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The Influence of Prior Motor Actions on Motor Planning in Children With Autism Spectrum Disorder

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THE INFLUENCE OF PRIOR MOTOR ACTIONS ON MOTOR PLANNING IN CHILDREN WITH AUTISM SPECTRUM DISORDER

by

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Abstract

Studies have found children with Autism Spectrum Disorder (ASD) have a rigidity of motor plans and difficulties planning and executing movements. Children with ASD also exhibit repetitive behaviors such as nail biting and rocking back and forth. When planning for movements, repetitive behaviors might manifest as difficulty in formulating new or switching between different motor plans. In typically developing individuals, actions are often influence by recently performed motor actions. We sought to determine if this influence was stronger in children with ASD.

A rotation motor task was created to evaluate the rigidity of motor planning of five children with ASD (7-10 years old). A control group, consisting of 5 age-matched participants was also tested. The participant sat across from the researcher. In successive trials, a wooden rod was placed in a different orientation around a circle grid system containing 24 positions. The orientation rotated either counterclockwise or clockwise around the 24 positions. The experimenter revealed the rod to the participant, and asked the child to return it to a home position. Researchers measured the orientation at which the child switched the thumb orientation (e.g. thumb pointing towards black) in both the clockwise and counterclockwise direction.

While moving the stick clockwise, the peak switch (the switch where the sum of all children switched grasps) occurred later for children with ASD than neurotypical children. Children with ASD also switched their grasp position less frequently than neurotypical children. The results of this study suggest that changing a grasp was more costly than being comfortable while performing the action in children with ASD than in neurotypical children.

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Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that can cause significant social, cognitive, and behavioral impairments (5th ed; DSM-5; American Psychiatric Association, 2013). Studies have found children with ASD have a rigidity of motor plans and difficulties planning and executing movements (Eigsti, 2013). Children with ASD also exhibit repetitive behavior patterns such as rocking back and forth and nail biting. Along with repetitive behaviors, children with ASD exhibit stereotyped behaviors such as lining up all their toys in a certain way according to size, shape, and color (Lord et al., 1994). These actions could indicate that children with ASD have difficulties forming new motor plans or switching between motor plans. However, few studies have looked at the difference in motor planning between children with ASD and neurotypical children.

Adults sometimes grasp objects in an initially uncomfortable position so their next action can be more comfortable. This is shown through the example of adults reaching for an overturned glass with an initial uncomfortable thumb-down grasp to flip the glass to a more comfortable thumb-up grasp when pouring water. This propensity to achieve a comfortable grasp position is referred to as the end-state comfort effect (Rosenbaum et al., 1990). The stage of a child's sensory-motor development and age has an influence on their use of end-state comfort (Weigelt & Schack, 2010). End-state comfort can be used to measure efficiency in motor planning.

In typically developing individuals, actions can be influence by recently performed, similar motor actions. In other words, repeating an action is cognitively simpler than creating an entirely new motor plan (Cohen & Rosenbaum, 2004). This experiment sought to determine if

the influence of previous action on future action was stronger in children with ASD than neurotypical children.

Methods

Participants:

Ten children ages 7-10 years old participated in the study. Five of the children were diagnosed with high-functioning ASD, and five of the children were neurotypical (see Table 1). Informed consent procedures were approved by the Utah State University Institutional Review Board (IRB).

Participant		Age (years;months)	Gender	Matched Control
Set 1				
	1	10;8	Female	10;2
	3	9;5	Female	8;5
	4	8;4	Male	7;11
Set 2				
	2	10;9	Male	10;11
	5	9;6	Male	9;2

Table 1. Mean descriptives for all participants prior to participation in intervention plan.

Apparatus and Task:

The child was seated at a table. In front of the child on the table, were two pieces of paper, 21.59 x 27.94 cm. The first paper had circle template printed on it. This circle was a grid system with twenty-five corresponding numbers. The second paper was directly above and had a printed black rectangle, which was referred to as the "home position" (Figure 1.).

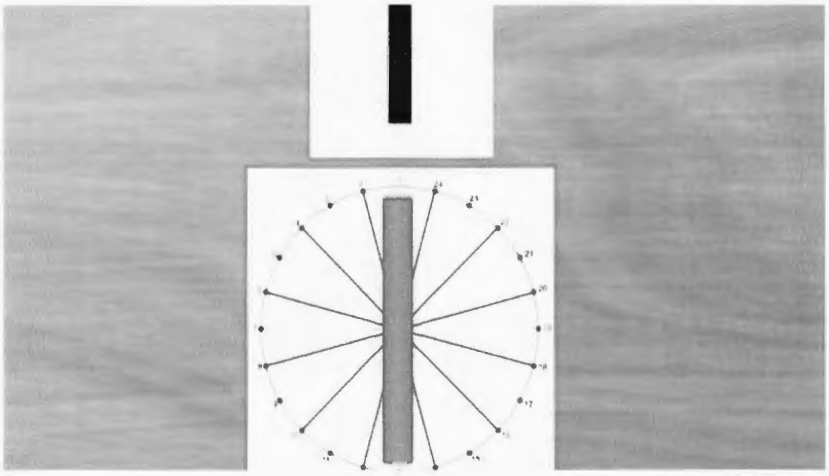

Figure 1. A representation of the experiment layout in vertical orientation (position 1)

Initially, a wooden rod was placed in front of the child on the grid system. The experimenter put a binder between the child and the grid system to prevent the child from seeing the location of the wooden rod. The binder was removed and the experimenter asked the child to return the rod to "home position." The child grasped the rod, lifted it, and returned it to the "home position." Then binder was then replaced to occlude the child's vision, and the rod was moved counterclockwise or clockwise 15 degrees (to the next position) and the task was repeated. This was completed for every successive position, and the final vertical position was performed one last time. Each child completed the task four times, twice clockwise and twice counterclockwise on separate days. The order of these tasks was randomized

Figure 2. Pictures of the experimental task. A) object was placed by the experimenter, b) object was grasped, c) object was moved to the home position.

Experimenters rated the direction of the thumb position in relation to a specific end of the wooden rod as well as the total number of times a participant switched a grasp from one end of the rod to the other. A "grasp switch" was defined as a thumb position change from one end of the rod to the other end at the point of grasping the rod. The sum total of "grasp switches that occurred at each rotation position for all subjects and all four trials were calculated and plotted for each group.

Results

The peak switch position (the position where the greatest number of grasp switches occurred) occurred for children with ASD at position 13 for both the clockwise and counter clockwise rotations. This represented the half way portion around the circle (Figures 3. and 4.). Neurotypical children had a peak grasp switch at a much earlier position (22) for clockwise and a later position (25) for clockwise rotation. For the clockwise rotation, neurotypical children had a broader distribution of grasp switch positions also reflected by the greater number of switches overall compared the children with ASD.

During the clockwise rotation, ASD children switched their grasp 22 times, and the neurotypical children switched their grasp 31 times. For the counter clockwise rotation, ASD children switched their grasp 16 times, while the neurotypical children switched 22 times. Overall, children with ASD switched their grasp positions less frequently than neurotypical children.

Clockwise Rotation

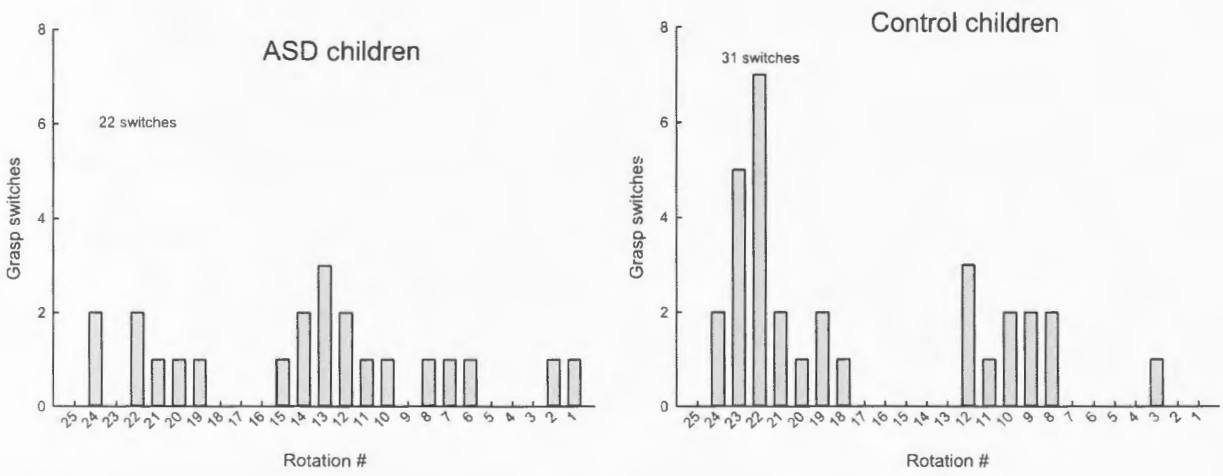

Figure 3. The number of grasp switches made at each rotation position (clockwise rotation) for children with ASD and neurotypical (control) children.

Counter-clockwise Rotation

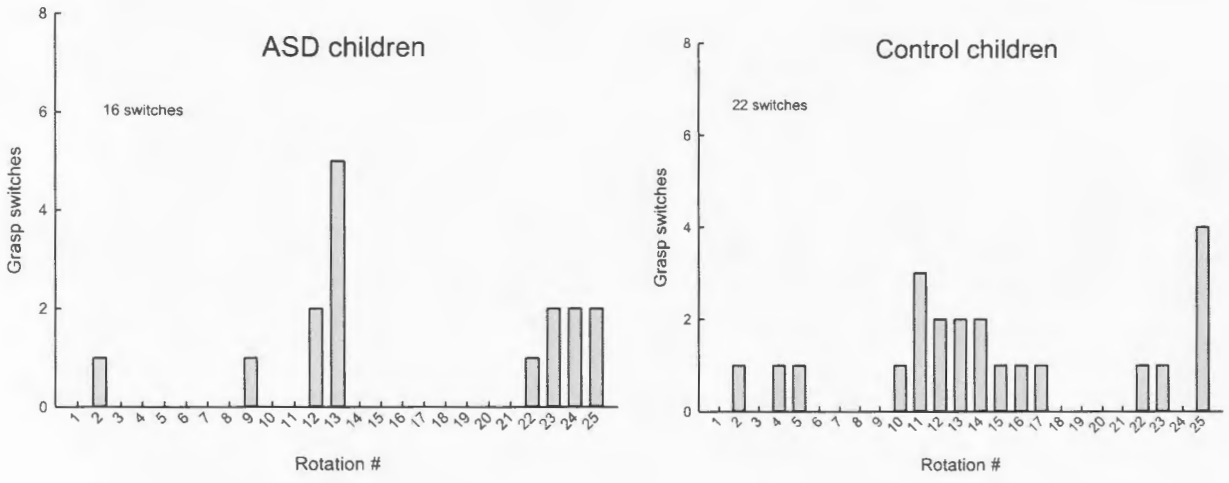

Figure 4. The number of grasp switches made at each rotation position (counter-clockwise rotation) for children with ASD and neurotypical (control) children.

Discussion

Overall, children with ASD switched their grasp positions at later positions and less frequently than neurotypical children. The results of this study suggest that changing a grasp may have been more costly for children with ASD than for neurotypical children. The preservation of a previous thumb position, even though the posture to maintain that position may have been awkward or uncomfortable could indicate a resistance to a change in motor plans. When the children with ASD maintained a previous grasp, this could indicate they had a resistance to a change in their motor plan. In general, the greater number of grasp switches that occurred for the neurotypical children versus those with ASD indicates greater flexibility of motor planning.

Current diagnostic criteria for ASD look at measures such as stereotyped behavior, communication, and social interaction. There is not an established method for evaluating deficits in motor planning. However, much of communication is nonverbal, and motor skills develop even earlier than verbal skills in children. Previous studies have found associations between early

oral and motor skills and speech fluency in children with ASD (Gernsbaher et al., 2008). Also, disturbances in motor planning for children with ASD could impact how a child plays, explores, and engages socially (Sacrey et al., 2015).

Individuals diagnosed with ASD have greater motor impairments than the general population. Current findings argue that motor planning deficits are a strong feature of ASD that could eventually be incorporated into diagnosis and treatment (Fournier et al., 2010). Of even greater impact is learning how motor planning might develop in sequence with other diagnosis criteria of ASD such as stereotyped behavior, verbal communication, and social interaction. Many clinicians are now proposing a multisystem approach to ASD intervention focusing on non-verbal and social communication (Larson et al., 2008). This project lays the foundation for further expanding knowledge of motor function in children with ASD across age groups and disability levels.

Reflective Writing

One of the main reasons I chose to complete my undergraduate education at Utah State University was the Undergraduate Research Fellows Program and the Honors Program. Throughout these programs, I started hands on research my first year of college. I started looking for research in the Biology and Chemistry departments reading different professors research interests. All of the research I came across sounded amazing; there were projects investigating different cell signaling pathways, watershed laboratories, and the role of metal ions in catalysts. But, I thrived with human interaction and wanted research where I would experience people instead of different types of bacteria. There was nothing I felt passionate about, until I came across Dr. Breanna Studenka's Sensory Motor Behavior lab. This was the research experience I was looking for and have continued there for six semesters. This is where I completed my honors thesis and various contracts.

In the Sensory Motor Behavior Lab, I have had the opportunity to work on many diverse projects. Under the direction of Dr. Breanna Studenka, we primarily study how people plan for and execute movement. I have had the opportunity to present about the influence of vision and additional feedback on timing tasks. And I also worked on a pilot project gathering information to develop a movement based exercise intervention for people with Parkinson's disease. However, where I have done the most presenting on and what my honors thesis came to be about was an experiment to study motor action planning in children with Autism Spectrum Disorder (ASD).

A year ago, Dr. Studenka created a rotation motor test to evaluate the rigidity of motor planning capabilities in children with ASD. A stick was placed in different orientations around a circle grid system containing 24 positions. The researcher would move the stick

counterclockwise or clockwise in these positions, reveal the position to the participant, and ask them to return it to the home position. I spent over forty hours watching the videos and measuring the position at which the child switched their thumb position in both the clockwise and counterclockwise direction. I had the opportunity to present how this experiment was performed and why it has clinical significance in diagnosing ASD at the USU Student Symposium and at the North American Society for the Psychology of Sport and Physical Activity (NASPSPA) June 2015 conference.

Originally because of these previous presentations and another experiment going on in the lab, my honors thesis wasn't going to be about the ASD project. My thesis was going to be conducting an experiment to investigate the results of our previous timing research. We designed an experiment where participants drew circles to get a baseline measurement and then practiced many trials of tapping. After participants had adequately practiced tapping, an event timing task, they drew circles again. The data collected was going to be analyzed to see if the practiced tapping made circle drawing, which is usually an emergent task, more event like. I had collected 30 subjects last semester and scored all the data.

However, my thesis changed when I received the invitation to speak at Ignite-USU about the previous ASD project. Because of the time commitment with Ignite and the work still needed for my prior thesis I knew I couldn't do both. I was being pulled in different directions by two different projects. During the month of February, I honestly didn't know if I was going to get a thesis done. However, with the help of Amber and Dr. Studenka a new thesis idea was proposed. Instead of doing two different projects, we decided to make my thesis about the ASD project because the manuscript still needed written and Ignite-USU would be my thesis defense. Within a matter of hours, my thesis had changed for the best. I quickly started focusing on my Ignite

presentation and reading literature for the ASD manuscript. As I did this, I realized how applicable the research was to me in a clinical setting and enjoyed the change of writing and reading instead of testing subjects.

My Ignite presentation became my thesis defense and was entitled "Simple Movements to Understand Autism Spectrum Disorder (ASD)." I spent over 15 hours with various members in the Office of Research and Graduate Studies to discuss my research and learn how to present it to a large audience. They helped me create graphics and videos to explain my task better. I learned vital skills in PowerPoint and presenting. I was also able to meet eight other graduate and undergraduate researchers who have become my friends. This was a great experience on learning how to work with other departments and how to avoid research jargon. I feel like after this opportunity, I can present this project to a large audience. Dr. Studenka was there to help me practice, send me articles about the task, and discuss the results of the project. I feel very lucky I was able to represent the lab, honors, and my college throughout Ignite. My Ignite presentation was also selected as a Sunrise Session talk, where I presented in Salt Lake.

Overall, the changes to my thesis offered a great way for me to present the SMB's research to a larger scale across USU and create a manuscript for a project that hopefully will be accepted for publication. It was a very rewarding experience, and here are my 3 tips for students completing their Honors Thesis:

1. Look around for a mentor and lab you are a good fit for. I spent almost an entire year meeting with professors, and I couldn't be happier I ended up with Dr. Studenka. She told me my research experience would be what I made it and gave me the independence and trust to work in the lab.

2. Try to learn about different projects going on in your lab and the other people involved. Although my thesis wasn't on the other timing projects in my lab, I learned testing procedures and computer programs that eventually helped me on my thesis. I also got to interact with other lab members I would eventually be scheduling with and around. I formed friendships with the members of my lab. We were able to support one another on projects and presentations.
3. Be flexible! If you would have told me the 30 hours I spent collecting data last fall wasn't going to be what my Honors Thesis was going to be on, I might have cried. Even though, I was stressed about switching my project it turned out for the best. As long as I had clear communication with the Honors Office and my advisor, things worked out for the final thesis.

In conclusion, through experiences in research, especially working on contracts and my thesis, I learned data analysis, how to run different equipment and computer programs, and knowledge in the field of motor learning. But, I came to realize again how much I loved interacting with people and presenting. After studies, I could explain what our study was aiming to accomplish and how it was relevant in their life, giving them a new sense of awareness of their actions. This is what makes research exciting to me, and it truly will be one of the greatest experiences I take away from college.

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Author Biography

Daisha Cummins will be graduating this spring with departmental honors dual majoring in Biology and Human Movement Science with minors in Chemistry and Public Health. Daisha has been privileged to be the recipient of the James Mohr College of Science Scholarship and the Honors Morse Family Scholarship. She is an Undergraduate Research Fellow and a Lilywhite Scholar. Throughout her time at Utah State, she has worked as a Teaching Assistant for Human Physiology and Advanced Human Physiology, a Resident Assistant and an Academic Mentor for Utah State Housing, and as an Undergraduate Researcher in the Sensory Motor Behavior Lab. She has had the opportunity to present research at UCUR, NCUR, NASPSPA, and Ignite-USU. She will continue her education this fall to become a physician at the University of Utah School of Medicine. Daisha is originally from Arco Idaho and enjoys spending time with her family, camping and boating, reading, and going to country concerts.