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Motor planning and End-state Comfort in Children with Autism Spectrum Disorders

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Abstract

Autism Spectrum Disorders are a cluster of disorders that effect communication, behavior and social ability. The Centers for Disease Control and Prevention (CDC) recently released that Autism affects 1 in 88 U.S. children (2012). The increasing prevalence of Autism has led to an increase in the body of research regarding Autism, however, there has not been extensive investigation into how movement and motor skills may play a role in this population. Those that have looked into movement and Autism have found that children with Autism Spectrum Disorders may show impairments in motor planning and coordination. This study investigates motor planning and ability in children with Autism Spectrum Disorders through a battery of fine and gross motor tasks, as well as postural components through alteration of sensory input, in order to determine if their ability to plan and complete motor tasks differs from their typically developing peers. The study includes children with a diagnosis of an Autism Spectrum Disorder, as well as typically developing children, between the ages of 5 and 13. The battery of tasks consisted of a dial-turning task, "Simon-Says" imitation task, drawing task, and beading task. Results show that children with Autism Spectrum Disorders show greater variability in hand selection during the dial turning task and a tendency to plan movements that are not in accordance with end state comfort. In addition, those withan Autism Spectrum Disorder displayed decreased ability to correctly imitate movements, had lower scores on both the drawing and sticker tasks, and took longer to bead the bracelet than their neurotypical peers.

Keywords: Motor control; Fine motor; Imitation; ASD

Introduction

Autism Spectrum Disorders are a group of developmental disorders, formally known as Pervasive Developmental Disorders. Autism Spectrum Disorders (ASDs) are diagnosed using the criteria in the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders (DSM) [1-3]. The DSM describes Autism Spectrum Disorders as a cluster of disorders characterized by impairments in social interaction and communication, with the presence of stereotyped interests or behaviors (Centers for Disease Control and Prevention, 2009). Though the current edition of the DSM, the DSM-IV-TR, includes repetitive movements, it makes no mention of impairments in motor skill or motor planning, though motor impairment has been noted in many children with Autism [4]. Differences in motor skills have been seen in handwriting reach-to-grasp movements and the use of visual and somatosensory systems [5-7].

A wide variety of impairments in motor skills have been found in children with Autism. Given the prevalence of motor impairment, it seems as though motor skills must play a larger role in Autism than currently accounted for in the DSM's diagnostic criteria [8]. The misunderstanding of the role of motor ability as it relates to Autism may be a component in the mis/over-diagnosis of Autism [9]. In order to better diagnose children, further research must be done in order to determine which motor impairments seem to be most correlated with Autism, as well as what seems to be causing the impairment. Hughes found that children with Autism showed significant impairment in the ability to complete goal-directed motor tasks, such as placing a rod in a base of a matching color. In completing this goal-directed task of placing the rod into a designated base, it was found that children on the Spectrum struggled to do so in a way that left them in a comfortable position following the movement (1996). This concept of planning movement in order to attain comfort at completion, though sacrificing initial comfort, is known as end-state comfort [10]. In studies of typically-developing children, end-state comfort seems to develop significantly between the ages of 3 and 7, with near-adult ability by age 10 (Thibaut & Toussaint, 2010) utilized a handle-turning task in which children with Developmental Coordination Disorder (and typically-developing children) were instructed to turn the handle located on a circular surface in order to face a stated image placed around the perimeter [2,11-17]. While no differences were found in the ability of children with DCD to comfortably plan movements to complete the task, the task had not been applied to any populations other that DCD and typical development. This study seeks to investigate the ability of children on the Autism Spectrum to complete a similar task of end-state comfort in order to obtain more information on motor skills and motor planning within this population, along with tasks such as an imitation task based on Simon Says, a drawing task, and a fine motor beading task.

Methods

This study consisted of 13 participants, ages 5-13 years (average age 8.8), of which the average age of typically developing children was 8.75 years (n=4, male=3, female=1) and the average age of children with an Autism Spectrum Diagnosis was 8.78 years (n=9, male=8, female=1) (Table 1). All children were recruited through letters to local therapeutic intervention centers and camps, as well as postings through University services such as E-Net and campus e-mails. Children in the experimental group required a diagnosis of an Autism Spectrum Disorder from a practitioner prior to the study.

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Participant	Age	Gender	Diagnosis
1	5	F	NT
2	9	M	NT
3	13	M	ASD
4	9	M	NT
5	5	M	ASD
6	8	M	ASD
7	11	F	ASD
8	6	M	ASD
9	10	M	ASD
10	12	M	NT
11	7	M	ASD
12	10	M	ASD
13	9	M	ASD

Table 1: Apparatus used for dial-turning task, consisting of base, blue and red-tipped dowel, and Velcro images.

Figure 1: Thera Putty with beads and chain used for beading task.

Table 1: Participant chart showing age, gender, and diagnoses as either Autism Spectrum Disorder (ASD) or Neurotypical (NT).

Dial turning task

This task consisted of a wooden circle, with Velcro placed around the perimeter at8 equidistant spots, similar to the numbers around the face of a clock (Figure 1). Children were able to choose 8 images, ranging from animals to sports balls and fruits, which were then attached to the wooden surface by Velcro. The center of the dial contained a dowel painted with a single red and a single blue tip. Children were instructed to grasp the painted dowel and turn it to point the designated tip to one of the images. Notes were taken as to which hand was used, whether it was turned clockwise or counterclockwise, and whether it was grasped with the thumb up or down. All of these factors help determine whether or not the grasp was comfortable, and therefore reflected end-state comfort. The order of the turns was chosen from a randomization table for each participant. A ratio of turns in accordance with end-state comfort and those that were uncomfortable was used to measure their mastery of this concept in motor planning.

Figure 1: Apparatus used for dial-turning task, consisting of base, blue and red-tipped dowel and Velcro images.

Imitation task

The imitation task consisted of a series of motor movements in order to test motor skill and proprioception. Items included touching their head, nose, knees, elbows, hopping, standing on one foot, galloping, and tossing a beanbag back and forth. Participants were given verbal and visual cues to indicate the action that was to then be imitated by the participant. Participants were given either "yes" or "no" scores reflecting whether or not they were able to complete the task, with additional notes taken for those who were unable to complete the task successfully.

Drawing and stickers

Participants were given a piece of paper and erasable colored pencils. First, they were asked to draw a picture of their family. No specific directions were given other than to draw a family, though drawing of other images was allowed when requested by participants. Second, they are asked to choose 5 stickers, which could be placed anywhere on the page. They were then instructed to connect the stickers with lines drawn with the colored pencils. Drawing was measured utilizing a variety of parameters to characterize fine motor skills and general planning skills. Parameters for the family portrait included clarity of image, scaling of individuals, color choice, neatness, and complexity for the drawing task, in addition to how realistic the image was and whether or not they drew a family. The sticker task was scored on the arrangement of stickers, whether or not they made a picture utilizing the stickers, and the straightness of the lines. For both tasks, scores were calculated based on scores within a scale of 1-10 or the corresponding points associated with yes/ no questions, where "yes" scores provided 1 point and "no" scores provided 0 points. Each image was independently scored by 2 researchers, with the average score used for analysis; there were no large discrepancies.

Beading

Participants had the choice of creating either a necklace or bracelet utilizing 5 beads from the set. The beads were then hidden in soft (low) strength Thera Putty (Figure 2). After explaining what the putty was

Figure 2: Scores for the turning task testing end-state comfort indicate that neurotypical children show a greater number of comfortable turns.

and where the beads went, the participants were instructed to remove the beads one at a time. The removal of the beads was timed using a stopwatch. After all the beads were removed and deposited in the empty container, the time was stopped and recorded. The stopwatch was then restarted as the participant began stringing the beads onto the chain. Time was the main measure used to determine ability in finding and stringing the beads, with notes taken as to how they completed the task and if/ where they experienced difficulty.

Figure 2: Thera Putty with beads and chain used for beading task.

Therapy cushion

Participants were provided with the option to utilize the therapy cushion during parts of the dial turning, drawing, and beading tasks. Use of the therapy cushion was noted during tasks, as well as any noticeable differences observed while using the cushion.

Results

Dial turning task

There was a significant difference in end-state comfort ability between groups. It was found that individuals with an Autism Spectrum Disorder had a higher frequency of uncomfortable end-state positions in relation to comfortable end-state positions, in comparison to the neurotypical group ($F_{(13,1)}$=5.47, p<.05, Figure 3). Ability on the turning task was also positively correlated with the time taken to find and remove the beads from the Thera Putty (r=0.573, p<0.05).

Figure 3: Scores for the turning task testing end-state comfort indicate that neurotypical children show a greater number of comfortable turns ($F_{(13,1)}$=5.47, p<0.05).

Imitation task

Two of the nine participants with Autism (22%) had at least one error on the imitation task, however, there was 0% error in the neurotypical group. Due to the low sample size, no statistical differences were found. Performance on the imitation task was negatively correlated with time taken to find beads in the Thera Putty (r=-0.566, p<0.05), indicating that those who were better able to imitate movements could also find and remove beads faster.

Drawing and stickers

Ability on the drawing task was correlated with age(r=0.498, p<.05), as we would expect, given the gradual increase in drawing ability throughout childhood. Scores on the sticker task were also correlated with age (r=.0.547, p<.05).While participants were asked to draw a family portrait, 5 of the 13 participants did not draw a family. These individuals all had an ASD and hide a wide range of ability ranging from large scribbled circles on the page to very detailed images of zoo animals.

These two tasks, drawing and stickers, were also positively correlated with each other (r=0.764, p<0.01); the mean score for neurotypical individuals was 5 points higher than the mean ASD score on the drawing task, and 2 points higher for the neurotypical group than the ASD group on the sticker task (Figure 4). Figure 4: Both NT and ASD groups fall below maximal values for both drawing and sticker tasks. However, the NT group does outperform the ASD group on both tasks.

Beading

Time taken to bead was negatively correlated with performance on the sticker task (r=-.666, p<0.05, Figure 5). This relationship between beading and the sticker task is reflective of their shared need for spatial planning ability and fine motor skills in order to complete the task.

Figure 5: Differences are seen between ASD and NT groups on average times to find beads and bead bracelets.

Therapy cushion use

The therapeutic seat cushion was offered to every child while they completed the turning, drawing, sticker, or beading tasks. All but a few of the children made use of the cushion and one child asked to use his

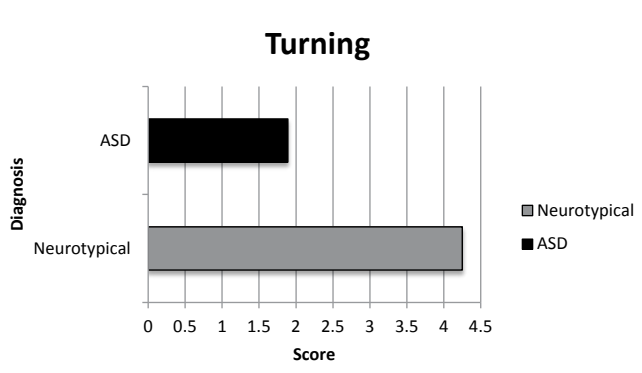

Figure 3: Both NT and ASD groups fall below maximal values for both drawing and sticker tasks.

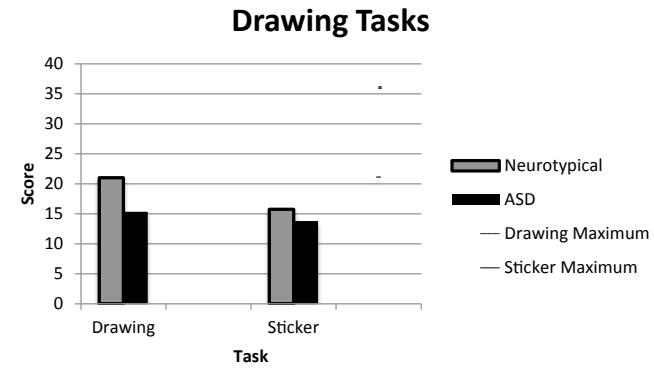

Figure 4: Both NT and ASD groups fall below maximal values for both drawing and sticker tasks.

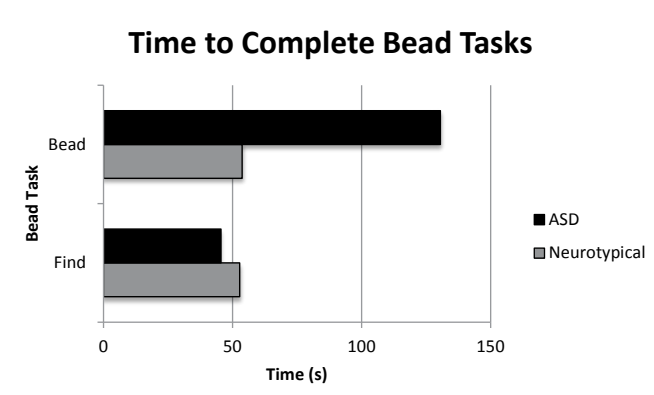

Figure 5: Differences are seen between ASD and NT groups on average times to find beads and bead bracelets.

own that he had with him, as it was his favorite. Parents observed some differences in fidgeting and stimulating movements while their child was seated on the cushion in comparison to their behavior without the cushion. No significant differences were able to be recorded and analyzed.

Discussion

Noticeable differences were observed between the ASD group and the neurotypical group. Differences between groups in end-state comfort turning, imitation, drawing, and beading tasks indicate motor impairment in individuals with ASD. Turning task scores indicated that neurotypical individuals showed a more positive ratio of comfortable to uncomfortable turns, indicating greater understanding and execution of end-state comfort. This understanding of end-state comfort is essential in planning movements to end in the least awkward way possible. As end-state comfort is expected to develop significantly between the ages of 3 and 7, with close to full ability at age 10, we would expect both groups to perform fairly well, as the mean age for both groups, 8.75 years (NT) and 8.78 years (ASD), is above this range for development, close to the age for adult-like ability (Thibaut and Toussaint, 2010). The positive correlation between the turning task and the ability of individuals to find beads in the Thera Putty, indicates that there may be general impairments in planning and organization of movement, as both of these tasks rely heavily on motor planning and lower scores were observed in the ASD group for both tasks. Individuals on the Autism Spectrum had a greater frequency of error on the imitation task than their NT peers, indicating some participants had difficulty in motor planning or gross motor ability. Differences in ability to imitate instructors or peers and successfully complete gross motor movements could lead to the "clumsiness" previously noted. However, the negative correlation found between the imitation task and the time taken to find beads indicates that the problem does not seem to be one of speed or muscle force, as individuals would have likely struggled on both tasks had this been the case [4]. Rather, it appears that the difficulty experienced by a handful of the children in the Autism group on the imitation task must be is related to motor planning. The positive correlation found between stickers and drawing is reflective of the fine motor and motor planning similarities between these two tasks. The neurotypical development group received higher scores on tests, indicating greater fine motor and motor planning ability than that of the individuals in the ASD group. These results are not surprising, as past studies, such as the one conducted by, have previously shown that children with ASDs display greater difficulty in fine motor tasks such as handwriting [5]. Fine motor ability is essential for elementary-aged children, as kids must have adequately developed fine motor skills in order to learn handwriting and perform tasks in school. The differences found between the Autism and neurotypical groups, indicate that the groups do not have equal fine motor or motor planning ability. While fine motor skills have been previously identified as an area of weakness in children with Autism Spectrum Disorders, the discovery of motor planning differences is new to the field. While there seem to be appreciable differences, these differences are not reflected in the diagnostic criteria. Exclusion of motor ability from the diagnostic criteria could be leading to incorrect diagnoses for many children. Correct diagnosis is crucial, especially during childhood, when children are rapidly developing. Without a proper diagnosis that is fully representative of the presenting symptoms, families, practitioners, and teachers are at a loss for deciding what is necessary in order to best aid the child. Inclusion of motor ability in the DSM to reflect the differences observed, could result in better diagnosis and treatment for children on the Autism Spectrum. Further research is needed in the area of motor planning, as well as general motor ability, in children with Autism in order to then establishes reflective criteria that will best serve this population in attaining the resources needed in order to attain the best possible developmental outcomes.

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