Harnessing the motor system for improved cognition

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Brain and behavior develop together with experience as a powerful teacher.
We are interested in learning how eye and body movements come together to produce learning opportunities in the world, or not, as the case may be for some children.
The Voluntary Saccades Circuit

Frontal eye field

Caudate nucleus

Substantia nigra

Vertical gaze center

Posterior parietal cortex

Superior colliculus

Paramedian pontine reticular formation
Attention
In the lab, we employ some useful (but rather dull) tasks to assess attention and gaze control

- Attention Network Task
- Basic saccade task (with gap and overlap variants)
- Posner-style cuing paradigm (with a discrimination) to assess attention orienting
Attention Network Task

Cue Conditions
- No Cue
- Alerting Cue
- Spatial Cue

Target Conditions
- Congruent
- Incongruent

Fixation
- 400-1600ms
- 100 ms
- RT or 1700
- 3000 - RT

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Example of a “better” ANT task
Attention Orienting Task (E-task)
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**Inaccurate saccades**

(Miller, et al. 2014)

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**Slow Attention Orienting**

**Attention Network Test**

(Keehne, et al. 2010)

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**Slow Attention Orienting**

**E-Task (slow and fast ISI)**

(Townsend, et al. 1999)
Saccade control is atypical in ASD....

**Saccades to Target**

**Latency**

**Saccade Accuracy**

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*Miller, Chukoskie, Zinni, Townsend and Trauner, 2014*
....and may share underlying mechanism with irregularity in finger tapping

Miller, Chukoskie, Zinni, Townsend and Trauner, 2014
How to remediate attention orienting?
Intervention Computer
<table>
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<th>Participant</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6*</th>
<th>7*</th>
<th>8</th>
<th>Mean (SD)</th>
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<td>M</td>
<td>F</td>
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<td>8</td>
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<td>2</td>
<td>1</td>
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<td>6</td>
<td>4</td>
<td>3.0 (2)</td>
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</tbody>
</table>

**Table 1.** Notes: * Participant 6 withdrew from the study after 3 weeks. Participant 7 withdrew after 1 week. Participant 5 has a clinical diagnosis of ASD; an SCQ score of 24 (ASD cutoff 15).
Spatial Attention and Speed of Orienting

Duration of Fixation

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Is there any transfer to more “real world” tasks?
Visuomotor Integration
Driving simulator as mid-level outcome measure
But what about *realistic* social interactions?
Social gaze as a high-level outcome measure
However, as you know, it isn’t just eye movements that develop atypically. We used a standardized motor battery (Florida Apraxia) to characterize.
Initial "Alien" Position - Will stay or travel to adjacent walls

Possible Endpoint

Straight Trials

Left Turn Trials

Possible Endpoint

Right Turn Trials

Possible Endpoint

Possible Paths of Movement

Initial Position

Alien movement cued when participant reaches center of room
Time needed to change direction

![Graph showing time needed to change direction for left and right turns in CTL and ASD groups. The graph indicates statistically significant differences with p < 0.01 and p < 0.05.]
What good balance looks like
What poor balance looks like
The diagram shows the relationship between age and average path length for individuals with TD (blue circles) and ASD (red circles). The x-axis represents age, ranging from 0 to 80 years, and the y-axis represents the average path length, ranging from 0 to 120 units. The data points indicate a scatter of values with no clear trend or pattern between age and average path length for both groups.
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Cognitive benefits of gross motor interventions?

- Currently, not much being done with special populations, but…
- FITKids intervention from Charles Hillman and colleagues shows expected fitness and metabolic benefits, as well as cognitive.
- We are creating balanced-based interventions for children with special needs
Many Thanks!!

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