney-U) were used to analyze results from the Short Sensory Profile, the Sensory Profile, the PDMS-2, the WeeFIM and the VABS-II. Descriptive data are presented to characterize children with ASD in terms of sensory responses, motor skills and functional skills in ADL. Pearson Product-moment correlations were conducted to verify associations between sensory responses and motor skills and between sensori-motor performances and functional skills in ADL of the ASD group. Finally, multiple linear regressions were performed to illustrate the influence of sensori-motor performances on functional skills in ADL. As the measure of personal skills of the VABS is similar to the self-care skills of the WeeFIM, the personal sub-domain of the VABS-II was included in the multiple linear regression as well as self-care of the WeeFIM and DLS of the VABS-II.

Chapter 5: RESULTS

5.1. Sensory responses

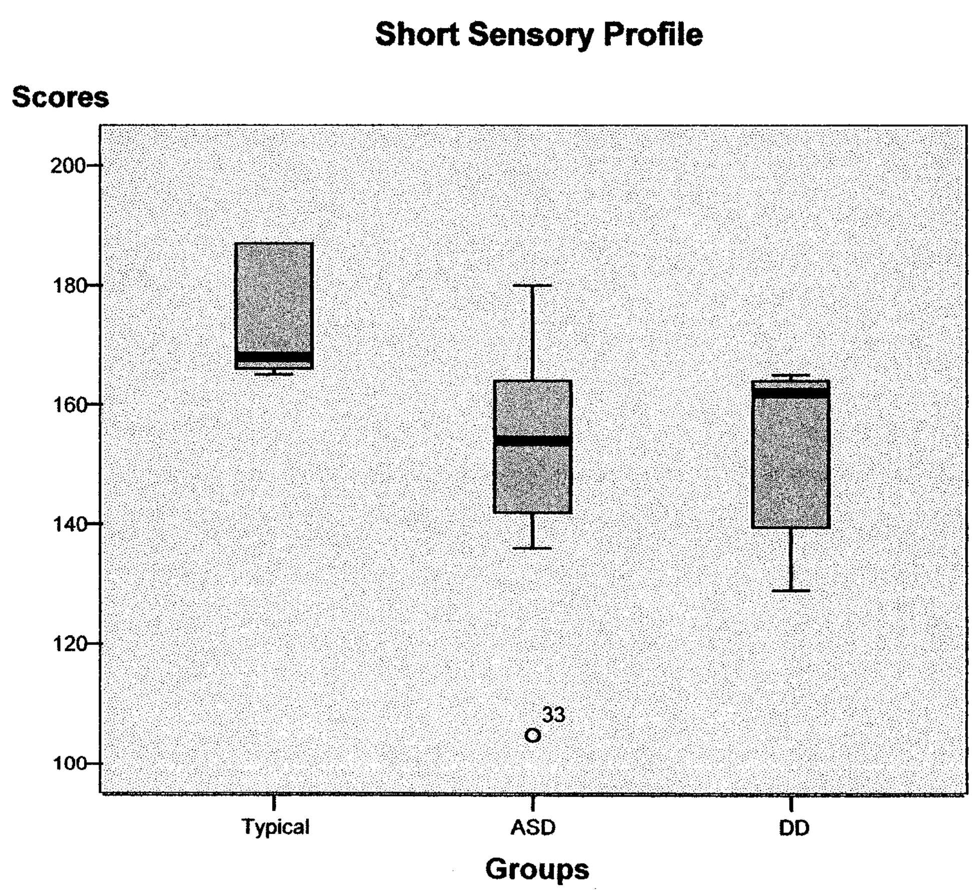
A significant difference was found between the TD and the other two groups for the mean score of total sensory performance on the Short Sensory Profile (Table 2). Similar to the ASD group, mean scores of the total sensory performance for the DD group fell below the range of typical responses (typical performance: between 190-155). In addition, the ASD group showed the highest percentage of children with atypical responses on total sensory performance, but there was no significant difference in percentage between the groups. Differences between the three groups are clearly illustrated in the box and whisker plot (Figure 2). The medians for the DD and ASD groups are below that of the typical group, and the ASD group is below that of the DD group. As well, the upper 50% of the DD group is concentrated at the median which is above the cutoff score for atypical responses, and most of the variability in the scores is in the lower 50% of the scores. In contrast, the median for the ASD group is closer to the mean, with fairly equal dispersion above and below the median. Although the number is small for the typically developing group, the lower 50% is concentrated in a range above the cutoff for atypical responses, with most of the variability in the upper 50%.

Table 2. Comparison of the total scores and percentages of atypical sensory responses between groups

Short Sensory Profile	*ASD* *n=33*	*DD* *N=7*	*TD* *n=5*	*P*
Total score				
Mean (SD)	153.2[a] (15.0)	151.9[a] (15.6)	174.6[b] (23.8)	.017
Range	105 – 180	129 – 165	165 – 187	
Median	154.0	162.0	168.0	
Atypical responses				
% (n)	57.8 (19)	42.8 (3)	0 (0)	.058

Total scores between 154 and 38 are considered atypical responses.
Different letters (a, b) denote significant differences between groups (Mann Whitney-U, p<.05).
Data are missing for two children with ASD and one child with DD.

Figure 2. Box and whisker plot – Short Sensory Profile (groups)



Our results also reveal that a very high percentage of the ASD and DD groups presented atypical sensory responses in at least one of the 14 sections or nine factors (Table 3a). Thus, to better describe sensory performances of the groups, data are presented by quadrants, sections and factors to illustrate the percentages of children presenting atypical responses (Table 3b). There is both variability and heterogeneity of atypical sensory responses within the ASD and DD groups. To represent the quadrants, sections and factors in which the majority showed atypical responses, the cut-off of 50% was arbitrarily chosen, based on a normal distribution. In the ASD group, the majority shows atypical responses in two of the four quadrants (sensory seeking and sensory sensitivity), two of the 14 sections (multisensory processing and modulation of sensory input affecting emotional responses) and two of the nine factors (sensory seeking and inattention/distractibility). Section J (modulation of sensory input affecting emotional) and factor 5 (inattention/distractibility) have the highest percentage of children presenting atypical responses of all the quadrants, sections and factors. Children with DD had four categories more (quadrants, sections and/or factors) that were greater than 50% compared to children with ASD, suggesting more variability and heterogeneity in the DD group. Specifically, the majority of the DD group presented atypical responses in quadrant 4 (sensory sensitivity), six of the 14 sections (multisensory processing, sensory processing related to endurance/tone, modulation related to body position & movement, modulation of movement affecting activity level, modulation of sensory input affecting emotional responses, and emotional/social responses) and four of the nine factors (emotional reactive, low endurance/tone, inattention/distractibility, and poor registration). The highest percentage of children presenting atypical responses is noted in quadrant 4 (sensory sensitivity). The TD group had only one category over 50% which is quadrant 1 (sensory seeking). Significant differences were found in scores of section K (modulation of visual input affecting emotional & activity level) and factor

5 (inattention/distractibility) between the ASD group and the two control groups and also, in sections A (auditory processing) and J (modulation of sensory input affecting emotional responses) between ASD and TD (Table 3c). In addition, scores of the DD group were significantly different from the ASD and TD group in section G (sensory processing related to endurance/tone) and factor 3 (low endurance/tone). No significant differences in quadrants were noted between groups.

Table 3a. Percentage of atypical responses in at least one section or factor in the groups

Sensory Profile	***ASD*** *n=33* *% (n)*	***DD*** *n=7* *% (n)*	***TD*** *n=5* *% (n)*
Atypical responses (Probable and/or Definite difference)	93.9 (31)	100.0 (7)	60.0 (3)
Probable difference	21.2 (7)	14.3 (1)	40.0 (2)
Definite difference	72.7 (24)	85.1 (6)	20.0 (1)

Probable difference: between -1SD and -2SD
Definite difference: below -2SD
Data are missing for two children with ASD and one child with DD.

Table 3b. Percentage of atypical sensory responses in the groups

Sensory Profile	*Atypical Responses*		
	ASD *n=33*	*DD* *n=7*	*TD* *N=5*
Quadrants	*% (n)*	*% (n)*	*% (n)*
Q1: Sensory seeking	**54.5** (18)	42.9 (3)	**60.0** (3)
Q2: Low registration	48.5 (16)	57.1 (4)	0 (0)
Q3: Sensory avoiding	39.4 (13)	42.9 (3)	0 (0)
Q4: Sensory sensitivity	**54.5** (18)	**85.7** (6)	0 (0)
Sections			
A. Auditory processing	48.5 (16)	42.9 (3)	0 (0)
B. Visual processing	18.2 (6)	42.9 (3)	0 (0)
C. Vestibular processing	36.4 (12)	42.9 (3)	20.0 (1)
D. Touch processing	48.5 (16)	42.9 (3)	20.0 (1)
E. Multisensory processing	**54.5** (18)	**71.4** (5)	20.0 (1)
F. Oral sensory processing	24.2 (8)	28.6 (2)	0 (0)
G. Sensory processing related to endurance/tone	24.2 (8)	**71.4** (5)	20.0 (1)
H. Modulation related to body position & movement	36.4 (12)	**57.1** (4)	0 (0)
I. Modulation of movement affecting activity level	24.2 (8)	42.9 (3)	0 (0)
J. Modulation of sensory input affecting emotional responses	**60.6** (20)	**71.4** (5)	0 (0)
K. Modulation of visual input affecting emotional & activity level	42.4 (14)	28.6 (2)	0 (0)
L. Emotional/social responses	45.5 (15)	**57.1** (4)	40.0 (2)
M. Behavioral outcomes of sensory processing	33.3 (11)	28.6 (2)	20.0 (1)
N. Items indicating thresholds	42.4 (14)	28.6 (2)	20.0 (0)
Factors			
1. Sensory seeking	**54.5** (18)	28.6 (2)	40.0 (2)
2. Emotional reactive	39.4 (13)	**57.1** (4)	40.0 (2)
3. Low endurance/tone	27.3 (9)	**71.4** (5)	20.0 (1)
4. Oral sensory sensitivity	24.2 (8)	28.6 (2)	0 (0)
5. Inattention/distractibility	**60.6** (20)	**57.1** (4)	10.0 (1)
6. Poor registration	42.4 (14)	**57.1** (4)	0 (0)
7. Sensory sensitivity	18.2 (6)	28.6 (2)	10.0 (1)
8. Sedentary	12.1 (4)	28.6 (2)	0 (0)
9. Fine motor/perceptual	12.1 (4)	14.3 (1)	0 (0)

Bold numbers illustrate frequencies greater than 50%.
Data are missing for two children with ASD and one child with DD.

Table 3c. Comparison of scores in sections and factors between groups

Sensory Profile	*ASD* *N=33*	*DD* *N=7*	*TD* *n=5*	*P*
Sections				
A. Auditory processing Mean (SD) Range	28.5 (6.5)[a] 15 – 39	31.4 (4.3)[a] 26 – 38	36.4 (4.0)[b] 30 – 40	.020
G. Sensory processing related to endurance/tone Mean (SD) Range	41.6 (5.6)[b] 20 – 45	35.9 (7.5)[a] 22 – 45	43.6 (3.1)[b] 38 – 45	.023
J. Modulation of sensory input affecting emotional responses Mean (SD) Range	14.5 (2.9)[a] 10 – 20	13.6 (2.8)[a] 10 – 17	18.4 (1.8)[b] 16 – 20	.017
K. Modulation of visual input affecting emotional & activity level Mean (SD) Range	13.8 (2.4)[a] 9 – 18	14.7 (3.4)[b] 9 – 19	17.4 (2.6)[b] 14 – 20	.035
Factors				
3. Low endurance/tone Mean (SD) Range	41.6 (5.6)[b] 20 – 45	35.9 (7.5)[a] 22 – 45	43.6 (3.1)[b] 38 – 45	.023
5. Inattention/distractibility Mean (SD) Range	23.2 (4.4)[a] 13 – 31	26.6 (5.7)[b] 19 – 34	30.8 (4.1)[b] 25 – 35	.011

Different letters (a, b) denote significant differences between groups (Mann Whitney-U, $p<.05$).
Data are missing for two children with ASD and one child with DD.

Despite the small number of participants, we explored the differences and similarities in the ASD and DD groups by subgroups (i.e. autistic disorder, PDD-NOS, GDD, SLI). On the Short Sensory Profile (Table 4a), mean scores of total sensory performance and percentages of children presenting atypical performance in total sensory performance, indicate that the PDD-NOS subgroup presented more atypical responses than the autistic subgroup, and so did the SLI compared to GDD subgroup.

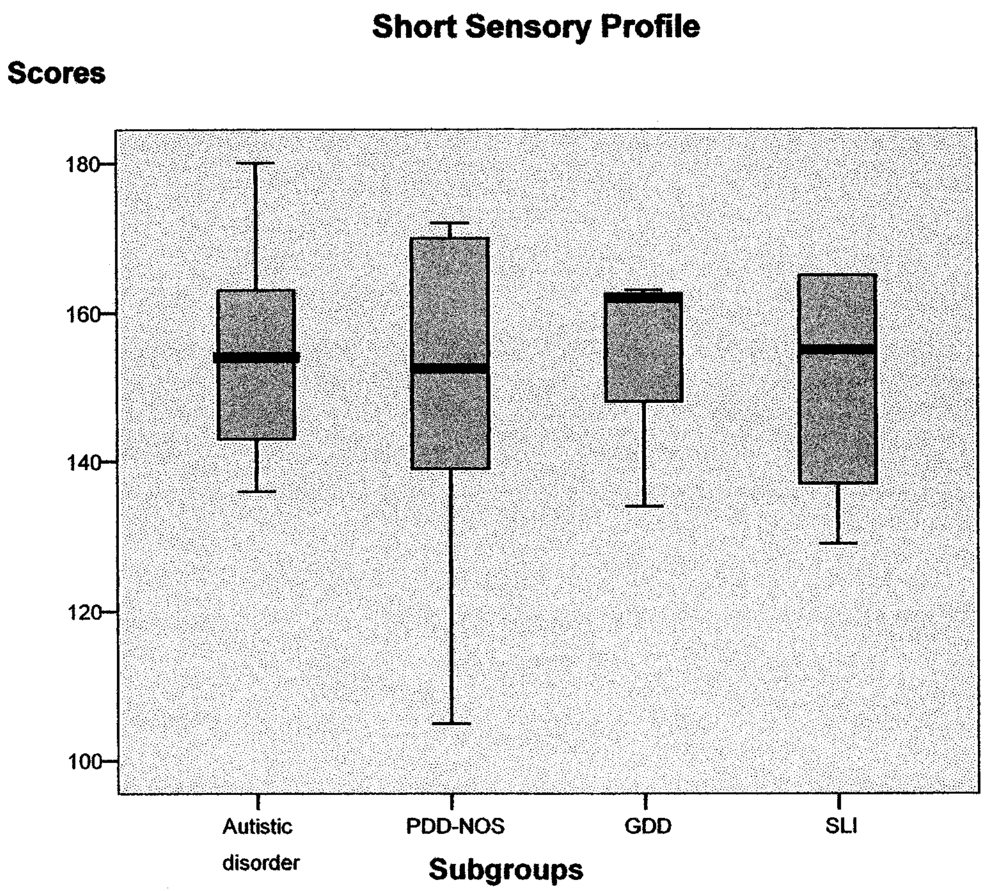
Table 4a. Comparison of the total scores and frequency of atypical sensory responses between subgroups

Short Sensory Profile	*AD*[1] *n=23*	*PDD-NOS*[2] *n=10*	*GDD*[3] *n=3*	*SLI*[4] *N=4*
Total score[1]				
Mean (SD)	154.5 (12.3)	151.9 (20.5)	153.0 (16.5)	151.0 (17.4)
Range	136 – 180	105 – 172	165 – 187	134-163
Median	154.0	152.5	162.0	155.0
Atypical responses				
% (n)	56.5 (13)	60.0 (6)	33.3 (1)	50.0 (2)

[1]AD: Autistic disorder. Data are missing for two children with autistic disorder.
[2]PDD-NOS: Pervasive developmental disorder – not otherwise specified.
[3]GDD: Global developmental delay.
[4]SLI: Speech language impairment.

Box and whisker plots illustrate the variability and differences between the subgroups (Figure 3). The medians for autistic disorder and PDD-NOS subgroups are below the cutoff score for atypical responses. The dispersion above and below the median appears very similar to the mean, but the PDD-NOS showed more variability and included an outlier. In comparison, the medians for GDD and SLI subgroups are in the range for typical responses. However, their dispersion above and below their median are different: the upper 50% of the GDD group is concentrated at the median while the SLI subgroup is more equally dispersed above and below the median.

Figure 3. Box and whisker plot – Short Sensory Profile (subgroups)



Percentages of atypical responses in the quadrants, sections and factors (Table 4b) illustrate differences between the subgroups. Within the ASD group, the autistic disorder subgroup showed the highest percentage of children presenting atypical responses as shown in section J (modulation of sensory input affecting emotional) and Factor 5 (inattention/distractibility). In the PDD-NOS subgroup, the highest percentages are indicated in quadrant 2 (low registration), quadrant 4 (sensory sensitivity) and section E (multisensory processing). Regarding controls, more homogeneity is found in the subgroups: all children of the GDD subgroup present atypical responses in section H (sensory processing related to endurance/tone), section J (modulation of sensory input affecting emotional responses) and factor 3 (low endurance/tone). The SLI subgroup only had one domain over 50%, showing 75% in section E (multi-sensory processing).

Table 4b. Percentage of atypical sensory responses in the subgroups

Sensory Profile	*Atypical Responses*			
	AD *N=23*	*PPD-NOS* *n=10*	*GDD* *n=3*	*SLI* *n=4*
Quadrants	*% (n)*	*% (n)*	*% (n)*	*% (n)*
Q1: Sensory seeking	**52.2** (12)	**60.0** (6)	33.3 (1)	50.0 (2)
Q2: Low registration	39.1 (9)	**70.0** (7)	**66.7** (2)	50.0 (2)
Q3: Sensory avoiding	39.1 (9)	40.0 (4)	33.3 (1)	50.0 (2)
Q4: Sensory sensitivity	47.8 (11)	**70.0** (7)	**66.7** (2)	50.0 (2)
Sections				
A. Auditory processing	**52.2** (12)	40.0 (4)	33.3 (1)	50.0 (2)
B. Visual processing	13.0 (3)	30.0 (3)	**66.7** (2)	25.0 (1)
C. Vestibular processing	30.4 (7)	50.0 (5)	**66.7** (1)	50.0 (2)
D. Touch processing	47.8 (11)	50.0 (5)	33.3 (1)	50.0 (2)
E. Multisensory processing	47.8 (11)	**70.0** (7)	**66.7** (2)	**75.0** (3)
F. Oral sensory processing	26.1 (6)	20.0 (2)	0 (0)	50.0 (2)
G. Sensory processing related to endurance/tone	21.7 (5)	30.0 (3)	**100** (3)	50.0(2)
H. Modulation related to body position & movement	30.4 (7)	50.0 (5)	**66.7** (2)	50.0 (2)
I. Modulation of movement affecting activity level	30.4 (7)	10.0 (1)	**66.7** (2)	25.0 (1)
J. Modulation of sensory input affecting emotional responses	**60.9** (14)	**60.0** (6)	**100** (3)	50.0 (2)
K. Modulation of visual input affecting emotional & activity level	39.1 (9)	50.0 (5)	**66.7** (2)	0 (0)
L. Emotional/social responses	39.1 (9)	**60.0** (6)	**66.7** (2)	50.0 (2)
M. Behavioral outcomes of sensory processing	26.1 (6)	50.0 (5)	33.3 (1)	25.0 (1)
N. Items indicating thresholds	39.1 (9)	50.0 (5)	33.3 (1)	25.0 (1)
Factors				
1. Sensory seeking	**56.5** (13)	50.0 (5)	33.3 (1)	25.0 (1)
2. Emotional reactive	30.4 (7)	**60.0** (6)	**66.7** (2)	50.0 (2)
3. Low endurance/tone	21.7 (5)	40.0 (4)	**100** (3)	50.0 (2)
4. Oral sensory sensitivity	26.1 (6)	20.0 (2)	0 (0)	50.0 (2)
5. Inattention/distractibility	**60.9** (14)	**60.0** (6)	**66.7** (2)	50.0 (2)
6. Poor registration	47.8 (11)	30.0 (3)	**66.7** (2)	50.0 (2)
7. Sensory sensitivity	17.4 (4)	20.0 (2)	33.3 (1)	25.0 (1)
8. Sedentary	17.4 (4)	0 (0)	33.3 (1)	25.0 (1)
9. Fine motor/perceptual	8.7 (2)	20.0 (2)	33.3 (1)	0 (0)

Bold numbers illustrate frequencies greater than 50%.
Data are missing for two children with autistic disorder.

5.2. Motor skills

Mean motor performances of the ASD group were significantly lower than controls (Table 5). Post hoc tests indicated significant differences between ASD group and both control groups in the three motor composites. Based on clinical interpretation, the mean motor quotients of the ASD group reveal very poor performance in gross motor and total motor composites (below -2 SD) and poor performance in the fine motor composite (between -1.5 and -2 SD). Therefore, compared to PDMS-2 norms, significant motor delays in gross and total motor skills and poor fine motor skills are found in the ASD group.

Table 5. Comparison of the motor quotient scores between the groups

*PDMS-2** *Composites*	***ASD*** *n = 35*	***DD*** *n = 8*	***TD*** *n = 5*	***P***
Gross motor				
Mean (SD)	**69.0**^{a} (7.3)	87.5^{b} (10.5)	94.6^{b} (8.0)	<.0001
Range	55 – 87	74 – 106	72 – 100	
Fine motor				
Mean (SD)	74.7^{a} (10.1)	90.6^{b} (22.3)	110.8^{b} (10.9)	0.001
Range	55 – 97	73 – 130	92 – 124	
Total motor				
Mean (SD)	**68.7**^{a} (8.3)	91.1^{b} (15.1)	101.0^{b} (7.1)	<.0001
Range	51 – 83	73 – 111	40 – 57	

*Quotient standard scores: mean = 100, SD = 15, < 70 = < -2SD
Bold numbers illustrate performance below 2 SD of the norm.
Different letters (a, b) denote significant differences between groups (Mann Whitney-U, p<.05).

Table 6 illustrates the motor performances of the groups on the five subtests of the PDMS-2. Mean scores, as compared to standardized scores, indicate that the ASD group performed below 1.5 SD of the standard for locomotion, object manipulation and grasping, but not for stationary and visual-motor integration tasks, where values are within 1 and 1.5 SD of the standardized values. As previously indicated, performance between -1.5 and -2 SD is considered clinically poor. The DD group performed on average within ±1 SD of the standardized scores (i.e. average range), except for the object manipulation subtest that fell between 1 and 1.5 SD. All mean scores of the typical group are above -1 SD.

Table 6. Motor performance in the ASD group (standard scores)

PDMS-2* *Subtests*	***ASD*** *n = 35*	***DD*** *n = 8*	***Typical*** *n = 5*
Stationary			
Mean (SD)	6 (1)	8 (2)	9 (2)
Range	4 – 7	6 – 11	6 – 12
Locomotion			
Mean (SD)	5 (2)	9 (2)	9 (2)
Range	1 – 8	5 – 12	6 – 11
Object manipulation			
Mean (SD)	5 (2)	7 (2)	9 (0)
Range	1 – 9	5 – 10	9 – 9
Grasping			
Mean (SD)	5 (2)	8 (5)	11 (2)
Range	3 – 10	3 – 19	9 – 13
Visual-motor integration			
Mean (SD)	6 (2)	10 (5)	13 (3)
Range	2 – 12	6 – 19	10 – 16

*Standard scores: mean = 10, SD = 3, < 4 = < -2SD

To validate our findings from observational testing, significant correlations between the total motor composite of the PDMS-2 and the motor skills domain of the VABS-II (r=.619, p<.001), and between the gross and fine motor skills (r=.592, p<.001 and r=.674, p<.001) were noted.

5.3. Functional skills in ADL

Mean scores in the cognition domain of the WeeFIM (Table 7), as well as all domains of the VABS-II (Table 8) were significantly poorer for the ASD compared to the TD group. In the VABS-II, the ASD group scores were significantly poorer than the DD group for DLS, socialization and total score on the VABS-II (Mann Whitney-U, p<.05). However, there was no significant difference between the ASD and DD groups in the domains of the WeeFIM and the communication and motor skills domains of the VABS-II. The ASD group showed very poor performance in self-care clinically, on the WeeFIM (below -2 SD), indicating a significant delay of functioning in ADL. On the VABS-II, DLS performance was interpreted clinically as moderately low (between -1 and -2 SD). A significant correlation was found between the self-care domain of the WeeFIM and the DLS of the VABS-II (r = .530, p=0.001), confirming an association between the results of the two tests.

Table 7. Comparison of functional independence quotients between groups

WeeFIM *Domains*	***ASD*** *N=35*	***DD*** *n=8*	***TD*** *n=5*	***p***
Self-care				
Mean (SD)	**55.5** (18.0)	**65.3** (25.5)	71.2 (23.0)	.210
Range	30 – 87	28 – 99	34 – 97	
% (< -2SD)	48.6	37.5	33.3	
Mobility				
Mean (SD)	91.0 (10.6)	96.3 (9.1)	92.8 (15.8)	.424
Range	68 – 110	78 – 107	68 – 108	
% (< -2SD)	22.9	12.5	0	
Cognition				
Mean (SD)	**52.8**[a] (15.4)	**63.3**[a] (18.4)	89.3[b] (9.3)	.001
Range	28 – 92	27 – 83	76 – 97	
% (< -2SD)	57.1	25.0	0	
Total				
Mean (SD)	**68.1** (13.2)	75.4 (15.5)	82.9 (15.3)	.060
Range	48 – 101	52 – 91	56 – 93	
% (< -2SD)	45.8	37.5	16.7	

Bold numbers illustrate performance below -2 SD of the norm.
Different letters (a, b) denote significant differences between groups (Mann Whitney-U, p<.05).

Table 8. Comparison of adaptive behavior standard scores between groups

*VABS-II** *Domains*	*ASD* *n = 35*	*DD* *n = 8*	*DT* *n = 5*	*P*
Communication				
Mean (SD)	70.2[a] (16.5)	82.1[a] (13.0)	101.4[b] (6.5)	.001
Range	42 – 104	59 – 100	91 – 108	
Daily Living Skills				
Mean (SD)	74.5[a] (11.6)	88.4[b] (13.9)	101.6[b] (9.6)	.001
Range	68 – 110	66 – 111	91 – 115	
Socialization				
Mean (SD)	71.0[a] (8.8)	90.0[b] (22.5)	104.2[b] (5.5)	.001
Range	57 – 94	27 – 83	100 – 112	
Motors Skills				
Mean (SD)	80.6[a] (11.1)	85.4[ab] (17.0)	104.0[b] (9,7)	.007
Range	59 – 104	64 – 111	91 – 114	
Total				
Mean (SD)	70.8[a] (10.4)	84.6[b] (16.2)	103.2[b] (7.9)	<.0001
Range	57 – 100	63 – 104	95 – 113	

*Standard scores: mean = 100, SD = 15, < 70 = < -2SD
Different letters (a, b) denote significant differences between groups (Mann Whitney-U, p<.05).

When examining the specific items in the self-care domain of the WeeFIM (Table 9), the ASD group scored the highest for eating independently and the lowest for bathing independently. When assessing the clinical relevance of the mean scores, the ASD group required moderate to total assistance in all self-care sub-domains, except for eating. Clinically, mean scores of the items reveal that, on average, total assistance is required for bathing and maximal assistance for grooming, dressing and toileting.

Table 9. Self-care skills of the ASD group

WeeFIM *Self-Care*	***Scores***
Eating	
Mean (SD)	5 (1)
Range	2 – 7
Grooming	
Mean (SD)	2 (1)
Range	1 – 5
Bathing	
Mean (SD)	1 (1)
Range	1 – 5
Dressing – Upper Body	
Mean (SD)	2 (1)
Range	1 – 4
Dressing – Lower Body	
Mean (SD)	2 (1)
Range	1 – 4
Toileting	
Mean (SD)	2 (1)
Range	1 – 6
Bladder Management	
Mean (SD)	3 (2)
Range	1 – 7
Bowel Management	
Mean (SD)	3 (3)
Range	1 – 7

Interpretation of the scores: 1 = *Total Assistance*; 2 = *Maximal Assistance*; 3 = *Moderate Assistance*; 4 = *Minimal Assistance*; 5 = *Supervision or Setup*; 6 = *Modified Independence*; 7 = *Complete independence.*

Mean V-scale scores (i.e. derived scores for sub-domains) of the 3 items in the DLS domain of the VABS-II showed poorest performance on the personal sub-domain. This sub-domain includes eating, drinking, bathing, toileting, grooming, dressing and health care. It is most similar to the self-care domain of the WeeFIM and correlated with it (r=.662, p<.0001). Table 10 illustrates results of the personal sub-domain of the VABS-II.

Table 10. VABS-II performance scores of daily living skills of the ASD group

Items in the Daily Living Skills Domain (VABS-II)	*V-scale*
Personal	
Mean (SD)	9.9 (2.0)
Range	6 – 13
Domestic	
Mean (SD)	11.7 (2.5)
Range	9 – 17
Community	
Mean (SD)	11.6 (2.3)
Range	8 – 16

Interpretation of the V-Scale scores: 1 – 9 = *Low Adaptive Level*; 10 – 12 = *Below Average Adaptive Level*; 13 – 17 = *Average Adaptive Level*.

5.4. Correlations between sensory responses, motor skills and functional skills in ADL

Few correlations (Pearson Product moment) were found between sensory responses and motor skills (Table 11a). Quadrant 1 (sensory seeking) and section D (touch processing) were significantly correlated with gross motor skills ($p<0.03$); no sensory responses correlated with fine motor skills. In contrast, there were many significant correlations between sensori-motor performances and functional skills of the self-care domain of the WeeFIM, the personal sub-domain of the VABS-II and DLS domain of the VABS-II (Table 11b). Among these sensori-motor items, there are quadrant 3 (sensory avoiding) of the Sensory Profile, the fine motor composite, total motor composite and the visual-motor integration of the PDMS-2, as well as the motor skills domain of the VABS-II.

Table 11a. Correlations between sensory responses and motor skills

	***Motor skills** (PDMS-2: Composites)*		
Sensory Responses *(Sensory Profile)*	**Gross motor**	**Fine motor**	**Total motor**
Short Form			
Total score	r = .172 p = .338	r = .042 p = .816	r = .127 p = .481
Quadrants			
Q1: Sensory seeking	r = .386* p = .027	r = .094 p = .603	r = .270 p = .128
Sections			
D. Touch processing	r = .433* p = .012	r = .211 p = .238	r = .364* p = .037

*Pearson's correlation is significant at 0.05 level (2-tailed).

Table 11b. Correlations between sensori-motor performances and functional skills

	Functional skills in ADL		
Sensori-motor performances	***Self-Care*** *WeeFIM*	***Personal*** *VABS-II*	***DLS*** *VABS-II*
Sensory Profile			
Short Form			
Total score	r = .318 *p* = .029	r = .258 *p* = .169	r = .255 *p* = .151
Quadrants			
Q3: Sensory avoiding	r = .380* *p* = .029	r = .457* *p* = 011	r = .372* *p* = .033
Sections			
A. Auditory processing	r = .418* *p* = .015	r = .263 *p* = .160	r = .282 *p* = .112
Factors			
5. Inattention/distractibility	r = .392* *p* = .024	r = .200 *p* = .289	r = .260 *p* = .144
PDMS-2			
Composites			
- Gross motor	r = .287 *p* = .095	r = .296 *p* = .106	r = .188* *p* = .388
- Fine motor	r = .401* *p* = .017	r = .531** *p* = .002	r = .453** *p* = .006
- Total motor	r = .394* *p* = .019	r = .477** *p* = .007	r = .478** *p* = .004
Subtests			
- Stationary	r = -.098 *p* = .575	r = .091 *p* = .628	r = .070 *p* = .687
- Locomotion	r = .317 *p* = .064	r = .380* *p* = .035	r = .460** *p* = .005
- Object manipulation	r = .346* *p* = .041	r = .202 *p* = .276	r = .330 *p* = .053
- Grasping	r = .187 *p* = .283	r = .400* *p* = .026	r = .201 *p* = .247
- Visual-motor integration	r = .429* *p* = .010	r = .478** *p* = .007	r = .477** *p* = .004
VABS-II			
Motor Skills	r = .424* *p* = .011	r = .636** *p* = .000	r = .669** *p* = .000

* Pearson's correlation is significant at 0.05 level (2-tailed).
** Pearson's correlation is significant at 0.01 level (2-tailed).

5.5. Predictions of functional skills in ADL from sensori-motor performances

Multiple linear regressions were performed to measure the influence of sensori-motor performances on functional skills in ADL (Tables 12a, 12b, 12c). Based on significant correlations between sensori-motor and functional variables, the following sensori-motor variables were selected: sensory avoiding, auditory processing, fine motor quotient and gross motor quotient. Cognitive functioning and total language skills were added as co-variables because they may influence functional skills in ADL. A stepwise method was used for the selection of significant variables in the model. First, in the self-care skills of the WeeFIM (Table 12a), cognitive functioning and auditory processing were the significant variables included in the model. The other variables (sensory avoiding, fine motor quotient and gross motor quotient) were excluded. The adjusted R^2 indicates that about 36% of the variance in self-care skills of the WeeFIM is explained by auditory processing and cognitive functioning. The standardized β coefficient shows that cognitive functioning has the greatest influence. Secondly, in the personal skills of the VABS-II (Table 12b), the included variables were fine motor quotient and sensory avoiding. The adjusted R^2 illustrates that 44% of the variance in personal skills is predicted by sensory avoiding and fine motor quotient. According to the standardized β coefficient, the fine motor skills are the best predictor for personal skills. Finally, in the DLS of the VABS-II (Table 12c), 44% of the variance is explained by sensory avoiding and fine motor skills: the fine motor skills show the greatest influence. In the three cases, total language skills were always excluded and then, not found to be a significant predictor.

Table 12a. Predictions of self-care skills (WeeFIM) from sensori-motor performances

Variables	Adjusted R^2	Standardized β Coefficient	*P*
Merrill-Palmer Cognitive functioning	.244	.521**	.004
Sensory Profile A. Auditory Processing	.364	.374*	.022

Excluded variables: gross motor quotient (β = -.296), fine motor quotient (β = .045), and total language skills (β = -.263).
* Correlation is significant at <0.05 level (2-tailed).
** Correlation is significant at <.005 level (2-tailed).

Table 12b. Predictions of personal skills (VABS-II) from sensori-motor performances

Variables	Adjusted R^2	Standardized β Coefficient	*P*
PDMS-2 Fine motor quotient	.287	.560**	.002
Sensory Profile Q3: Sensory avoiding	.436	.408*	.010

Excluded variables: gross motor quotient (β = -.169), total language skills (β = .125) and cognitive functioning (β = -.014).
* Correlation is significant at <0.05 level (2-tailed).
** Correlation is significant at <.005 level (2-tailed).

Table 12c. Predictions of daily living skills (VABS-II) from sensori-motor performances

Variables	Adjusted R^2	Standardized β Coefficient	*P*
Merrill-Palmer Cognitive functioning	.289	.561**	.002
Sensory Profile Q3: Sensory avoiding	.403	.367*	.022

Excluded variables: gross motor quotient (β = .161), fine motor quotient (β = .330), and total language skills (β = .079).
* Correlation is significant at <0.05 level (2-tailed).
** Correlation is significant at <.005 level (2-tailed).

Chapter 6: DISCUSSION

6.1. Sensory responses

We hypothesized that the ASD group will have more atypical sensory responses than the controls. We found that the TD group differed significantly from the ASD and DD groups on the mean score of the total sensory performance as measured by the Short Sensory Profile, but there was no significant difference between the ASD and DD groups. The mean scores of the ASD and DD groups were similar and fell in the atypical response range while the mean score of the TD group was in the typical performance range. In addition, the ASD group had the highest percentage of children with atypical responses on the total score of sensory responses, but no significant difference was found between the ASD group and controls (DD and TD groups) in terms of percentage. However, with a larger control group, a significant difference between ASD and TD groups would be expected due to the marginally significant p-value ($p=.058$). Therefore, as noted by other researchers (Leekam et al. 2006, Baranek et al. 2006), atypical sensory responses are very frequent but not unique to children with ASD. The box and whisker plot of Figure 2 illustrated that only children on and below the median of the ASD group fell into the atypical response range. To be noted is the fact that the ASD group is more normally dispersed and closer to the mean than controls which may be explained by the small number of participants in the control groups. The dispersions of the DD and TD group are in opposite directions: the DD group dispersion is mainly below the median (i.e. poor), whereas the main dispersion in the TD group is above the median (i.e. in the more typical range).

The high percentage (93.9%) of atypical responses of the ASD group within the sections and factors of the Sensory Profile is closer to the 90% reported by Leekam et al. (2006) than the 69% reported by Baranek et al. (2006) and in the higher range of the frequencies of the review by Dawson and Watling (2000), where they estimated the range of atypical responses in autism to be between 30 and 100%. However, direct comparisons are difficult to make as each study used different instruments. Leekam et al. (2006) used the Diagnostic Interview for Social and Communication Disorders (DISCO) and Baranek et al. (2006) used the Sensory Experiences Questionnaire (SEQ). Further examination with similar instruments may yield more comparable results.

As well, there was considerable variability and heterogeneity within the ASD group with respect to the sensory responses that were atypical when looking at the percentage in quadrants, sections and factors. This finding is in agreement with those of Rogers and Ozonoff (2005) who concluded in their review that atypical sensory responses are insufficient to characterize children with ASD. They further hypothesized that these symptoms should not be considered as primary to the diagnosis, but rather, secondary. Taken together, it may not be possible to generalize about atypical sensory responses in children with ASD. At this stage, sensory responses may need to be assessed individually, in order to plan specific interventions for each child who has sensory issues.

As the highest percentages of atypical responses were shown in section J, measuring emotional responses, and factor 5, measuring inattention/distractibility, and these two categories are related to atypical sensory responses, a close relationship appears to exist between the processing and modulation of emotion, attention and sensory information. Liss et al. (2006) suggested that attention abnormalities in ASD may be due to a cerebellar dysfunction, since anatomic abnormalities in the cerebellum have been reported consistently (Allen 2006). As with the cerebellum, the amygdala, a structure that plays a crucial role in emotional modulation, has been postulated to be involved in ASD (Baron-Cohen, 2000), as well as abnormal cerebral growth patterns have been found in this population (DiCicco-Bloom et al. 2006, Dziobek et al. 2006).

We only found significant differences on factor 5 (i.e. inattention/distractibility), in contrast to Watling et al. (2001) who found significant differences on eight factors (sensory seeking, emotional reactive, low endurance/tone, oral sensitivity, inattention/distractibility, poor registration, fine motor/perceptual, and other) in children with autism compared to controls. This may be due to the small number of controls in our study and the age difference. Watling et al. (2001) included children from three to six years of age. Others reported that the most common atypical sensory response was in auditory processing (Baranek et al. 1997; Gillberg et al. 1990; Dahlgren and Gillberg, 1989). While comparing sections, we also found a significant difference in section A (auditory processing) between the ASD and TD group. A significant difference in section K (modulation of visual input affecting emotional and activity level) between the ASD group and controls may suggest that atypical responses in visual processing related to emotion/activity level, may differentiate children with ASD from others without ASD. This observation is coherent, as the first item of section K, 'avoids eye contact,' may be an indicator for suspicion of ASD. Another study by Rogers et al. (2003) indicated that atypical responses in taste/smell sensitivity, tactile sensitivity, and auditory filtering were most common. However, it is difficult to compare our results with this study because it included younger children (mean age 31 months, range from 21 to 50 months) than our participants. Some of these atypical responses may be age specific as Kern et al. (2007, 2006) found that abnormal sensory responses (except sensation avoidance and low threshold touch) became more similar to controls as the individuals matured, suggesting neurological normalization.

When we divided the ASD group into an autistic and PDD-NOS subgroup, we found that the PDD-NOS subgroup had more atypical sensory responses (mean scores and percentages) than the autistic subgroup on the Short Sensory Profile. However, there was an outlier in the PDD-NOS subgroup that markedly depressed the mean score and increased the percentage of atypical responses. Without this outlier, the mean score of the PDD-NOS subgroup became higher than the autistic subgroup, indicating more atypical responses in the autistic group than in the PDD-NOS group. This result would be more consistent with the study of Baranek et al. (2005) who found higher atypical sensory responses in children with autism compared to other PDD, based on mean scores.

The DD group showed the highest percentage of children presenting atypical responses in quadrant 4 (sensory sensitivity) which was also higher than in the ASD group. In addition, the DD group presented a higher percentage than the ASD group in section G (sensory processing related to endurance/tone) and factor 3 (low endurance/tone). These highest percentages in quadrant 4, section G and factor 3 may explain the 100% of atypical responses within the sections and factors of the Sensory Profile of the DD group. Also, when the DD group was divided into a GDD and SLI subgroup, all children with GDD demonstrated atypical responses in section G (sensory processing related to endurance/tone) and factor 3 (low endurance/tone) suggesting that children with GDD present more difficulties with endurance and tone than the children with ASD or SLI. Expanding the sample of DD children will allow further comparisons between ASD and DD children to better define differences in their sensory processing and modulation as well as their neural functioning.

We were struck by the findings that for the TD group 60% of the children had atypical responses in quadrant 1 (sensory seeking), as compared to norms for three and four year olds. This raises the question as to whether or not sensory seeking behaviors in pre-school children have changed since the norms for the profile were established. For example, Majnemer and Barr (2006) found that many motor milestones have been delayed in children due to being placed preferentially in the supine position as infants. This may similarly affect the sensory seeking aspects of normal development. As well, the advent of modern electronic games for preschoolers may similarly impact on sensory seeking. Moreover, as boys seem to be more active than girls (Finn et al. 2002), norms differentiating sensory responses by gender may be needed.

6.2. Motor skills

The motor performance of the ASD group was significantly poorer than the control groups, as was expected. In addition, mean scores of the ASD group revealed significant gross motor delay and poor fine motor skills, compared to the norms, similar to the findings of Provost et al. (2007). However, contrary to Provost et al. (2007), we found a significant difference between the motor performances of children with ASD and children with DD. This divergence may be explained by the different definition and inclusion criteria of our DD group. In Provost et al. (2007), children with DD were defined as children with motor delay while in our study, children with DD presented cognitive and/or language delay. Although language, socialization and cognitive difficulties may have decreased performance of children with ASD during the assessment, motor difficulties were also reported from daily observations by caregivers.

The worst motor performances were found in locomotion, object manipulation (i.e. ball skills) and grasping, where the mean score of the ASD group fell in the poor range. As the locomotion subtest measures how a child moves from one place to another and the motor skills were demonstrated by the examiner before the child imitated them, the poor performance may suggest dynamic balance and/or motor planning difficulties. The general consensus that imitation of body movements is impaired in ASD (Smith, 2004) may also explain, in part, the poor performance in locomotion. However, as shown by Mostofsky (2006), the poor performance of children with ASD in locomotion may not only be due to impaired imitation, but also to a perceptual-motor impairment (Vanvuchelen et al. 2007), a generalized praxis deficit (Mostofsky, 2006), or to a mental loss of the goal of their motor action (Vernazza-Martin et al. 2005). As many cortical and sub-cortical regions are important for motor learning, the underlying cause is not clear, but abnormal patterns of brain activation during motor activity have been documented in ASD (Müller et al. 2004). In addition, abnormal mirror neuron functioning has been found in ASD during imitation (Williams et al. 2006).

In the object manipulation subtest, which includes kicking, throwing and catching a ball, poor performance may indicate the presence of gross motor coordination difficulties and/or again, motor planning difficulties. As mentioned by Mostofsky (2006), the poor performance in object manipulation, requiring the manipulation of a ball, reflects that motor difficulties are not limited to imitation, but to a generalized praxis impairment. Moreover, the grasping subtest, a measure of a child's ability to use his or her hands, may suggest dexterity and/or motor planning difficulties. Indeed, Mari et al. (2003) found differences in reach-to-grasp movements in individuals with autism, suggesting motor planning difficulties. Therefore, our results suggest and support previous findings (Mostofsky et al. 2006; Smith, 2004) that children with ASD present motor planning difficulties. However, it is still unclear if they also present specific difficulties with balance, motor coordination and dexterity. Further investigations are necessary to clarify the nature and extent of their motor skills and to understand the neurological bases of their motor difficulties. In addition, as sensori-motor experiences are critical in the development of perceptual learning and social cognition (Piaget, 1952; Gibson, 2000; Diamond, 2000), it seems essential to put more emphasis on the study of sensori-motor development in children with autism in order to gain a better understanding on what basis evaluation and intervention should proceed.

Motor difficulties may have been neglected in the recent past because children with ASD, in general, start to walk at the same age of typically developing children (Provost et al. 2007). Therefore, they have functional mobility, as shown with the average performance of mobility on the WeeFIM (e.g.: they can walk, sit, go up and down stairs). This suggests that the mobility domain of the WeeFIM may measure a different construct compared to the locomotion section of the PDMS-2. Mobility, in the WeeFIM, is a functional measure of independence, whereas locomotion in the PDMS-2 is a qualitative and quantitative indicator of motor skill. Therefore, the locomotion subtest of the PDMS-2 measures if the child uses the correct movements (e.g.: crawling, walking, running, hopping, jumping) rather than functional independence. This lack of distinction between motor skills and mobility may explain why the literature on motor skills/difficulties in ASD remains contradictory and is overlooked by many. This could also explain why so few interventions have been designed to target motor skills in children with ASD.

6.3. Functional skills in ADL

As hypothesized, the ASD group showed poorer functional independence in ADL than the controls. Significant differences between the groups in DLS in the VABS-II were obtained, but there were no differences between the ASD and DD group on the measures of the WeeFIM. Compared to the norms, the ASD group performed, on average, in the very poor range on the WeeFIM and in the moderately low range on the VABS-II, indicating poor functional skills in ADL. Previous studies, using the VABS, concluded that DLS is a strength in individuals with autism (Carter et al. 1998; Stone et al. 1999), because socialization and communication domains were more impaired, which may further explain why this area is also neglected in the literature. Our results show that children with autism have severe difficulties with their functional skills in ADL. Therefore, children with autism may have better functional skills in ADL than in socialization and communication, but the severity of their difficulties does not suggest that they are a strength.

According to caregivers' responses on the WeeFIM, children with ASD are dependent for bathing, grooming, dressing and toileting; however, they are more independent for eating, requiring only supervision or setup. While children with ASD may be able to deal with the motor aspects of eating, Nadon and collaborators (2007) showed that the nutritional aspects of meals are of major concern to their parents. Interactions with sensory processing may have an impact on the ability to perform some of the ADL. For example, some caregivers mentioned that their child reacts negatively during grooming (e.g.: distress during tooth brushing), resulting in avoidance of these self-care tasks. Because of time constraints, caregivers will often perform ADL for their child. While the majority of three and four year-olds are toilet trained, it is often a task that is postponed by caregivers. Many children with ASD are dependent in bathing. However, it is often a time that the children enjoy because they play in the water. The personal sub-domain in the VABS-II, comparable to the self-care domain of the WeeFIM, had the poorest performance in DLS and results fell in the low adaptive level. Therefore, our results confirm that children with ASD present a burden of care to their caregiver. In addition, as mentioned by DeGrace (2004), there is a need for comprehensive family interventions and support for families.

6.4. Correlations between sensory responses, motor skills and daily living skills

To explain the expected poorest functional skills in ADL of the ASD group, we predicted correlations between sensori-motor performance and functional skills in ADL. Few correlations were found between sensory responses and motor skills, but there were many between sensori-motor performances and functional skills in ADL. However, when illustrated in a scatter plot, correlations clustered around the extreme values. Therefore, these have to be interpreted with caution (Martin and Bateson, 1993). Sensory seeking and touch processing were correlated with performance in gross motor skills. These correlations suggest that atypical somato-sensory responses may explain difficulties with gross motor skills. Atypical somato-sensory responses may influence the variety of sensori-motor experiences of the child and as a result interfere with motor development. Our results suggest that difficulties in processing somato-sensory information may be related to motor planning difficulties similar to the results of Weimer et al. (2001) who found a relationship between proprioceptive deficits and apraxia in individuals with Asperger Syndrome. Of the functional skills in ADL, sensory avoiding and fine motor performances, especially in visual-motor integration, were the most highly correlated. These correlations make sense because they indicate that a child who manifests sensory avoiding would probably have poor participation in ADL, and a child with fine motor difficulties, such as visual-motor integration, may have difficulties with tasks requiring fine motor skills, like dressing, grooming, bathing and toileting. We would also expect that touch processing will be more related to self-care skills because touch processing difficulties may affect grooming, bathing and dressing. The study by Baranek et al. (1997) showed an association between tactile defensiveness and rigidity, inflexible behaviors and repetitive verbalizations that may interfere with ADL.

6.5. Predictions of functional skills in ADL from sensori-motor performances

Multiple linear regressions indicated that cognitive functioning and auditory processing predict the largest percentage of variability in self-care skills as measured by the WeeFIM. In the VABS-II, the largest percentage of variability in personal skills was explained by fine motor skills and sensory avoiding. Therefore, functional skills in ADL of children with ASD may be predicted not only by cognitive functioning, but also by fine motor skills, auditory processing and sensory avoiding. Thus, fine motor skills and sensory responses have an impact on functional skills in ADL of children with ASD and as a consequence, on care load and integration into social environments, such as daycare and school. Contrary to expectation, language skills did not show a significant influence on ADL, suggesting that language impairments are not the main barrier in the development of functional skills in children with ASD. As fine motor skills and sensory responses are significant predictors of functional skills in ADL, interventions that improve fine motor skills and normalize sensory responses in children with ASD may lead these children to greater functional autonomy and better social integration.

Chapter 7: LIMITATIONS

The comparison between ASD and controls requires expansion to a larger sample of controls to allow for a more normal distribution of the controls and to increase the confidence level of comparisons between the groups. In addition, a larger number of children with GDD and SLI are recommended, to achieve better homogeneity within groups. Also, data of the Sensory Profile were missing for two children with ASD and from a child with DD because the questionnaires were not returned, reducing the number of available data points for analysis. Observational testing of sensory responses and functional skills in ADL should be added to validate caregivers' answers, to better identify specific needs that will assist in the planning of intervention. Finally, the motor skill scores of the PDMS-2 are more quantitative than qualitative. However, scores are based on qualitative observations of performance during motor tasks. Therefore, the validity of results depends on the expertise of the evaluator in assessing motor skills in children.

Chapter 8: SUMMARY

Until recently, sensory responses and motor skills in children with autism were neglected in the scientific literature. Emphasis was placed on communication, socialization and cognition in terms of their spheres of development. In addition, functional skills in ADL were little documented and controversial in the literature, and the possible impact of sensory responses and motor skills on functional skills in ADL was overlooked. In this study, we assessed the sensory responses, motor skills and functional skills of children with ASD in order to determine the extent of their difficulties and the impact of their sensori-motor difficulties on the functional skills in ADL.

First, we found that atypical sensory responses were very frequent in children with ASD, but not unique to them. In addition, they showed heterogeneity in the type of sensory responses among them. Therefore, atypical sensory responses are insufficient to characterize children with ASD, but should be individually evaluated in order to find strategies to reduce and normalize them. The highest percentages of atypical sensory responses were in emotional responses and measuring inattention/distractibility. Significant differences with controls were only found for inattention/distractibility. Also, a significant difference in auditory processing was shown between the ASD and TD groups. After eliminating an outlier, the autistic group presented more atypical responses than the PDD-NOS group.

Motor performance of children with ASD was significantly poorer than the control groups. The worst motor performances were found in locomotion, object manipulation (i.e. ball skills) and grasping, all falling in the poor range compared to norms. Therefore, despite the fact that their mobility may be functional, as shown on the WeeFIM, children with ASD have motor difficulties that need to be assessed and treated.

Children with ASD showed poorer performance of functional skills in ADL than the controls. Self-care skills, as measured by the WeeFIM, fell in the very poor range compared to norms. Significant differences were only found on the VABS-II between the ASD group and controls. Our results confirm that children with ASD present a burden of care to their caregivers and they certainly need help and support to improve their autonomy.

Sensory avoiding and fine motor performances, especially in visual-motor integration, were the most highly correlated with functional skills in ADL. The largest percentage of variability of self-care skills, as measured by the WeeFIM, was predicted by cognitive functioning and auditory processing. Fine motor skills and sensory avoiding explained the largest variability of personal skills, as measured by the VABS-II.

Chapter 9: CONCLUSION

On average, children with ASD present atypical sensory responses, motor difficulties as well as functional difficulties in ADL. The poorer functional independence in ADL of children with ASD is related to and caused in part by their atypical sensory responses and motor difficulties, especially their fine motor difficulties. Therefore, it is important to put more emphasis on rehabilitation as well as research on sensori-motor development and functional skills in children with ASD to improve the development and autonomy of these children, as well as to help and support their caregivers.

9.1. Clinical contribution to rehabilitation

As the sensori-motor period is the first stage in the social-cognitive development of the child and exploratory activities influence perceptual learning, it is important to firmly establish this foundation in order to facilitate the acquisition of later milestones. Therefore, to help caregivers reduce their care load, and to improve and support the development and autonomy of these children, it is important for clinicians in rehabilitation to individually assess and consider children's sensori-motor performances and their functional skills in ADL, in order to identify their special needs and to plan child specific interventions.

9.2. Futures directions

In research, there is a need to better understand the nature and extent of these sensory responses, motor skills and functional skills in relation to their neurological processes. In addition, the inter-relatedness between motor development and social-cognitive development, as well as their motor development over time, needs to be better documented in children with ASD. Finally, there is a need to develop and document the efficacy of interventions that aim to normalize sensory responses, and improve motor and functional skills in ADL of children with ASD.

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Impact of sensory processing and motor skills on daily living skills in children with autism spectrum disorders
(Caregiver Consent; child 3-6 years-old; 3-2005)

Dr. Gisel from the School of Physical and Occupational Therapy, and Dr. Reid, from Kinesiology and Physical Education, both at McGill University and Dr. Fombonne from Montreal Children's Hospital are studying children who have difficulties with their self-care activities (bathing, dressing, eating). Our long-term goal is to better understand how self-care skills can be improved through treatment. Your child's participation in this research study will contribute significantly in helping us to achieve this goal.

This research study involves three visits with your child: two to the Montreal Children's Hospital and one to the Currie Gym at McGill University. Please note that this research study is not a treatment study, but it will help us to design the best treatment in the future.

Visit One, at the Montreal Children's Hospital
Evaluation 1
Evaluation 1 will determine if your child qualifies for our study. Children must have a diagnosis of autism, Asperger disorder, or pervasive developmental disorder-not otherwise specified (PDD-NOS). Children with PDD-NOS have similar delays or deficits as children with autism, but do not meet all criteria for autism. Children will be evaluated by experienced clinicians.

You will provide information regarding your child's early development and day-to-day functioning. This will take approximately 3h. During the same time, your child's language development will be evaluated. This will take approximately 1h45. Next, Dr. Couture, an occupational therapist and post-doctoral fellow, will evaluate your child's intellectual development. This may take approximately 1h30. During all evaluations your child will be allowed to take breaks as often as needed.

We will meet with you after the first visit to discuss results. If your child does not qualify for our study, no further evaluations will be necessary. You will continue to receive the services available at Montreal Children's Hospital.

Visit Two, at the Montreal Children's Hospital
Evaluation 2
A second visit will be scheduled for Evaluation 2.

A therapist will evaluate your child's motor skills. The evaluation will take approximately 1h30.

During the time your child meets the therapist you will meet with Dr. Gisel or Dr Couture, to provide information regarding your child's self-care skills and responses to touch, light, sound, taste and smell. This will take 1h30. The evaluation schedule is summarized for your convenience in the attached table.

Visit Three, at the McGill Gym

Evaluation 3

The third evaluation will occur at the Currie Gymnasium at McGill University, 475 Pine Avenue West. A physical educator will ask your child to perform skills such as running, skipping, and jumping, going down stairs, as well as throwing and catching a ball. Your child will be videotaped, but all tapes will be erased following analysis. This evaluation will take about 30 minutes. None of the items require a great deal of exertion, since each takes about 15 seconds. During these evaluations you will meet with Dr. Greg Reid who will ask you questions about your child's participation in physical activities. This will take approximately an hour.

Benefits

In participating in this study, your child will receive extensive clinical evaluation, providing a profile of his/her strengths and weaknesses. These evaluations cover a broader area than what is currently offered in routine clinical evaluation. You will receive a written report of these evaluations.

Risks

Testing requires three half day visits and may be tiring to your child. However, as mentioned above, your child will be allowed to take breaks as needed. Routine clinical tests are used that have no risks associated with them.

Your participation in the research study is voluntary and you may withdraw your child from the study at any time. If you withdraw, your child will continue to receive the same care at the hospital as if he/she had not been enrolled in the study.

Confidentiality

All information obtained about you and your child during this study will be treated confidentially within the limits of the law. This information of you and your child will be under lock and key. The study files and videotapes of your child will be kept in a locked cabinet dedicated to this study at Dr. Couture's office at the Montreal Children's Hospital for a period of five years. After this time all tapes and records will be destroyed. Access to your and your child's identifying information will be restricted and supervised by Dr. Couture. No information that discloses your and your child's identity will be allowed to leave Dr. Couture's office. She is also the only person that holds the assignment code of this study and will group children, after the study is completed for analysis of results. The Research Ethics Committee may also have access to the results of this study.

If you would like additional information or have any questions or concerns regarding this study please contact Dr. Erika Gisel at: School of Physical and Occupational Therapy, McGill University, 3630 Promenade Sir-William-Osler, Montreal, QC, H3G 1Y5; telephone (514) 398-4510, fax (514) 398-8193.

Assessment Schedule for Children 3 to 6 Years of Age

Visit 1, to the Montreal Children's Hospital **Evaluation 1**	**Parent**	**Child**
Interview regarding your child's development	3h	
Assessment of intellectual functioning		1h30
Language assessment		1h45
Total	**3h**	**3h15**
Visit 2, to the Montreal Children's Hospital, **Évaluation 2**		
Assessment of fine and gross motor skills		1h30
Interview regarding your child's responses to touch, light, sound, taste and smell	30 minutes	
Interview regarding your child's self-care skills	1h	
Total	**1h30**	**1h30**
Visit 3, Currie Gym ***Evaluation 3***		
Assessment of gross motor skills		30 minutes
Interview regarding your child's participation in physical activities	1 h	
Total	**1h**	**30 minutes**

~~Impact des habiletés motrices et de modulation sensorielle sur les activités de la~~ vie quotidienne des enfants avec trouble envahissant du développement. (Consentement des parents; enfants de 3 à 6 ans; 3-2005)

Dr. Gisel de l'école de physiothérapie et d'ergothérapie et Dr. Reid du Département de kinésiologie et d'éducation physique de l'Université McGill et Dr. Fombonne de l'Hôpital de Montréal pour Enfants étudient les enfants qui ont des difficultés avec leurs soins personnels (bain, habillage, alimentation). Notre but à long terme est de mieux comprendre comment les habiletés de soins personnels peuvent être améliorés avec des interventions. La participation de votre enfant à notre étude contribuera significativement à nous aider à atteindre notre objectif.

Cette étude implique trois visites avec votre enfant : 2 à l'Hôpital de Montréal pour Enfants et une au gymnase Currie de l'Université McGill. Veuillez noter que cette étude n'est pas une recherche sur les interventions, mais va nous aider à développer de meilleures interventions dans le futur.

Première Visite à l'Hôpital de Montréal pour Enfants
Évaluation *1*
L'évaluation 1 va déterminer si votre enfant rencontre les critères d'éligibilité de notre étude. Les enfants doivent avoir un diagnostic d'autisme, de syndrome d'Asperger ou de troubles envahissants du développement non spécifiés (TED-NS). Les enfants avec TED-NS ont des retards et difficultés similaires aux enfants avec autisme, mais ne rencontrent pas tous les critères de l'autisme. Votre enfant sera évalué par des cliniciens d'expérience.

Vous devrez nous informer du développement en bas âge de votre enfant et de son fonctionnement au quotidien. Ceci prendra environ 3 heures. Pendant ce temps, une thérapeute évaluera le langage de votre enfant. Ceci prendra environ 1h45. Ensuite, votre enfant rencontrera Dr. Couture une ergothérapeute qui fait un post-doctorat, pour évaluer son fonctionnement intellectuel. Ceci prendra environ 1h30. Pendant toutes les évaluations, votre enfant aura droit de prendre toutes les pauses dont il aura besoin.

Nous vous rencontrerons après la première rencontre afin de discuter des résultats. Si votre enfant ne rencontre pas les critères d'éligibilité, aucune autre évaluation supplémentaire ne sera nécessaire et vous continuerez de recevoir les services disponibles à l'Hôpital de Montréal pour Enfants.

Visite deux, à l'Hôpital de Montréal pour Enfant
Évaluation 2
Une deuxième visite sera planifiée pour l'évaluation 2.

Une thérapeute évaluera les habiletés de motricité de votre enfant. L'évaluation prendra environ 1h30.

Pendant que votre enfant rencontrera la thérapeute, vous rencontrerez Dr. Gisel ou Dr. Couture, afin de documenter les habiletés de votre enfant à l'égard des soins personnels et de ses réponses au toucher, à la lumière, aux sons, aux goûts et aux odeurs. Ceci prendra environ 1h30. La planification de l'évaluation est résumée en annexe.

Visite Trois au Gymnase Currie de l'Université McGill
Évaluation 3
La troisième évaluation aura lieu au Gymnase Currie de l'Université McGill au 475 avenue des Pins Ouest. Un éducateur physique demandera à votre enfant de courir, de gambader, de sauter et de descendre des escaliers ainsi que de lancer et attraper une balle. Votre enfant sera filmé, mais toutes les cassettes vidéo seront effacées suite à l'analyse des résultats. Cette évaluation prendra environ 30 minutes. Aucune de ces tâches devrait fatiguer votre enfant de façon excessive puisqu'elle dure environ 15 secondes chacune. Votre enfant pourra prendre des pauses quand il le désirera. Pendant ces évaluations, vous rencontrerez Dr Greg Reid qui vous posera des questions sur la participation de votre enfant dans des activités physiques. Ceci prendra environ 1h.

Bénéfices
En participant à cette étude, votre enfant recevra une évaluation très complète de ses capacités ce qui nous permettra de mettre en évidence un profile de ses forces et faiblesses. Ces évaluations couvrent un plus large domaine que les évaluations qui sont offertes de routine en clinique. Vous recevrez également un rapport à la suite de ces évaluations.

Risques
Les évaluations prennent environ 3 demi-journées et peuvent être fatigantes pour votre enfant. Toutefois, comme il l'a été mentionné plus haut, votre enfant pourra prendre toutes les pauses dont il aura besoin. Les tests utilisés sont des évaluations de routine qui ne sont associés à aucun risque pour votre enfant.

Votre participation à cette étude est volontaire et vous pouvez retirer votre enfant de l'étude à tout moment. Si vous vous retirez, votre enfant continuera de recevoir les mêmes soins et services à l'hôpital que s'il n'avait pas participé à l'étude.

Confidentialité
Toutes les informations obtenues à l'égard de votre enfant et de votre famille seront traitées de façon confidentielle à l'intérieure des limites de la loi. Les données recueillies seront codées numériquement et anonymisées sur logiciel informatique alors que les questionnaires seront gardés dans un classeur barré dans le laboratoire de recherche. Les données seront conservées pendant une période de 5 ans suivant la fin de la recherche. Après cette période tous les dossiers et vidéo cassettes seront détruites. Cependant, aux fins de vérifier la saine gestion de la recherche, il est possible qu'un délégué du comité d'éthique de la recherche et des organismes commanditaires consultent les données de recherche et le dossier médical de votre enfant. Par ailleurs, les résultats de cette étude pourront être publiés et communiqués dans un congrès scientifique mais aucune information pouvant identifier votre enfant ne sera alors dévoilée. De fait, tous les

Horaire des évaluations pour les enfants de 3 à 6 ans

Visite 1, à l'Hôpital de Montréal pour Enfant **Évaluation 1**	**Parent**	**Enfant**
Entrevue concernant le développement de votre enfant et ses habiletés de soins personnels Évaluation du fonctionnement intellectuel Évaluation du langage	3 h	 1h30 1h45
Total	**3 h**	**3h15**
Visite 2, à l'Hôpital de Montréal pour Enfants **Évaluation 2**		
Évaluation de la motricité globale et de la motricité fine Entrevue concernant les réponses de votre enfant au toucher, à la lumière, les sons, les saveurs et les odeurs. Entrevue concernant les activités de soins personnels	 30 minutes 1,0 h	1h30
Total	**1h30**	**1h30**
Visite 3, au gymnase ***Évaluation 3*** Évaluation de la motricité globale Entrevue sur la participation aux activités physiques	 1,0 h	 30 minutes
Total	**1,0 h**	**30 minutes**

~~Impact of sensory processing and motor skills on daily living skills in children~~ with autism spectrum disorders
(Caregiver Consent Control; child 3-6 years-old; 3-2005)

Dr. Gisel from the School of Physical and Occupational Therapy, and Dr. Reid, from Kinesiology and Physical Education, both at McGill University, and Dr. Fombonne from Montreal Children's Hospital are studying children who have difficulties with their self-care activities (bathing, dressing, eating). Children with autism will be compared to children with other developmental disabilities or typically developing children. Our long-term goal is to better understand how self-care skills can be improved through treatment. Your child's participation in this research study will contribute significantly in helping us to achieve this goal.

This research study involves three visits with your child: two to the Montreal Children's Hospital and one to the Currie Gym at McGill University. Please note that this research study is not a treatment study, but it will help us to design the best treatment in the future.

Visit One, at the Montreal Children's Hospital
Evaluation 1
Evaluation 1 will determine if your child qualifies for our study. Children must have a diagnosis of developmental language delay, or mental retardation, or be typically developing. Children will be evaluated by experienced clinicians.

You will provide information regarding your child's early development. This will take 20 minutes. During the same time, your child's language development will be evaluated. This will take approximately 1h45. Next, Dr. Couture, an occupational therapist and post-doctoral fellow, will evaluate your child's intellectual development. This may take 1h30. During all evaluations your child will be allowed to take breaks as often as needed.

We will meet with you after the first visit to discuss results. If your child does not qualify for our study, no further evaluations will be necessary. You will continue to receive the services available at Montreal Children's Hospital.

Visit Two, at the Montreal Children's Hospital
Evaluation 2
A second visit will be scheduled for Evaluation 2.

A therapist will evaluate your child's fine and gross motor skills. The evaluations will take approximately 1h30.

During this time, you will meet with Dr. Gisel or Couture, to provide information regarding your child's self-care skills and responses to touch, light, sound, taste and smell. This will take 1h30. The evaluation schedule is summarized for your convenience in the attached table.

Visit Three, at the McGill Gym

Evaluation 3

The third evaluation will occur at the Currie Gymnasium at McGill University, 475 Pine Avenue West. A physical educator will ask your child to perform skills such as running, skipping, jumping and going down stairs, as well as throwing and catching a ball. Your child will be videotaped. This evaluation will take about 30 minutes. None of the items require a great deal of exertion, since each takes about 15 seconds. During this evaluation you will meet with Dr. Greg Reid who will ask you questions about your child's participation in physical activities. This will take approximately 1 hr.

Benefits

In participating in this study, your child will receive extensive clinical evaluation, providing a profile of his/her strengths and weaknesses. These evaluations cover a broader area than what is currently offered in routine clinical evaluation. You will receive a written report of these evaluations

Risks

Testing requires three half day visits and may be tiring to your child. However, as mentioned above, your child will be allowed to take breaks as needed. Routine clinical tests are used that have no risks associated with them. However, should typically developing children show any problems in sensory or motor development, they will be referred for further evaluation.

Your participation in the research study is voluntary and you may withdraw your child from the study at any time. If you withdraw, your child will continue to receive the same care at the hospital as if he/she had not been enrolled in the study.

Confidentiality

All information obtained about you and your child during this study will be treated confidentially within the limits of the law. This information of you and your child will be under lock and key. The study files and videotapes of your child will be kept in a locked cabinet dedicated to this study at Dr. Couture's office at the Montreal Children's Hospital for a period of five years. After this time all tapes and records will be destroyed. Access to your and your child's identifying information will be restricted and supervised by Dr. Couture. No information that discloses your and your child's identity will be allowed to leave Dr. Couture's office. She is also the only person that holds the assignment code of this study and will group children, after the study is completed for analysis of results. The Research Ethics Committee may also have access to the results of this study.

If you would like additional information or have any questions or concerns regarding this study please contact Dr. Erika Gisel at: School of Physical and Occupational Therapy, McGill University, 3630 Promenade Sir-William-Osler, Montreal, QC, H3G 1Y5; telephone (514) 398-4510, fax (514) 398-8193.

Assessment Schedule for Children in Control Group 3 to 6 Years of Age

Visit 1, to the Montreal Children's Hospital **Evaluation 1**	**Parent**	**Child**
Interview regarding your child's development	20 minutes	
Assessment of intellectual functioning		1h30
Language assessment		1h45
Total	**20 minutes**	**3h15**
Visit 2, to the Montreal Children's Hospital, parent only **Évaluation 2**		
Assessment of fine and gross motor skills		1h30
Interview regarding your child's responses to touch, light, sound, taste and smell	30 minutes	
Interview regarding your child' self-care skills	1h	
Total	**1h30**	**1h30**
Visit 3, Currie Gym ***Evaluation 3***		
Assessment of gross motor skills		30 minutes
Interview regarding your child's participation in physical activities	1 h	
Total	**1h**	**30 minutes**

~~Impact des habiletés motrices et de modulation sensorielle sur les activités de la~~ vie quotidienne des enfants avec trouble envahissant du développement. (Consentement des parents; Enfants du groupe de contrôle de 3 à 6 ans; 3-2005)

Dr. Gisel de l' École de physiothérapie et d'ergothérapie et Dr. Reid du Département de kinésiologie et d'éducation physique de l'Université McGill et Dr. Fombonne de l'Hôpital de Montréal pour Enfants étudient les enfants qui ont des difficultés avec leurs soins personnels (bain, habillage, alimentation). Les enfants avec trouble envahissant du développement seront comparés aux enfants dont le développement est normal ainsi qu'à d'autres enfants avec problèmes de développement comme la déficience intellectuelle ou les troubles spécifiques du langage. Notre but à long terme est de mieux comprendre comment les habiletés de soins personnels peuvent être améliorés avec des interventions. La participation de votre enfant à notre étude contribuera significativement à nous aider à atteindre notre objectif.

Cette étude implique trois visites avec votre enfant : 2 à l'Hôpital de Montréal pour Enfants et une au gymnase Currie de l'Université McGill. Veuillez noter que cette étude n'est pas une recherche sur les interventions, mais va nous aider à développer de meilleures interventions dans le futur.

Première Visite à l'Hôpital de Montréal pour Enfants
Évaluation *1*
L'évaluation 1 va déterminer si votre enfant rencontre les critères d'éligibilité de notre étude. Les enfants doivent avoir un diagnostic de déficience intellectuelle ou de trouble spécifique du langage ou encore être un enfant avec un développement normal. Votre enfant sera évalué par des cliniciens d'expérience.

Vous devrez nous informer du développement en bas âge de votre enfant et de son fonctionnement au quotidien. Ceci prendra environ 20 minutes. Pendant ce temps, une thérapeute évaluera le langage de votre enfant. Ceci prendra environ 1h45. Ensuite, Dr Couture une ergothérapeute qui fait un post-doctorat évaluera son fonctionnement intellectuel. Ceci prendra environ 1h30. Pendant toutes les évaluations, votre enfant aura droit de prendre toutes les pauses dont il aura besoin.

Nous vous rencontrerons après la première rencontre afin de discuter des résultats. Si votre enfant ne rencontre pas les critères d'éligibilité, aucune autre évaluation supplémentaire ne sera nécessaire et vous continuerez de recevoir les services disponibles à l'Hôpital de Montréal pour Enfants.

Visite deux, à l'Hôpital de Montréal pour Enfant
Évaluation 2
Une deuxième visite sera planifiée pour l'évaluation 2.

Une thérapeute évaluera les habiletés de motricité fine et globale de votre enfant. L'évaluation prendra environ 1h30 au total.

Pendant ce temps, vous rencontrerez Dr. Gisel ou Dr. Couture, afin de documenter les habiletés de votre enfant à l'égard des soins personnels et de ses réponses au toucher, à la lumière, aux sons, aux goûts et aux odeurs. Ceci prendra environ 1h30. La planification de l'évaluation est résumée en annexe.

Visite Trois au Gymnase Currie de l'Univeristé McGill
Évaluation 3
La troisième évaluation aura lieu au Gymnase Currie de l'Univeristé McGill au 475 avenue des Pins Ouest. Un éducateur physique demandera à votre enfant de courir, de gambader, de sauter et de descendre des escaliers, ainsi que de lancer et attraper une balle. Votre enfant sera filmé, mais toutes les cassettes vidéo seront effacées suite à l'analyse des résultats. Cette évaluation prendra environ 30 minutes. Aucune de ces tâches devrait fatiguer votre enfant de façon excessive puisqu'elle dure environ 15 secondes chacune. Votre enfant pourra prendre des pauses quand il le désirera. Pendant ces évaluations, vous rencontrerez Dr Greg Reid qui vous posera des questions sur la participation de votre enfant dans des activités physiques. Ceci prendra environ 1h.

Bénéfices
En participant à cette étude, votre enfant recevra une évaluation très complète de ses capacités ce qui nous permettra de mettre en évidence un profile de ses forces et faiblesses. Ces évaluations couvrent un plus large domaine que les évaluations qui sont offertes de routine en clinique. Vous recevrez également un rapport à la suite de ces évaluations.

Risques
Les évaluations prennent environ 3 demi-journées et peuvent être fatigantes pour votre enfant. Toutefois, comme il l'a été mentionné plus haut, votre enfant pourra prendre toutes les pauses dont il aura besoin. Les tests utilisés sont des évaluations de routine qui ne sont associés à aucun risque pour votre enfant. Cependant, si un enfant au développement normal présente des problèmes sensoriel ou moteur, il sera référé pour d'autres évaluations.

Votre participation à cette étude est volontaire et vous pouvez retirer votre enfant de l'étude à tout moment. Si vous vous retirez, votre enfant continuera de recevoir les mêmes soins et services à l'hôpital que s'il n'avait pas participé à l'étude.

Confidentialité
Toutes les informations obtenues à l'égard de votre enfant et de votre famille seront traitées de façon confidentielle à l'intérieure des limites de la loi. Les données recueillies seront codées numériquement et anonymisées sur logiciel informatique alors que les questionnaires seront gardés dans un classeur barré dans le laboratoire de recherche. Les données seront conservées pendant une période de 5 ans suivant la fin de la recherche. Après cette période tous les dossiers et vidéo cassettes seront détruites. Cependant, aux

Horaire des évaluations pour les enfants du groupe contrôle de 3 à 6 ans

Visite 1, à l'Hôpital de Montréal pour Enfant **Évaluation 1**	**Parent**	**Enfant**
Entrevue concernant le développement de votre enfant	20 minutes	
Évaluation intellectuelle		1h30
Évaluation du langage et de la communication		1h45
Total	**20 minutes**	**3h15**
Visite 2, à l'Hôpital de Montréal pour Enfants **Évaluation 2**		
Évaluation de la motricité fine et globale		1h30
Entrevue concernant les réponses de votre enfant au toucher, à la lumière, les sons, les saveurs et les odeurs.	30 minutes	
Entrevue concernant les activités de soins personnels	1,0 h	
Total	**1h30**	**1h30**
Visite 3, au gymnase ***Évaluation 3***		
Évaluation de la motricité globale		30 minutes
Entrevue sur participation aux activités physiques	1,0 h	
Total	**1,0 h**	**30 minutes**