RESEARCH ARTICLE

Children with Autism and Attention Difficulties: A Pilot Study of the Association between Sensory, Motor, and Adaptive Behaviors

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Abstract

Objectives: This pilot study aimed to compare sensory processing, motor skills and adaptive behaviors in children with a double diagnosis of Autism Spectrum Disorder (ASD) and Attention Deficit Hyperactivity Disorder (ADHD) (ASD+ADHD) with children with ADHD alone and to examine the association of sensory processing and motor skills with adaptive behaviors (self-care). **Method:** Thirty children aged 5-14 years diagnosed with ASD+ADHD (n = 13) or ADHD (n = 17) were evaluated on their sensory processing and motor skills and adaptive behaviors. Analysis of covariance compared the groups on these dimensions. Correlation analyses examined the association between sensory processing and motor skills and adaptive behaviors. **Results:** Compared to children with ADHD alone, children with ASD+ADHD had poorer skills in sensory processing ($p < 0.001$), motor ($p = 0.001$) and adaptive behaviors ($p < 0.001$). For all children, increased autonomy in self-care was correlated with better sensory processing ($p < 0.001$) and motor skills ($p = 0.002$). **Conclusion:** Children with ASD+ADHD have poorer sensory processing, motor and adaptive skills than those with ADHD alone. Sensory processing and motor deficits were negatively associated with autonomy in self-care. Interventions aiming to improve sensory processing and motor skills and autonomy in self-care should become important targets for these children.

Key Words: *Attention Deficit Hyperactivity Disorder, Autism Spectrum Disorder, sensory processing, motor skills, adaptive behaviors*

Résumé

Objectifs: Cette étude pilote visait à comparer les habiletés de traitement de l'informaiton sensorielle, la motricité et les comportments adaptatifs d'enfants avec un double diagnostic de trouble du spectre autistique (TSA) et de trouble de l'attention avec hyperactivité (TSA + TDAH) à des enfants avec un diagnostic simple de TDAH et étudier l'association entre les habiletés de traitement de l'information sensorielle et de motricité avec les comportements adaptatifs (soins personnels). **Méthode:** Trente enfants âgés de 5 à 14 ans avec un diagnostic de TSA + TDAH (n = 13) ou de TDAH (n = 17) ont été évalués sur le plan des habiletés sensorielles, de la motricité et de leurs comportements adaptatifs. Des analyses de covariance ont comparés les groupes sur ces 3 aspects. Des analyses de corrélations ont documenté l'association entre les habiletés de traitement de l'information sensorielle, la motricité et les complortements adaptatifs. **Résultats**: Comparé aux enfants avec un TDAH uniquement, les enfants avec un double diagnostic de TSA + TDAH avaient des habiletés de traitement de l'information sensorielle ($p < 0.001$), de motricitité ($p = 0.001$) et des comportements adaptatifs ($p < 0.001$) plus faibles. Pour tous les enfants, une augmentation de l'autonomie dans les soins personnels était corrélée à de meilleures habiletés de traitment de l'information sensorielle ($p < 0.001$) et de motricité ($p = 0.002$). **Conclusion:** Les enfants avec un TSA+TDAH combiné ont de plus faibles habiletés de traitement de l'information sensorielle, de motricité et de comportements adaptatifs que les enfants avec un TDAH uniquement. Les difficultés sensorielles et motrices étaient négativement associées à l'autonomie dans les soins personnels. Des interventions visant à améliorer les habiletés de traitement de l'information sensorielle, la motricité et l'autonomie dans les soins personnels devraient devenir des cibles importantes pour ces enfants.

Mots clés: *trouble d'attention avec hyperactivité, trouble du spectre autistique, traitement de l'information sensorielle, habiletés motrices, comportements adaptatifs*

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Introduction

Attention Deficit Hyperactivity Disorder (ADHD) and Autism Spectrum Disorder (ASD) are common mental health disorders in childhood. ADHD is characterized by inattention, hyperactivity and impulsivity, while ASD associates social deficits, communication difficulties and stereotyped behaviors (American Psychiatric Association [APA], 2000). ASD without intellectual disability is a subgroup considered as High Functioning ASD (HFASD) (Corbett, Constantine, Hendren, Rocke, & Ozonoff, 2009).

An association between ADHD and HFASD has been reported in a few studies (Goldstein & Schwebach, 2004), although these two diagnoses are considered mutually exclusive in *Diagnostic and Statistical Manual of Mental Disorders - 4th edition - Text Revision* (DSM-IV-TR) (APA, 2000). In fact, the presence of sufficient symptoms to diagnose ADHD is reported in 59% to 83% of children with ASD (Goldstein & Schwebach, 2004). Similarly, 65% to 80% of children with ADHD had autistic symptoms (Gillberg et al., 2004).

This frequent association has generated questions about distinctive behaviors between children presenting both diagnoses and those with a single diagnosis of ADHD or HFASD (Corbett et al., 2009). Studies have compared communication and cognitive skills, but sensory processing and motor skills as well as adaptive behaviors remain largely unexplored.

Sensory processing is defined as the way visual, auditory, gustatory, tactile, olfactory, vestibular and proprioceptive information is perceived and organized in the central nervous system in order to allow optimal functioning in daily life activities (Dunn, 2001). About 50% of children with ADHD (Yochman, Ornoy, & Parush, 2006) and 90% of children with ASD (Jasmin et al., 2009) have sensory processing difficulties.

Motor skill deficits are also observed in about 50% of the ADHD population (Pitcher, Piek, & Hay, 2003) and 70% of the ASD population (Green et al., 2009). In ADHD, difficulties in manual dexterity and movement skills (Pitcher et al., 2003), balance and coordination (Dewey, Cantell, & Crawford, 2007; Pan, Tsai, & Chu, 2009) are reported. In ASD, similar difficulties to ADHD are reported, with poor ball and execution skills, motor planning, lower strength, speed and agility, in addition to poor visual motor control (Green et al., 2009; Pan et al., 2009).

Adaptive behaviors are defined as everyday skills required to meet environmental demands (American Association on Mental Retardation [AAMR], 2002). Three domains are identified: (1) conceptual (communication and academic skills); (2) social (interpersonal and social competence); and, (3) practical (independent, daily living skills). Children with ADHD and ASD have significant impairments in all domains of adaptive behaviors (Saulnier & Klin, 2007).

Some studies support the association between sensory processing and motor skills and adaptive behaviors in children with ASD or ADHD (Ben-Sasson et al., 2008; Jasmin et al., 2009). However, only one study has demonstrated a specific link between sensory processing, motor skills and autonomy (Jasmin et al., 2009). This area, therefore, remains largely unexplored.

In summary, to our knowledge, the sensory processing, motor skills and adaptive behaviors of children with a diagnosis of ADHD+HFASD have not been reported in the literature. A study reporting such skills in children with a dual diagnosis and in children with a single diagnosis of ADHD or HFASD would help to characterize the group with the double diagnosis and could also potentially improve rehabilitation services.

The objectives of this pilot study were to:

1. compare sensory processing, motor skills and adaptive behaviors in children with a dual diagnosis of HFASD+ADHD to children with ADHD or HFASD alone; and
2. examine the association of sensory processing and motor skills with the children's adaptive behaviors.

Methodology

Participants

Thirty-seven children were recruited in the greater Quebec City area (Canada). Two families withdrew before the study started, and one child with severe dysphasia was excluded.

Inclusion criteria were: diagnosis of ADHD or ASD, and age between 5 and 14 years old. Exclusion criteria were: Childhood Disintegrative Disorder, Rett syndrome or IQ < 70. A total of 13 children with HFASD+ADHD (Asperger syndrome n = 6; Autistic Disorder n = 3; Pervasive Development Disorder-Not Otherwise Specified (PDD-NOS) n = 4), four with HFASD alone (Asperger syndrome n = 1; Autistic Disorder n = 1; PDD-NOS n = 2) and 17 with ADHD alone (inattentive n = 5; combined n = 11; hyperactive/impulsive n = 1) were evaluated. Experienced child psychiatrists diagnosed all the children with ADHD and HFASD (DSM-IV-TR). Children with ADHD only were recruited from a larger ongoing genetic imaging study (PI: Ben Amor).

Measures

Outcome measures were selected to offer a wide but complementary perspective on the sensory-motor performance and adaptive behaviors of the child. Perspectives from the parents were recorded with questionnaires and objective measures were also obtained from direct testing with the child and a qualified professional.

*Social Communication Questionnaire (*SCQ) (Rutter, Bailey, & Lord, 2003). The lifetime form was completed by

Table 1. Clinical and sociodemographic characteristics

	HFASD+ADHD[1] n = 13	ADHD n = 17	*t* or X^2	p	*d*
Average age in months, mean (SD)	117.8 (34.0)	101.8 (25.8)	1.412	0.172	
Gender, male, % (n)	100 (13)	58.8 (10)	6.982	0.010	
Income					
<$40,000, % (n)	7.7 (1)	5.9 (1)	1.831	0.400	
$40,000–$80,000, % (n)	69.2 (9)	47.1 (8)			
>$80,000, % (n)	23.1 (3)	47.1 (8)			
Education level					
Mother, university, % (n)	53.8 (7)	23.5 (4)	2.916	0.132	
Father, university, % (n)	38.5 (5)	11.8 (2)	2.935	0.190	
Parents living together, % (n)	76.9 (10)	64.7 (11)	0.524	0.691	
Total IQ, mean (SD)	95.6 (17.2)	102.5 (12.2)	-1.234	0.231	0.491
Verbal IQ, mean (SD)	93.2 (20.8)	100.2 (11.7)	-1.081	0.294	0.446
Non verbal IQ, mean (SD)	100.5 (19.3)	106.8 (15.1)	-0.994	0.329	0.383
SCQ scores, mean (SD)	24.8 (5.1)	4.5 (4.0)	12.204	0.0001	4.66
> cut-off for ASD, % (n)	100 (13)	0 (0)			
ADHD Index score, mean (SD)	67.2 (7.3)	72.9 (7.4)	-2.076	0.047	0.802

[1]High functioning autism spectrum disorder + Attention deficit hyperactivity disorder

IQ = intellectual quotient

SCQ = Social Communication Questionnaire

parents and used as a screening tool for ASD. Only children with a score above 15 were included in the HFASD group.

Autism Diagnostic Observation Schedule (ADOS) (Lord, Rutter, DiLavore, & Risi, 1999) was used with the SCQ to validate the ASD diagnosis.

Conners' Parent Rating Scale – Revised (CPRS-R) (Conners, 1997) parent's form was used to document behavioral problems. Scores above 65 are clinically relevant. The CPRS-R was used to support the ADHD diagnosis.

The *Wechsler Intelligence Scale for Children – Fourth Edition* (WISC-IV) and a shorter version *Wechsler Abbreviated Scale of Intelligence* (WASI) (Wechsler, 1999; 2004) were administered respectively to children with ADHD alone, and to the HFASD groups.

Sensory Profile (SP) (Dunn, 1999) is a questionnaire documenting sensory processing skills (125 items). It provides scores for the different senses, and four quadrants (registration, seeking, sensitivity, avoiding). The total score from the shorter version (38 items) was also computed.

Bruininks-Oseretsky Test of Motor Proficiency Second Edition (BOT-2) (Bruininks & Bruininks, 2005) documents gross and fine motor skills (four motor areas, eight subtests).

Adaptive Behavior Assessment System Second Edition (ABAS-II) (Harrison & Oakland, 2008) is a parent's questionnaire divided into 10 sections, grouped under three domains of adaptive behaviors: conceptual; social; and, practical.

Procedures

Local research ethics committees approved the project. Parents signed consent forms for their children. All the assessments were conducted unblinded by trained evaluators.

Statistical analysis

The first objective was to compare three groups of children: ADHD, ADHD+HFASD, and HFASD. However, our small sample size in the HFASD group (n=4) prevented any statistical tests with this group.

T-tests and chi-square tests were conducted to compare HFASD+ADHD and ADHD groups on the sociodemographic variables, IQ, and ADHD Index (CPRS-R).

ANCOVA was performed to compare sensory, motor, and adaptive skills, while controlling for the "ADHD Index" as it is significantly different between the two groups, and it influences motor skills (Flapper, Houwen & Schoemaker, 2006). Given the multiple comparisons, the Holm statistical method was used to determine the significance level and to minimize Type 1 errors (Holm, 1979).

Pearson correlation analyses were performed on the results for sensory, motor and adaptive skills with all children.

Table 2. Comparison of scores on the sensory profile Average of scores (SD)

	HFASD+ADHD n = 13	ADHD n = 17	*F*	p	*d*
Quadrants					
Sensation seeking (103 – 123)[1]	92.2 (13.7)	100.2 (18.6)	7.111	**0.013**	0.497
Low registration (64 – 72)	51.9 (9.3)	63.5 (7.9)	17.025	**0.0001**	1.408
Sensation avoidance (113 – 133)	93.2 (12.7)	114.8 (13.4)	21.631	**0.0001**	1.706
Sensation sensitivity(81 – 94)	68.0 (8.5)	81.2 (8.0)	33.848	**0.0001**	1.663
Sections					
Auditory (30 – 40)	23.8 (6.6)	27.4 (4.7)	5.031	0.033	0.666
Visual (32 – 45)	28.7 (4.9)	36.7 (4.3)	28.065	**0.0001**	1.813
Vestibular (48 – 55)	44.2 (6.0)	48.5 (3.6)	12.412	**0.002**	0.931
Touch (73 – 90)	65.1 (6.5)	76.9 (8.7)	29.5	**0.0001**	1.555
Multisensory (27 – 35)	25.0 (2.5)	26.6 (3.3)	7.169	**0.012**	0.555
Oral sensory (45 – 60)	44.2 (9.5)	48.7 (8.5)	4.415	0.045	0.521
Short sensory profile total score (155 – 190)	126.1 (18.2)	152.5 (17.2)	26.909	**0.0001**	1.549
% Atypical answers, (n)	100 (13)	47.1 (8)	9.832	**0.002**	

[1]Data in brackets correspond to the normal expected range. Low scores indicate more sensory characteristics while higher scores indicate better sensory functioning.

Significant results were identified (bolded) with the Holm method for multiple comparisons.

Results

Clinical and sociodemographic characteristics

The two groups were similar on sociodemographic variables and IQ. However, there was a significant difference for gender, and levels of symptoms of inattention and hyperactivity (see Table 1).

Sensory processing (SP)

All children with HFASD+ADHD and 47% of children with ADHD showed scores below one standard deviation (SD) for the SP total score, indicating global difficulties in sensory processing (see Table 2). ANCOVA analysis on the total score showed that children with HFASD+ADHD had overall significantly more atypical sensory processing than children with ADHD ($p < 0.001$), and significantly lower scores in the four sensory quadrants, as well as in four of the SP's six sections on the senses.

Motor

Nearly 62% of children with HFASD+ADHD and 23.5% of children with ADHD had a total motor performance of -1 SD (Table 3). The lower total motor performance of children with HFASD+ADHD is mainly due to poorer gross motor skills.

Adaptive behaviors

All children with HFASD+ADHD and 41.2% of those with ADHD had a global adaptive score below one SD (see Table 4). Children with HFASD+ADHD had a lower score than children with ADHD in the ABAS-II's three main domains ($p < 0.001$) and all of the adaptive functions except home/school living.

Association between sensory processing, motor skills and adaptive behaviors

Pearson correlation coefficients with a significance level (*p*) of .01 and .001 are highlighted in Table 5. Auditory processing was only associated with the conceptual domain, while visual and touch processing were associated with all aspects of adaptive behaviors. Multisensory processing was associated with the conceptual and practical domains, while oral sensory and vestibular processing was associated with none of the aspects of adaptive behaviors. Three of the four quadrants (except sensation seeking) and the total score of the SP were associated with all aspects of adaptive behaviors.

Strength and agility were related to all aspects of adaptive behaviors. Total motor composite and body coordination were related to the conceptual domains and global competence. Manual coordination was related only to self-care, and fine manual control was not related to any aspects of adaptive behaviors (see Table 5).

Table 3. Comparison of standard scores on BOT-2 motor skills Average of standard scores (SD)

	HFASD+ADHD n = 13	ADHD n = 17	*F*	p	d
Fine manual control	44.2 (7.4)	47.1 (8.0)	0.425	0.520	0.387
Fine motor – precision	10.3 (2.6)	12.6 (3.9)	2.119	0.157	0.699
Fine motor – integration	14.5 (5.3)	15.4 (3.9)	1.078	0.824	0.205
Manual coordination	38.6 (6.3)	46.5 (7.1)	8.268	0.008	1.208
Manual dexterity	10.0 (4.5)	13.8 (3.4)	3.782	0.062	1.006
Upper-limb coordination	9.9 (4.6)	13.5 (4.4)	6.451	0.017	0.831
Body coordination	35.8 (4.2)	46.1 (10.2)	8.283	0.008	1.302
Bilateral coordination	10.5 (3.3)	14.0 (4.1)	5.350	0.029	0.959
Balance	7.8 (3.3)	13.0 (4.7)	7.649	0.010	1.294
Strength and agility	44.0 (5.4)	55.1 (9.3)	13.764	**0.001**	1.460
Running speed and agility	14.5 (3.0)	19.6 (3.4)	15.035	**0.001**	1.632
Strength/endurance	9.8 (3.2)	14.6 (4.4)	12.039	**0.002**	1.264
Total motor composite	37.8 (4.2)	47.8 (7.4)	14.847	**0.001**	1.661
% -1 standard deviation, (n)	61.5 (8)	23.5 (4)	4.434	0.061	

The average standard score is 50±10 for the four motor composite areas and 15±5 for the eight subtests.

Significant results were identified (bolded) with the Holm method for multiple comparisons.

Table 4. Comparison of standard scores on ABAS-II adaptive behaviors

	HFASD+ADHD n = 13	ADHD n = 17	*F*	p	*d*
Conceptual	70.9 (10.1)	88.1 (13.2)	21.461	**0.0001**	1.487
Communication	4.1 (1.7)	7.6 (3.8)	12.753	**0.001**	1.176
Functional academics	5.2 (1.7)	8.4 (2.7)	13.888	**0.001**	1.425
Self-direction	4.8 (3.4)	7.4 (2.7)	10.753	**0.003**	0.891
Social	65.5 (11.0)	85.5 (13.1)	21.217	**0.0001**	1.691
Leisure	4.3 (2.6)	7.4 (2.9)	9.913	**0.004**	1.156
Social	2.2 (2.2)	6.8 (2.9)	24.648	**0.0001**	1.815
Practical	61.4 (11.6)	86.8 (18.3)	21.812	**0.0001**	1.666
Community use	4.8 (2.2)	8.5 (3.9)	10.064	**0.004**	1.167
Home/school living	2.6 (2.0)	4.9 (3.9)	3.966	0.057	0.738
Health and safety	3.8 (1.7)	7.7 (3.3)	19.46	**0.001**	1.478
Self-care	4.2 (2.3)	9.4 (3.0)	33.671	**0.0001**	1.977
Global competence score	62.8 (8.5)	85.1 (15.5)	26.961	**0.0001**	1.797
% -1 standard deviation, (n)	100 (13)	41.2 (7)	11.471	**0.001**	

The average standard score is 100±15 for the components and 10±3 for the scale score.

Significant results were identified (bolded) with the Holm method for multiple comparisons.

Table 5. Correlations between the ABAS-II, Sensory Profile and BOT-2 in the total group of children

	ABAS-II				
Sensory profile	Conceptual	Social	Practical	Autonomy	Global competence
Processing					
Auditory	0.500*	0.232	0.38	0.212	0.386
Visual	0.571**	0.501*	0.571**	0.636**	0.555**
Vestibular	0.34	0.41	0.352	0.361	0.391
Touch	0.577**	0.546**	0.586**	0.628**	0.595**
Multisensory	0.541**	0.259	0.509*	0.505*	0.476*
Oral Sensory	0.133	0.096	0.169	0.216	0.163
Quadrants					
Sensation seeking	0.332	0.197	0.284	0.264	0.304
Low registration	0.574**	0.578**	0.547**	0.572**	0.576**
Sensation avoidance	0.498*	0.589**	0.515*	0.490 *	0.511*
Sensation sensitivity	0.591**	0.503*	0.612**	0.606**	0.606**
SSP – Total	0.619**	0.523*	0.617**	0.576**	0.620**
BOT–2					
Fine manual control	0.186	0.071	0.069	-0.109	0.134
Manual coordination	0.365	0.254	0.26	0.474*	0.307
Body coordination	0.545**	0.335	0.536**	0.277	0.598**
Strength and agility	0.543**	0.447*	0.534**	0.446*	0.588**
Gross motor score	0.573**	0.4	0.529*	0.373	0.598**

* Significance threshold ≤ 0.01

** Significance threshold ≤ 0.001

Specifically, autonomy in self-care was associated with visual, tactile and multisensory information processing, as well as with three sensory quadrants (except sensation seeking) and the total SP score (see Table 5).

Discussion

With respect to the first objective of our poilot study, our results show that children with HFASD+ADHD have poorer sensory, motor and adaptive skills than children with ADHD.

Sensory processing skills

The presence of sensory difficulties in all children with HFASD+ADHD and half of children with ADHD is consistent with recent findings (Jasmin et al., 2009; Yochman et al., 2006). The high frequency of sensory processing difficulties in the two groups highlights the importance of assessing these skills.

Children with HFASD+ADHD have all their scores within the abnormal range and have poorer sensory processing than those with ADHD, whereas children with ADHD are within the lower limits of the normal range and have only isolated areas of deficits.

Contrary to our results, the only other study that compared sensory processing of children with ADHD to those with ASD (Cheung & Siu, 2009) reported no significant difference between the two groups in a Chinese population. This discrepancy could be explained by the exclusion of children with intellectual disabilities and the presence of ADHD symptoms in addition to HFASD in our study. Also, the Chinese version of the SP differs significantly from the original version that we used.

Motor skills

The two groups had better motor skills than anticipated. Nevertheless, our results are similar to those of Pan et al. (2009) indicating fewer motor disorders in children with ADHD than HFASD. However, the prevalence in ADHD (24%) is below the 50% of motor difficulties described by Pitcher et al. (2003). Differences can be explained in part by the fact that our children with ADHD had fewer symptoms of autism (SCQ = 4.5). According to Gillberg et al. (2004), the presence of motor difficulties in children with ADHD rises with the increase in autistic behaviors. It

could also be explained by exposure to medication, which was not stopped in our participants, contrary to the study by Pitcher et al. (2003). In fact, Flapper et al. (2006) maintain that medication can improve motor skills. Finally, the frequent presence of motor difficulties in children with HFASD+ADHD is close to the results obtained by Green et al. (2009) in ASD.

Children with ADHD have motor skills within the normal range for the BOT-2. In contrast, children with HFASD+ADHD have poorer strength and agility motor skills than children with ADHD. Pan et al. (2009) reported the same decrease in locomotor skills and dexterity in children with ASD as observed in our HFASD+ADHD group. However, contrary to our results, in an ASD group without the exclusion of intellectual disabilities, Dewey et al. (2007) observed a significant difference between the two groups in terms of gestural and coordination performance.

Adaptive behaviors

The frequency of adaptive behavior difficulites in our groups is quite high (HFASD+ADHD: 100%; ADHD: 41.2%). Consistent with a study by Stein, Szumowski, Blondis, and Roizen (1995) in the ASD population, children with HFASD+ADHD had a lower performance than children with ADHD alone in all domains and functions of adaptive behaviors evaluated, with the exception of home/school living, where both groups had similar below average scores.

Association between sensorimotor skills and adaptive behaviors

In general, sensory processing skills and motor skills were associated with domains and global competence in adaptive behaviors, in particular autonomy in self-care.

Autonomy in self-care was correlated with the processing of visual, tactile and multisensory information, and with sensory quadrants. As observed by Jasmin et al. (2009), children who avoided sensation had poorer autonomy in self-care. In addition, children who were more sensitive to stimuli (sensation sensitivity) and who were more passive in their search for sensation (low registration) were less involved in their self-care and daily living skills in general. Baranek, Foster, and Berkson (1997) reported that difficulties in sensory processing information are negatively related to personal hygiene and grooming. In our study, auditory processing was related only to the conceptual domain. Children who are easily distracted by noise or have auditory sensitivities appear to be less functional in academic skills and assume their individual responsibilities less.

Manual coordination and strength and agility were correlated with increased autonomy in self-care. It is interesting to note that a decrease in strength was connected to poorer functioning in all adaptive behavior domains, which could be explained by the child having difficulty persevering in her/his task. Consistent with Jasmin et al. (2009), our results suggest that manual dexterity and upper limb coordination are important for autonomy in self-care.

Limitations of the study

Our results should be interpreted cautiously, considering the relatively small sample size of our pilot study, which limits generalization. The small number of participants may have limited the statistical power to detect other differences between the groups. Another limitation is that the evaluators were not blinded, which could have led to a bias in scoring the performances. However, this is the typical clinical situation where qualified professionals can distinguish children with ASD from children with ADHD. We have attempted to limit this bias by triangulating the parental perspective with objective measures from direct observation made by a professional.

Conclusion

The results of our pilot study contribute to a growing body of evidence that relates sensory processing and motor skills to autonomy in self-care and adaptive behaviors in general (Jasmin et al., 2009). The presence of ADHD symptoms in children with HFASD seems to worsen the profile of motor skills and adaptive behaviors. Therefore it is important to assess these skills in order to offer proper support to the child and family. Further research is needed to document more detailed profiles distinguishing between children with a single diagnosis (ADHD and HFASD) and those with a double diagnosis, as well as the effectiveness of interventions targeting these skills and promoting autonomy.

Acknowledgments / Conflicts of Interest

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References

American Association on Mental Retardation (2002). *Mental retardation: Definition, classification, and system of support.* Washington, DC: American Association on Mental Retardation.

American Psychiatric Association (2000). *Diagnostic and Statistical Manual of Mental Disorders (4th ed., Text rev.)*. Washington, DC: American Psychiatric Association.

Baranek, G. T., Foster, L. G., & Berkson, G. (1997). Tactile defensiveness and stereotyped behaviors. *American Journal of Occupational Therapy, 51*(2), 91-95.

Ben-Sasson, A., Cermak, S. A., Orsmond, G. I., Tager-Flusberg, H., Kadlec, M. B., & Carter, A. S. (2008). Sensory clusters of toddlers with autism spectrum disorders: Differences in affective symptoms. *Journal of Child Psychology and Psychiatry, 49*(8), 817-825.

Bruininks, R. H., & Bruininks, B. D. (2005). *Bruininks-Oseretsky Test of Motor Proficiency Second Edition: Manual*. Minneapolis, MN: NCS Pearson.

Cheung, P. P. P., & Siu, A. M. H. (2009). A comparison of patterns of sensory processing in children with and without developmental disabilities. *Research in Developmental Disabilities*, *30*(6)*,* 1468-1480.

Conners, K. (1997). *Conners Rating Scales-Revised: Technical Manual*. North Tonawanda, NY: Multi-Health Systems.

Corbett, B. A., Constantine, L. J., Hendren, R., Rocke, D., & Ozonoff, S. (2009). Examining executive functioning in children with autism spectrum disorder, attention deficit hyperactivity disorder and typical development. *Psychiatry Research*, *166*(2-3), 210-222.

Dewey, D., Cantell, M., & Crawford, S. G. (2007). Motor and gestural performance in children with autism spectrum disorders, developmental coordination disorder, and/or attention deficit hyperactivity disorder. *Journal of International Neuropsychological Society, 13*(2), 246-256.

Dunn, W. (2001). The sensations of everyday life: Empirical, theoretical, and pragmatic considerations. *American Journal of Occupational Therapy, 55*(6), 608-620.

Dunn, W. (1999). *Sensory Profile*. San Antonio, TX: Psychological Corporation.

Flapper, B. C. T., Houwen, S., & Schoemaker, M. M. (2006). Fine motor skills and effects of methylphenidate in children with attention-deficit-hyperactivity disorder and developmental coordination disorder. *Developmental Medicine and Child Neurology, 48*(3), 165-169.

Gillberg, C., Gillberg, I. C., Rasmussen, P., Kadesjö, B., Söderström, H., Råstam, M.,…Niklasson, L. (2004). Co-existing disorders in ADHD: Implications for diagnosis and intervention. *European Child and Adolescent Psychiatry, 13*(1), 80-92.

Goldstein, S., & Schwebach, A. J. (2004). The comorbidity of Pervasive Developmental Disorder and Attention Deficit Hyperactivity Disorder: Results of a retrospective chart review. *Journal of Autism Developmental Disorders, 34*(3), 329-339.

Green, D., Charman, T., Pickles, A., Chandler, S., Loucas, T., Simonoff, E., & Baird, G. (2009). Impairment in movement skills of children with autistic spectrum disorders: A preliminary investigation. *Adapted Physical Activity Quarterly, 14*, 189-202.

Harrison, P. L., & Oakland, T. (2008). *Adaptive Behavior Assessment System Second Edition: Manual*. Los Angeles, CA: Western Psychological Services.

Holm, S. A. (1979). A simple sequentially rejective multiple test procedure. *Scandinavian Journal of Statistics, 6*, 65-70.

Jasmin, E., Couture, M., McKinley, P., Reid, G., Fombonne, E., & Gisel, E. (2009). Sensori-motor and daily living skills of preschool children with autism spectrum disorders. *Journal of Autism Developmental Disorders, 39*(2), 231-241.

Lord, C., Rutter, M., DiLavore, P. C., & Risi, S. (1999). *Autism Diagnostic Observation Schedule (ADOS)*. Los Angeles, CA: Western Psychological Services.

Pan, C. Y., Tsai, C. L., & Chu, C. H. (2009). Fundamental movement skills in children diagnosed with Autism Spectrum Disorders and Attention Deficit Hyperactivity Disorder. *Journal of Autism Developmental Disorders, 39*(2), 1694-1705.

Pitcher, T. M., Piek, J. P., & Hay, D. A. (2003). Fine and gross motor ability in males with ADHD. *Developmental Medecine and Child Neurology, 45*(8), 525-535.

Rutter, M., Bailey, A., & Lord, C. (2003). *The Social Communication Questionnaire (SCQ) Manual*. Los Angeles, CA: Western Psychological Services.

Saulnier, C. A., & Klin, A. (2007). Brief report: Social and communication abilities and disabilities in higher functioning individuals with autism and Asperger Syndrome. *Journal of Autism and Developmental Disorders, 37*(4), 788-793.

Stein, M. A., Szumowski, E., Blondis, T. A., & Roizen, N. J. (1995). Adaptive skills dysfunction in ADD and ADHD children. *Journal of Child Psychology and Psychiatry, 36*(4), 663-670.

Wechsler, D. (1999). *Wechsler Abbreviated Scale of Intelligence (WASI)*. San Antonio, TX: The Psychological Corporation.

Wechsler, D. (2004). *Wechsler Intelligence Scale for Children - Fourth Edition: Canadian Manual*. Toronto, ON: Harcourt Assessment.

Yochman, A., Ornoy, A., & Parush, S. (2006). Co-occurrence of developmental delays among preschool children with attention-deficit-hyperactivity disorder. *Developmental Medicine and Child Neurology, 48*(6), 483-488.