How one moves speaks loudly - investigating motor function in children with Autism Spectrum Disorders

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Background

- Motor deficits are prevalent in Autism Spectrum Disorders (ASD). Nearly 90% of syndromes have significant motor impairment. *(Geschwind DH., 2009)*

- A wide range of motor delays and deficits has been reported in ASD, although only repetitive behaviors are included in the diagnostic criteria.

- Given their prevalence, a key question is whether motor impairments should be considered a core deficit of ASD.
Background

1) Motor signs are highly quantifiable and can be objectively measured.

2) Motor deficits and delays may shed a light on clinical phenotypes within the heterogeneous spectrum.

3) Recognition of motor anomalies may guide the definition of underlying aberrant neural circuits leading to ASD.

4) Motor function is critical for broader aspects of development, including language, social interaction and learning, and therefore an early identification of motor abnormalities may facilitate interventions that could improve functional and behavioral outcomes.

5) By investigating the timing of motor impairments and their specificity to ASD, we may identify motor markers that facilitate earlier diagnosis of ASD.
Objective 1

- Acquire knowledge of current evidence related to gross and fine motor control impairments, postural control and praxis impairments in children and adults with ASD.
Gross motor impairments in ASD

- Gross motor delays in supine, prone, and sitting skills.
- Delayed onset of walking
- Gait abnormalities have been extensively reported in children with ASD, including toe walking, ataxia, variable stride length and duration, reduced plantar flexion and increased dorsiflexion.
- Poor upper limb and lower limb coordination including bilateral coordination and visuomotor coordination.

(Weber D., 1978; Vilensky JA 1981; Rinehart NJ, 2006; Calhoun M 2010;
Fine motor impairments in ASD

- Reaching and grasping are delayed in infants at risk for ASD, and fine motor delays persist in the second and third years of life.
- Poor fine motor coordination such as in performance of manual dexterity tasks (Purdue Pegboard Test) are present in school-aged children and adults with ASD.
Postural control impairments in ASD

- Fournier et al. 2010, meta-analysis of 41 studies found significantly more motor incoordination, postural abnormalities in the head and trunk, and postural instability in the ASD group compared to controls, regardless of diagnostic category (ASD, autism, Asperger’s).
- Delays in postural control are evident in postures such as rolling, sitting and standing.
- Feedback and feedforward control of posture are affected in children and adults with ASD, deficient postural control persists in adults.

M. Calhoun et al., (2011)
Praxis impairments in ASD

- Imitation impairments are present during postural, gestural, and oral imitation.

- Performance of complex movement sequences is poor during imitation, on verbal command, and during tool use, suggesting generalized dyspraxia not specific to imitation. (Dziuk MA, 2007; Mostofsky SH, 2006)
Objective 2

Discuss the theoretical framework proposing that motor delays contribute to social impairments and if identified on a timely fashion may serve as a behavioral motor marker for earlier diagnosis in infants and children with ASD.
Motor – social links in ASD

- To fully engage in social interaction, a child requires a full repertoire of movement behaviors for use in communication and for understanding the communicative nature of others’ movements.

- Emerging empirical support for motor –social communication impairments linkage:
  - Motor delays at 18 months of age are highly predictive of ASDs at 3 years of age in toddlers at risk for ASDs. (Brian J, Autism 2008)
  - Better motor performance in 2-year old children newly diagnosed with ASDs significantly correlates with better future outcomes at 4 years of age. (Sutera S, J Autism Dev Disord, 2007)
Motor – social links in ASD

The ecological dynamic system theory emphasizes the multifactor, cyclical nature of development of perception-action-cognition and the critical role of daily exploratory interactions of a child with his/hers world.

- Poor coordination
- Slowed movement
- Motor clumsiness
- Missed opportunities for play
- Reduced engagement with peers
- Limits initiation and maintenance of friendship
- Delayed social skills
- Long term social impairments
- Difficulties of developing social and peer relationships
- Emotional and behavioral problems
Motor development in relationship to ASD diagnosis & treatment

- Motor development
- Language development

Current “early” diagnosis
Novel approaches

Evaluate motor function and provide therapeutic intervention for children with ASD using novel technologies such as virtual reality and robots that **engage children in interactive gaming scenarios.**
Objective 3

- Understand the potential of two technological tools, the virtual reality and child-robot interactions, currently employed in research projects for early diagnosis and treatment of motor impairments present in children with ASD.
Virtual environments at UNTHSC

- Assessment of sensory-motor and postural control with a unique tool, the V-Gait Computer Assisted Rehabilitation Environment Network (CAREN) system.
- Allows children to play while kinematic and balance data are collected.
Children sit/stand on force plate and shoot virtual ducks.

Development of skills such as accuracy of pointing, reaction time are recorded by the motion analysis and force plate data inform about balance control.
Magician’s apprentice

Children stand/walk through a virtual library, need to perform arm movements to interact with animated objects.
Characteristics of skills such as balance while standing, walking pattern, reaching kinematics for upper arm movements are recorded by the system.
Center of pressure data in standing

Shoulder width apart

Feet side by side
Human-Robot Interaction for ASD

- Children with ASD have difficulty imitating movements and that impacts their ability to play, learn, and interact socially.
- Zeno is a child-size humanoid robot by Hanson Robokind

The robot interacts with children in three modes:
- Interactive mode – responds to user actions
- Teaching mode – the robot leads the child to perform exercises
- Reward mode – the robot rewards appropriate action for the child
ZENO and Children with ASD

• Zeno is interactive, non-threatening for the children with ASD
• Simple interaction behaviors such as: look/follow me, imitate my facial gestures and head-eye motion, hand extension and grasping, hand waving, show emotions
Human-Robot Interaction for ASD

- Implementation status:
  - Interactive mode: Head/eye coordination for tracking user, arm gestures – UTA
  - Teaching mode: Hand gestures (tummy rub, hand wave) – UTA/UNTHSC
  - Reward mode: Voice conversations and encouragement - ATC / Hanson Robokind
Robot Modes of Operation

**Teaching/Reward mode: Motion & Speech**
- Plays a specific combination of body movement, facial expressions and speech for controlled sessions

**Interactive mode via Kinect:**
- Can generate a more human-like motion during iTherapy
- Can generate any desired motion, with a joint velocity generated by the human motion as long as it does not exceed the servo’s velocity constraints
- Smooth motion that resembles human-like movement with a 0.235 second robot response time
Zeno human-like movements to be imitated

- Hello/ Goodbye - Waving with Left/ Right arm
- Good Job - “Fist to Fist” with Left/ Right arm
Interactive Mode: Hand-wave Trajectory

Angles Sent to Servos $a$, $b$, $g$ and $t$ vs. Actual Position of Servos SID4-SID1
Conclusions

1. There is growing evidence of a diverse set of gross motor, fine motor, postural control and imitation impairments present in children and adults with ASD.


3. Increased interactivity via virtual reality technology and interaction with human-like robots may better motivate children to engage in motor activities leading to improvements not only in motor function, but also in social behaviors.
Links to audiovisual material

- Video that describes the research project.
  UNT Health Science And UT Arlington Studying Autism Movement | Watch the video - Yahoo! News

Link to the Star telegram article July 2012
Photos and video attached to the star telegram article are also available on the same page.
  DFW researchers use 'toy' robot to gain insight into autistic children | Health | Dallas-Fort...
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