Motor Differences Identify Children with Autism Engaged in iPad Gameplay

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Abstract

Autism is a developmental disorder evident from infancy. Yet, its clinical identification is often not possible until after the third year of life. New evidence indicates disruption to motor timing and integration may underpin the disorder, providing a potential new marker for its early identification. We employed smart tablet computers with touch-sensitive screens and embedded inertial movement sensors to record the movement kinematics and gesture forces made by 37 children 3-6 years old with autism and 45 age- and gender-matched children developing typically. Machine learning analysis of the children’s motor patterns identified autism with 93% accuracy. Analysis revealed these patterns consisted of greater forces at contact and with a different distribution of forces within a gesture, and gesture kinematics were faster and larger, with more distal use of space. These data support the notion disruption to movement is a core feature of autism and demonstrate autism can be assessed by smart device gameplay.

Method

Participants. ASD Group: 37 children 3-6 years old clinically diagnosed with Childhood Autism (ICD-10 2010), 12 female. TD Group: 45 children age- and gender-matched with no concern for developmental pathology. Inclusion criteria normal or corrected-to-normal vision, no other sensory or motor deficits.

Serious Games. Two games (www.duckiedeck.com) running on iPad mini tablets (Apple Inc.) set within a bespoke app to organise the display of the games sequentially for a 2 minute training phase followed by a single 5 minute test phase. The app included code for collecting inertial sensor and touch screen data.

Results

Machine Learning Identification of Autism

Three machine learning algorithms differentiated individuals within the autism group from the control group with accuracy up to 93% (Table 1). Data from Creativity produced greater predictive accuracy. The most effective algorithm was the Regularized Greedy Forest with age and gender data excluded (RGF2; Figure 3, Table 2).

Motor Kinematic Differences

Ten features with the greatest Kolmogorov-Smirnov (KS) distance give an approximation of those most significant to the machine-learning differentiation (Figure 4).

Inertial data are the predominant identifiers (19/10 in Sharing; 4/10 in Creativity) indicate impact and gesture forces are different in ASD. Screen data indicate gesture kinematics significantly differ.


Conclusion.

- Children with autism can be identified by iPad gameplay.
- Identification based on simple computations of an autism-specific motor signature.
- Gesture force patterns appear significant contributors.
- Motor differences appear to be a core component of autism.
- Machine learning identification of autism by motor analysis of serious tablet gameplay provides a promising new bio-behavioural marker for early detection.

Future Work. (1) To replicate these findings. (2) To commercialise this assessment for clinical, educational, and parent use (playcareapp.com).

Table 1. Area Under Curve mean (and SD) obtained from three machine learning algorithms.

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Sharing Force</th>
<th>Sharing Force (SD)</th>
<th>Creativity Force</th>
<th>Creativity Force (SD)</th>
<th>Tracking Force</th>
<th>Tracking Force (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RGF1</td>
<td>0.824</td>
<td>0.088</td>
<td>0.835</td>
<td>0.092</td>
<td>0.958</td>
<td>0.070</td>
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<td>RGF2</td>
<td>0.867</td>
<td>0.079</td>
<td>0.878</td>
<td>0.081</td>
<td>0.960</td>
<td>0.072</td>
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<td>RGF3</td>
<td>0.853</td>
<td>0.081</td>
<td>0.864</td>
<td>0.083</td>
<td>0.961</td>
<td>0.071</td>
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</tbody>
</table>

Table 2. Sensitivity and specificity of RGF2 with thresholds selected at 0.50 and 0.55.

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Sensitivity</th>
<th>Specificity</th>
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</thead>
<tbody>
<tr>
<td>Sharing Force</td>
<td>0.82</td>
<td>0.85</td>
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<tr>
<td>Sharing Force (SD)</td>
<td>0.08</td>
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<tr>
<td>Creativity Force</td>
<td>0.83</td>
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<tr>
<td>Creativity Force (SD)</td>
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<tr>
<td>Tracking Force</td>
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<td>0.97</td>
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<tr>
<td>Tracking Force (SD)</td>
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<td>0.05</td>
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References