2021 Gatlinburg Conference Poster Submission

Title: Sensory mechanisms of motor variability and regularity in autism spectrum disorder

Authors: Robin Shafer[1,2], Zheng Wang[3], James Bartolotti[1,2], Matt Mosconi[1,2,4]

Introduction: Deficits in sensorimotor integration are highly prevalent in persons with Autism Spectrum Disorders (ASD) and are associated with more severe core symptoms. Our prior ASD studies of precision manual motor control demonstrate increased motor variability and regularity that are exacerbated when visual feedback is either enhanced or degraded (Mosconi et al., 2015). These findings suggest individuals with ASD show an over-reliance on visual feedback during basic motor actions. Other studies have indicated that individuals with ASD show a heightened reliance on proprioceptive feedback during motor learning, suggesting separate sensory feedback processes may be selectively altered in ASD (Haswell et al., 2009; Izawa et al., 2012; Marko et al., 2015). Given the pervasiveness of sensorimotor behavioral differences in ASD, a better understanding of the sensory and motor control processes that drive them is important for determining new targets for interventions and identifying physiological mechanisms. To clarify sensory mechanisms of increased motor variability and regularity in ASD, the present study characterized precision manual motor behavior during conditions in which visual and proprioceptive feedback were altered.

Method: Forty-three participants with ASD and 23 controls matched on age (10-20 years) and non-verbal IQ completed tests of precision gripping. Participants pressed on force sensors with their dominant hand index finger and thumb. They viewed a stationary target force bar and a separate force bar that moved up with increased force. Participants were instructed to press so that the force bar reached the level of the target bar, and then to keep it as steady as possible. Visual feedback was manipulated by changing the visual gain of the force bar across three levels (low, medium, and high). The force bar moved more per change in force output for higher compared to lower gains. To assess the impact of altering proprioceptive feedback, 80 Hz tendon vibration was applied at the wrist to induce an illusion of muscle contraction and compared to a condition with the tendon vibrator turned off. Force variability (standard deviation) and regularity (sample entropy) each were examined.

Results: Controls showed increased force variability with tendon vibration turned on compared to off ($t = -2.665$, $p = 0.0081$); however, individuals with ASD showed no significant difference in force variability between the tendon vibration on and off conditions ($t = -0.171$, $p = 0.864$). Individuals with ASD showed stronger age-associated reductions in force variability relative to controls across tendon vibrator conditions and gain levels (Group x Age: $t = -4.50$, $p < .0001$). Individuals with ASD also showed greater age-associated increases in force regularity relative to controls, especially at higher gain levels (Group x Gain Level x Age: $t = -3.22$, $p = 0.0014$). Individuals with ASD showed age-associated increases in regularity across tendon vibrator conditions, but these age-associated gains were only seen in controls when the tendon vibrator was turned off (Group x Vibration Frequency x Age: $t = 2.46$, $p = .0144$).

Discussion: Our finding that healthy controls show greater force variability when proprioceptive feedback is disrupted (tendon vibrator on) indicate that they integrate proprioceptive feedback to reactively adjust precision force during continuous motor behavior. In contrast, persons with ASD do not change the variability of their force output when proprioceptive feedback is disrupted, suggesting that they rely primarily on visual feedback and minimally on proprioceptive feedback for continuous motor control. Our results also suggest altered developmental trajectories of sensorimotor processing in individuals with ASD. Control participants show minimal change in motor variability and regularity across our age range while persons with ASD continue to show age-associated gains across adolescence and early adulthood suggesting sensorimotor issues may be more prominent in early development. Our findings help clarify the sensory integration deficits that contribute to motor behavioral issues in individuals with ASD. These specific behavioral deficits implicate the presence of distinct, atypical neurodevelopmental mechanisms in patients. Discerning these mechanisms will be the focus of future studies. **References:** Lough, E. & Fisher, M.H. (2016). Internet use and online vulnerability in adults with Williams syndrome. *Journal of Intellectual Disability Research, 60,* 1020-1030

Author Affiliations

[1] Schiefelbusch Institute for Life Span Studies, University of Kansas, Lawrence, KS

[2] Kansas Center for Autism Research and Training, University of Kansas, Lawrence, KS

[3] Department of Occupational Therapy, University of Florida, Gainesville, FL

[4] Clinical Child Psychology Program, University of Kansas, Lawrence, KS

References

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*(8), 970–972. https://doi.org/10.1038/nn.2356

Izawa, J., Pekny, S. E., Marko, M. K., Haswell, C. C., Shadmehr, R., & Mostofsky, S. H. (2012). Motor Learning Relies on Integrated Sensory Inputs in ADHD, but Over-Selectively on Proprioception in Autism Spectrum Conditions: Distinct patterns of motor memory in Autism. *Autism Research*, *5*(2), 124–136. https://doi.org/10.1002/aur.1222

Marko, M. K., Crocetti, D., Hulst, T., Donchin, O., Shadmehr, R., & Mostofsky, S. H. (2015). Behavioural and neural basis of anomalous motor learning in children with autism. *Brain*, *138*(3), 784–797. https://doi.org/10.1093/brain/awu394

Mosconi, M. W., Mohanty, S., Greene, R. K., Cook, E. H., Vaillancourt, D. E., & Sweeney, J. A. (2015). Feedforward and Feedback Motor Control Abnormalities Implicate Cerebellar Dysfunctions in Autism Spectrum Disorder. *Journal of Neuroscience*, *35*(5), 2015–2025. https://doi.org/10.1523/JNEUROSCI.2731-14.2015