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Motor Kinematic Differences in Children with ASD: Ecological Gameplay with a Sensorised Toy

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Background

Evidence suggests gross motor differences are present in children with Autism Spectrum Disorder (ASD) from birth. Trevarthen and Delafield-Butt (2013) proposed that one of the early markers of ASD are abnormalities in the development of intentional movements, which are present before the manifestations of symptoms typically associated with autism, like deficiencies in social interaction and communication. A growing body of literature demonstrates kinematic and action patterns differences in children and adults with ASD. However, these experiments typically require expensive laboratory-based optical motion tracking systems. Here, we developed bespoke, sensorised wooden cubes for motor assessment of children's play and report on the kinematic and action pattern differences of the children with autism compared to children developing typically.

Objectives

A description of ASD-specific action patterns and kinematics using sensorised toys.

Methods

Participants. Children 3 to 5 years diagnosed with ASD (n = 15) recruited from the Scottish Centre for Autism, Glasgow, UK. Children 3 to 5 years old developing typically recruited from nurseries in Glasgow, UK. Adults 20 to 25 years old without ASD recruited from Glasgow, UK. The study was approved by the University of Strathclyde Ethics Committee and consent obtained from the parents of children or the adults. In the case of the children with ASD, pre-screening with Vineland-II, AQ-Child and Leiter-R Brief IQ was performed.

Procedure. The children were seated at a table and instructed to play two simple games that involved moving the cube from one position to another: a Serially Organized Action (SOA) game and a Single Repetitive Action (SRA) game. The first required complex motor sequencing and engagement with the

experimenter, while the second consisted of a simple repetitive movement. Each game produced a single measured movement to a goal with 25 iterations or repetitions to yield 50 movements in total. An electronic board inside the cubes was equipped with tri-axial magnetometer, gyroscope and accelerometer wirelessly transferred the cube's motion data to a laptop. The signal (raw motion data) was extracted through a Matlab-based platform and analysed.

Data Analysis. Kinematic features of movement duration; maximum value of acceleration, velocity, and jerk during each movement; time to maximum value; % duration to maximum value; and the acceleration, velocity, and jerk action patterns profiles were calculated.

Results

The jerk profile of children with ASD was significantly different, showing increased maximum jerk, reduced time to maximum value and & duration to maximum value, and lower variability than typically developing children. Further, movement duration was shorter compared to age-matched typically developing children, and maximum velocity was significantly higher in children with ASD compared to children developing typically.

Conclusion

The increased jerk values and onset times in the ASD group are a particularly interesting finding that support new data appearing by other groups. It appeared, especially in the SRA game, that when moving the cube from one position to the next, the children with autism impacted on the surface of the table with greater velocity and typically included the resulting force immediately into to the next movement, giving it a greater jerk value in a shorter span of time that typically children. Typically developing children, on the other hand, paused for a moment (>100 ms) before commencing the next movement.

Further, children with autism did not enjoy the SRA game, but they did enjoy the simpler, more repetitive SOA one. The repetitive simplicity of the SOA game and its resulting jerk profile appears to report on a particular behavioural motor feature distinct to ASD, namely stopping an action and starting a new one, while also describing an underlying motor difference that may contribute to it.