

Proprioceptive Processing Difficulties Among Children With Autism Spectrum Disorders and Developmental Disabilities

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KEY WORDS

- autistic disorder
- developmental disabilities
- feedback, sensory
- proprioception
- somatosensory disorders

OBJECTIVE. Sensory processing difficulties among children with autism spectrum disorders (ASD) have been extensively documented. However, less is known about this population's ability to process proprioceptive information.

METHOD. We used the Comprehensive Observations of Proprioception (COP; Blanche, Bodison, Chang, & Reinoso, in press) to describe the proprioceptive difficulties experienced by children with ASD. A sample of 32 children with ASD, 26 children with developmental disabilities excluding ASD, and 28 typically developing control children were studied using the COP.

RESULTS. Children with ASD present with proprioceptive processing difficulties that are different from those of children with developmental disabilities and their typically developing counterparts. Specific data, potential clinical applications, and directions for future research are described.

CONCLUSION. Results suggest that the COP has useful clinical research applications. Further assessment of psychometric properties, clinical utility, and meaningful differences among diverse clinical populations are needed.

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Sensory processing difficulties among children with autism spectrum disorders (ASD) have been extensively documented (Baranek, David, Poe, Stone, & Watson, 2006; Baranek, Foster, & Berkson, 1997; Ben-Sasson et al., 2009; Jones, Quigney, & Huws, 2003; Leekam, Nieto, Libby, Wing, & Gould, 2007). Less frequently described are the proprioceptive difficulties of this population. Although reports have been emerging (Glazebrook, Gonzalez, Hansen, & Elliott, 2009; Haswell, Izawa, Dowell, Mostofsky, & Shadmehr, 2009; Mukhopadhyay, 2003; Weimer, Schatz, Lincoln, Ballantyne, & Trauner, 2001), the evidence is mixed. *Proprioception*, defined as the sum of neuronal inputs from the joint capsules, ligaments, muscles, tendons, and skin, is a multifaceted system that affects motor control and is hypothesized to have an impact on behavior regulation (Ayres,

1972, 1989; Blanche & Schaaf, 2001; Dunn, 1999, 2001; Mukhopadhyay, 2003) and motor control (Ayres, 1972, 1989; Lephart & Fu, 2000).

Several authors have reported on the motor control difficulties related to poor proprioceptive processing among children with ASD, including decreased postural control and motor planning (Weimer et al., 2001), overreliance on proprioception (Haswell et al., 2009), difficulty matching proprioception with vision during reach (Glazebrook et al., 2009), decreased organization of space (Vakalopoulos, 2007), and poor motor anticipation (Schmitz, Martineau, Barthélémy, & Assaïante, 2003). In addition, Mukhopadhyay (2003) and others with ASD have provided detailed descriptions of the behavior regulation difficulties affected by poor proprioceptive processing among people with ASD. In his

autobiography, Mukhopadhyay attributed the feeling of a disjointed or “scattered” body to a faulty proprioceptive sense, which he reported to be restored by engaging in behaviors that provide proprioceptive input such as running and flapping.

Although some proprioceptive difficulties are identifiable in clinical practice through observation, clinicians lack a systematic, comprehensive tool that measures more than one aspect of proprioception in children with ASD. Most of the difficulties in proprioceptive processing are reported in parent questionnaires (Dunn, 1999; Parham & Ecker, 2007) and standardized tests such as the Kinesthesia and Standing/Walking Balance subtests of the Sensory Integration and Praxis Tests (Ayres, 1989). In this study, we compared the performance of children with ASD with that of children with developmental disabilities (DD) and with matched control children on the Comprehensive Observations of Proprioception (COP; Blanche, Bodison, Chang, & Reinoso, in press), a scale that measures proprioceptive processing by direct observation.

The COP comprises 18 items focusing on motor and behavior regulation aspects of proprioceptive processing among children. The COP has demonstrated psychometric properties including adequate validity and reliability for clinical use and research, which are described elsewhere (Blanche et al., in press). In this study, we used only 16 items; 2 items were eliminated from the analysis because of incomplete scores in the data set. The COP items used were as follows: decreased muscle tone; joint hypermobility; poor joint alignment and cocontraction; inefficient ankle strategies; inadequate weight-bearing and weight-shifting patterns; decreased postural control; decreased feedback-related motor planning abilities; decreased feedforward-related motor planning abilities; inefficient grading of force; tiptoeing; pushing others or objects; enjoyment when being pulled; tendency to lean on others; overactive; overpassive; and crashing, falling, running.

The COP guides clinicians’ observations and helps them identify adequate performance (i.e., muscle tone, joint alignment) and deviation from typical parameters (i.e., decreased muscle tone, decreased

joint alignment) using specifically and operationally defined criteria. The measure requires the clinician to observe the child during the usual developmental assessment (i.e., gross motor testing, clinical observations, free play) to rate the aforementioned items. If additional activities are required to collect the necessary information, they are completed subsequently. Our purpose in this study was to evaluate comprehensively proprioceptive processing difficulties among children with ASD using an observation-based, psychometrically sound assessment (COP) and to elucidate the unique nature of these difficulties.

Method

We used a retrospective group-comparison design. The participants included 32 children diagnosed with ASD and without any additional motor difficulties (mean age = 6.3, standard deviation [*SD*] = 1.3, range = 3–10 yr); 26 participants with DD excluding ASD (mean age = 6.8, *SD* = 1.9, range = 3–10 yr) who were referred to an occupational therapy clinic, with DD diagnosed by the referring professional (children with cerebral palsy or ASD were not included in the sample with DD); and 28 age-matched control participants without known proprioceptive difficulties or DD (mean age = 6.7, *SD* = 1.8, range = 4–10 yr). The participants with ASD were diagnosed clinically by a pediatric neurologist or clinical psychologist using *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., text revision; American Psychiatric Association, 2000) criteria and parent and teacher reports. De-identified data were collected from a chart review at two occupational therapy clinics by means of the COP, following a protocol with institutional review board approval described in detail in the original study (Blanche et al., in press). The de-identified data of the typically developing matched control children were collected in a natural setting.

Results

We used analysis of variance for the three-group comparison and applied a post hoc analysis with Tukey–Kramer method for pairwise comparison (Kramer, 1956).

Tukey–Kramer is used because it is a conservative method recommended for use in situations of unequal sample size (Dunnnett, 1980). Significance level was set at $p < .05$. The results shown in Table 1 indicate that the three groups were significantly different on all COP individual items, on the total score for the COP scale, and on the four factors. Post hoc analysis with Tukey–Kramer’s adjustment indicate that the ASD and DD groups were not significantly different except on four items: feedback-related motor planning; tiptoeing; pushing others or objects; and crashing, falling, and running. The ASD and DD groups were also not significantly different on Factor 1 (decreased tone and joint alignment) and Factor 3 (decreased postural control and grading of force).

Discussion

This study’s results suggest that children with ASD present with distinct patterns of proprioceptive processing difficulties on four items measured by the COP, when compared with typically developing children and children with DD. These difficulties include difficulty with feedback-related motor planning skills; tiptoeing; pushing others or objects; and crashing, falling, and running. Our findings suggest that proprioceptive difficulties among children with ASD may contribute to decreased motor planning and postural control and to disruptive behaviors that negatively affect their participation in daily tasks.

Our findings add to the varied literature on proprioceptive processing in ASD. Fuentes, Mostofsky, and Bastian (2011) and Weimer et al. (2001) did not find proprioceptive differences in their cohorts of participants with ASD. However, their studies focused on isolated aspects of proprioception, such as the perception of joint position or balance and visuomotor functions. Conversely, Grob, Kuster, Higgins, Lloyd, and Yata (2002) did find proprioceptive processing difficulties. Our study provides a comprehensive assessment of proprioception based on standardized observation and includes many relevant aspects of proprioceptive processing identified in the literature. Clearly, further research is needed to evaluate proprioceptive differences among

Table 1. Analysis of Variance for the Three-Group Comparison and Post Hoc Analysis With Tukey–Kramer’s Adjustment for Pairwise Comparisons

Measure	Mean (SD)			ANOVA	Post Hoc Comparison With Tukey–Kramer’s Adjustment		
	ASD (n = 32)	DD (n = 26)	TYP (n = 28)		ASD–DD	ASD–TYP	DD–TYP
Decreased muscle tone	2.5 (0.8)	2.1 (1.0)	1.2 (0.4)	*		*	*
Joint hypermobility	2.2 (0.9)	2.4 (1.2)	1.0 (0.2)	*		*	*
Poor joint alignment and cocontraction	2.8 (1.0)	2.5 (1.0)	1.0 (0.2)	*		*	*
Inefficient ankle strategies	2.8 (1.0)	2.6 (0.9)	1.0 (0.2)	*		*	*
Inadequate weight-bearing and weight-shifting patterns	2.9 (1.1)	2.4 (0.9)	1.0 (0.2)	*		*	*
Decreased postural control	2.6 (1.0)	2.2 (1.1)	1.1 (0.3)	*		*	*
Decreased feedback-related motor planning abilities	2.6 (0.8)	1.9 (0.9)	1.0 (0.2)	*	*	*	*
Decreased feedforward-related motor planning abilities	3.4 (1.3)	3.0 (0.8)	1.0 (0.0)	*		*	*
Inefficient grading of force	3.0 (1.1)	2.8 (0.8)	1.0 (0.2)	*		*	*
Tiptoeing	2.0 (1.2)	1.1 (0.3)	1.0 (0.0)	*	*	*	
Pushing others or objects	2.7 (1.3)	1.9 (1.0)	1.1 (0.3)	*	*	*	*
Enjoyment when being pulled	3.0 (1.2)	3.2 (0.9)	1.1 (0.3)	*		*	*
Tendency to lean on others	3.3 (1.1)	2.8 (1.1)	1.1 (0.3)	*		*	*
Overactive	3.0 (1.4)	2.8 (1.3)	1.2 (0.4)	*		*	*
Overpassive	2.3 (1.3)	1.8 (0.9)	1.2 (0.4)	*		*	*
Crashing, falling, running	3.4 (1.0)	2.7 (1.3)	1.1 (0.3)	*	*	*	*
COP total scores	44.3 (10.5)	37.9 (9.5)	17.2 (1.9)	*	*	*	*
Factor 1, Tone and Joint Alignment	7.5 (2.4)	7.0 (2.9)	3.3 (0.5)	*		*	*
Factor 2, Behavior Manifestation	14.0 (4.0)	11.7 (3.6)	5.5 (0.9)	*	*	*	*
Factor 3, Postural Motor	14.6 (4.1)	12.6 (4.0)	5.3 (0.9)	*		*	*
Factor 4, Motor Planning	8.2 (2.6)	6.7 (1.9)	3.2 (0.5)	*	*	*	*

Note. Blank cells indicate that the comparison was nonsignificant. ANOVA = analysis of variance; ASD = autism spectrum disorder; COP = Comprehensive Observations of Proprioception Scale; DD = developmental disability without ASD; SD = standard deviation; TYP = typically developing children.

* $p < .05$.

people with ASD and their contribution to functional behavior and motor skills.

Our study suggests that the COP may have useful clinical research applications; however, further assessment of psychometric properties, clinical utility using the COP in different settings (i.e., community and clinical settings), and meaningful differences among diverse clinical populations are needed. Additional studies may also seek to determine whether patterns of scores on the COP are different when other variables such as IQ or chronological age are controlled. The COP is a useful clinical tool for measuring the proprioceptive difficulties presented by children with ASD and may aid clinicians in planning further assessment and observations as well as incorporating intervention strategies in different settings.

Implications for Occupational Therapy Practice

The results of this study have the following implications for occupational therapy practice:

- The COP is a useful clinical tool for identifying proprioceptive difficulties in children with ASD.
- The COP can help clinicians plan intervention strategies for children with ASD. ▲

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References

- American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed., text rev.). Washington, DC: Author.
- Ayres, A. J. (1972). *Sensory integration and learning disorders*. Los Angeles: Western Psychological Services.
- Ayres, A. J. (1989). *Sensory Integration and Praxis Tests*. Los Angeles: Western Psychological Services.
- Baranek, G. T., David, F. J., Poe, M. D., Stone, W. L., & Watson, L. R. (2006). Sensory Experiences Questionnaire: Discriminat-

- ing sensory features in young children with autism, developmental delays, and typical development. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, 47, 591–601. <http://dx.doi.org/10.1111/j.1469-7610.2005.01546.x>
- Baranek, G. T., Foster, L. G., & Berkson, G. (1997). Tactile defensiveness and stereotyped behaviors. *American Journal of Occupational Therapy*, 51, 91–95. <http://dx.doi.org/10.5014/ajot.51.2.91>
- Ben-Sasson, A., Hen, L., Fluss, R., Cermak, S. A., Engel-Yeger, B., & Gal, E. (2009). A meta-analysis of sensory modulation symptoms in individuals with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, 39, 1–11. <http://dx.doi.org/10.1007/s10803-008-0593-3>
- Blanche, E. I., Bodison, S., Chang, M., & Reinoso, G. (in press). Development of the Comprehensive Observations of Proprioception: Validity, reliability and factor analysis. *American Journal of Occupational Therapy*.
- Blanche, E. I., & Schaaf, R. C. (2001). Proprioception: A cornerstone of sensory integration intervention. In S. S. Roley, E. I.

- Blanche, & R. C. Schaaf (Eds.), *Understanding the nature of sensory integration with diverse populations* (pp. 109–124). San Antonio, TX: Harcourt Assessment.
- Dunn, W. (1999). *Sensory Profile*. San Antonio, TX: Psychological Corporation.
- Dunn, W. (2001). The sensations of everyday life: Empirical, theoretical, and pragmatic considerations. *American Journal of Occupational Therapy, 55*, 608–620. <http://dx.doi.org/10.5014/ajot.55.6.608>
- Dunn, C. W. (1980). Pairwise multiple comparison in the homogeneous variance, unequal sample size case. *Journal of the American Statistical Association, 75*(372), 789–195.
- Fuentes, C. T., Mostofsky, S. H., & Bastian, A. J. (2011). No proprioceptive deficits in autism despite movement related sensory and execution impairments. *Journal of Autism and Developmental Disorders, 41*, 1352–1361. <http://dx.doi.org/10.1007/s10803-010-1161-1>
- Glazebrook, C., Gonzalez, D., Hansen, S., & Elliott, D. (2009). The role of vision for online control of manual aiming movements in persons with autism spectrum disorders. *Autism, 13*, 411–433. <http://dx.doi.org/10.1177/1362361309105659>
- Grob, K. R., Kuster, M. S., Higgins, S. A., Lloyd, D. G., & Yata, H. (2002). Lack of correlation between different measurements of proprioception in the knee. *Journal of Bone and Joint Surgery, 84*, 614–618. <http://dx.doi.org/10.1302/0301-620X.84B4.11241>
- Haswell, C. C., Izawa, J., Dowell, L. R., Mostofsky, S. H., & Shadmehr, R. (2009). Representation of internal models of action in the autistic brain. *Nature Neuroscience, 12*, 970–972. <http://dx.doi.org/10.1038/nn.2356>
- Jones, R. S. P., Quigney, C., & Huws, J. C. (2003). First-hand accounts of sensory perceptual experiences in autism: A qualitative analysis. *Journal of Intellectual and Developmental Disability, 28*, 112–121. <http://dx.doi.org/10.1080/1366825031000147058>
- Kramer, C. Y. (1956). Extension of multiple range tests to group means with unequal numbers of replications. *Biometrics, 12*, 307–310.
- Leekam, S. R., Nieto, C., Libby, S. J., Wing, L., & Gould, J. (2007). Describing the sensory abnormalities of children and adults with autism. *Journal of Autism and Developmental Disorders, 37*, 894–910. <http://dx.doi.org/10.1007/s10803-006-0218-7>
- Lephart, S. M., & Fu, F. H. (2000). *Proprioception and neuromuscular control in joint stability*. Champaign, IL: Human Kinetics.
- Mukhopadhyay, T. (2003). *The mind tree*. New York: Arcade.
- Parham, L. D., & Ecker, C. (2007). *Sensory Processing Measure: Home Form (SPM–Home)*. Los Angeles: Western Psychological Services.
- Schmitz, C., Martineau, J., Barthélémy, C., & Assaiante, C. (2003). Motor control and children with autism: Deficit of anticipatory function. *Neuroscience Letters, 348*, 17–20. [http://dx.doi.org/10.1016/S0304-3940\(03\)00644-X](http://dx.doi.org/10.1016/S0304-3940(03)00644-X)
- Vakalopoulos, C. (2007). Unilateral neglect: A theory of proprioceptive space of a stimulus as determined by the cerebellar component of motor efference copy (and is autism a special case of neglect). *Medical Hypotheses, 68*, 574–600. <http://dx.doi.org/10.1016/j.mehy.2006.08.013>
- Weimer, A. K., Schatz, A. M., Lincoln, A., Ballantyne, A. O., & Trauner, D. A. (2001). “Motor” impairment in Asperger syndrome: Evidence for a deficit in proprioception. *Developmental and Behavioral Pediatrics, 22*, 92–101. <http://dx.doi.org/10.1097/00004703-200104000-00002>