Egocentric Vision: Potential Applications for Very Early Intervention in Autism

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Overview

- Joint engagement and development
- ASD and joint engagement
- Parent-mediated intervention for ASD
  - Joint engagement as a primary target
- Dyadic head mounted eye tracking as a tool
- Future directions
Joint Engagement is Critical for Development

Brain development
Communication development
Play development
Joint Engagement is Critical for Development

Levels of Joint Engagement (Adamson et al. 2004)
Can move through multiple engagement states during interaction
Joint Engagement is Critical for Development

Adamson et al., 2010
Bottema-Beutel et al., 2014

\[\text{In ASD} \quad \text{Predictive of language development}\]

Levels of Joint Engagement (Adamson et al. 2004)
Can move through multiple engagement states during interaction
Autism Spectrum Disorder: Trajectory Towards ASD

Ozonoff et al., JAACAP, 2014
Autism Spectrum Disorder: Early Diagnostic Stability

### Table 1
Previously published stability studies of children diagnosed with autism spectrum disorder (ASD) before age 3

<table>
<thead>
<tr>
<th></th>
<th>ASD n</th>
<th>Not ASD n</th>
<th>Time 1 age</th>
<th>Time 2 age</th>
<th>True positives</th>
<th>False positives</th>
<th>False negatives</th>
<th>True negatives</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>Positive predictive value (Stability) (%)</th>
<th>Negative predictive value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All ASD, no non-spectrum</td>
<td>Stone 1999</td>
<td>37</td>
<td>0</td>
<td>31 m</td>
<td>43 m</td>
<td>31</td>
<td>6</td>
<td>84</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Takeda 2005</td>
<td>57</td>
<td>0</td>
<td>31 m</td>
<td>67 m</td>
<td>57</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Turner 2007</td>
<td>48</td>
<td>0</td>
<td>2 y</td>
<td>4 y</td>
<td>30</td>
<td>18</td>
<td>63</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Paul 2008</td>
<td>37</td>
<td>0</td>
<td>22 m</td>
<td>37 m</td>
<td>37</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Itzchak 2009</td>
<td>68</td>
<td>0</td>
<td>25 m</td>
<td>37 m</td>
<td>66</td>
<td>2</td>
<td>100</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Both ASD &amp; non-spectrum – clinically ascertained</td>
<td>Eaves 2004</td>
<td>43</td>
<td>6</td>
<td>33 m</td>
<td>57 m</td>
<td>40</td>
<td>3</td>
<td>0</td>
<td>6</td>
<td>100</td>
<td>67</td>
<td>93</td>
</tr>
<tr>
<td></td>
<td>Lord 2006</td>
<td>130</td>
<td>42</td>
<td>14-25 m</td>
<td>16-30 m</td>
<td>124</td>
<td>6</td>
<td>11</td>
<td>3</td>
<td>96</td>
<td>84</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td>Chawarska 2007</td>
<td>73</td>
<td>17</td>
<td>16-30 m</td>
<td>27 m</td>
<td>60</td>
<td>13</td>
<td>0</td>
<td>17</td>
<td>100</td>
<td>57</td>
<td>82</td>
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<tr>
<td></td>
<td>Suttera 2007</td>
<td>73</td>
<td>17</td>
<td>16-30 m</td>
<td>27 m</td>
<td>60</td>
<td>13</td>
<td>0</td>
<td>17</td>
<td>100</td>
<td>57</td>
<td>82</td>
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<tr>
<td></td>
<td>Kleinman 2008</td>
<td>61</td>
<td>16</td>
<td>27 m</td>
<td>53 m</td>
<td>46</td>
<td>15</td>
<td>0</td>
<td>16</td>
<td>100</td>
<td>52</td>
<td>75</td>
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<tr>
<td></td>
<td>Chawarska 2009</td>
<td>61</td>
<td>16</td>
<td>27 m</td>
<td>53 m</td>
<td>46</td>
<td>15</td>
<td>0</td>
<td>16</td>
<td>100</td>
<td>52</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>Worley 2011</td>
<td>53</td>
<td>61</td>
<td>23 m</td>
<td>31 m</td>
<td>38</td>
<td>15</td>
<td>12</td>
<td>49</td>
<td>76</td>
<td>77</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>Corsello 2013</td>
<td>26</td>
<td>6</td>
<td>30 m</td>
<td>3-8 y</td>
<td>20</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>91</td>
<td>44</td>
<td>80</td>
</tr>
<tr>
<td>Both ASD &amp; non-spectrum – community ascertained</td>
<td>Cox 1999</td>
<td>12</td>
<td>38</td>
<td>20 m</td>
<td>42 m</td>
<td>12</td>
<td>0</td>
<td>9</td>
<td>29</td>
<td>57</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Ventola 2007</td>
<td>46</td>
<td>17</td>
<td>27 m</td>
<td>45 m</td>
<td>46</td>
<td>7</td>
<td>2</td>
<td>76</td>
<td>96</td>
<td>92</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td>van Daalen 2009</td>
<td>53</td>
<td>78</td>
<td>26 m</td>
<td>45 m</td>
<td>46</td>
<td>7</td>
<td>2</td>
<td>76</td>
<td>96</td>
<td>92</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td>Guthrie 2013</td>
<td>56</td>
<td>26</td>
<td>19 m</td>
<td>37 m</td>
<td>56</td>
<td>3</td>
<td>2</td>
<td>23</td>
<td>95</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Note: m, months; y, years; -, age not reported; TN, true negatives; TP, true positives; FN, false negatives; FP, false positives. Sensitivity = TP/(TP + FN); Specificity = TN/(TN + FP); Positive predictive value = TP/(TP + FP); Negative predictive value = TN/(TN + FN).

### Table 4
Patterns of Clinical Best Estimate outcome classifications across visits

<table>
<thead>
<tr>
<th>Clinical Best Estimate Outcome</th>
<th>Total (n = 418)</th>
<th>ASD at 36 months (n = 110)</th>
<th>Not ASD at 36 months (n = 308)</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 months</td>
<td>ASD A A A</td>
<td>38</td>
<td>35%</td>
<td>–</td>
</tr>
<tr>
<td>24 months</td>
<td>ASD A A N</td>
<td>2</td>
<td>–</td>
<td>0.7%</td>
</tr>
<tr>
<td>36 months</td>
<td>Not ASD N N A</td>
<td>1</td>
<td>–</td>
<td>0.3%</td>
</tr>
<tr>
<td></td>
<td>Not ASD N N A</td>
<td>12</td>
<td>–</td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td>Not ASD N A A</td>
<td>3</td>
<td>–</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>Not ASD N A A</td>
<td>27</td>
<td>25%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Not ASD N A A</td>
<td>42</td>
<td>38%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Not ASD N A N</td>
<td>293</td>
<td>–</td>
<td>95%</td>
</tr>
</tbody>
</table>

ASD, autism spectrum disorder; A, ASD; N, Not ASD.
Therapeutic Ports of Entry

Stern, 1995
Therapeutic Ports of Entry

Parent responsiveness
Use of behavioral skills

Joint engagement
Child initiated JE

Shire, Gulsrud, & Kasari, 2016
ASD Intervention: Common Principles

Original Paper

Naturalistic Developmental Behavioral Interventions: Empirically Validated Treatments for Autism Spectrum Disorder

Laura Schreibman · Geraldine Dawson · Aubyn C. Stahmer · Rebecca Landa · Sally J. Rogers · Gail G. McGee · Connie Kasari · Brooke Ingersoll · Ann P. Kaiser · Yvonne Bruinsma · Erin McNerney · Amy Wetherby · Alycia Halladay

Koegel Autism: Pivotal Response Treatment (PRT)® Training and Services

Early Social Interaction Project

ESDM

IMPACT

JA
Joint Attention

SP
Symbolic Play

E
Engagement

R
Regulation
NDBI: Core Components

- Focus on socio-communicative learning via interactions with others
  - Joint engagement
- Learning is enhanced when embedded in activities that contain emotionally meaningful social interactions
  - Transforming common daily activities into motivating ‘play’ routines
- Begin as very simple action sequences
  - As duration and quality of interaction increases ‘teachable moments’ are identified and used to expand child’s skills using well validated behavioral techniques
    - Joint attention, imitation, language

Schreibman et al., JADD, 2015
Initial Evaluation

Week 1: L.O.V.E. I.T.

Week 2: Attentional Spotlight

Week 3: Sharing the Play

Week 4: Play as Learning/ABCs

Weeks 5 & 6: First Steps to First Words

Weeks 7, 8, 9, & 10: Parent Guided

Week 11 & 12: G.E.T. I.T. Booster Sessions

Post Evaluation/Next Steps
Session Outline

Check-in 10 minutes
Observation 10 minutes
Intro/Demo 10 minutes
Parent-Coach 20 minutes
Reflect/Problem Solve/Homework 10 minutes

Check-in 10 minutes
Direct Demo 40 minutes
Reflect/Problem Solve/Homework 10 minutes
NDBI: Increasing Join Engagement

Object engaged

Coordinated Joint
Facilitating Joint Engagement: A Therapeutic Port of Entry for ASD

Infants who are able to incorporate a partner into their play experience are effectively engaging in rudimentary social exchanges through objects. By increasing the amount of time an infant with ASD spends in joint engagement with others, we create increased access to play situations where social communication is relevant and opportunities for facilitating development and learning can be capitalized upon.

However, the mechanisms of change underlying the positive effects of NDBI remain largely unknown.
Dyadic Head-Mounted Eye Tracking: Tracking Visual Engagement and Play

Yu & Smith, PLoS ONE, 2013
Dyadic Head-Mounted Eye Tracking: Tracking Visual Engagement and Play

<table>
<thead>
<tr>
<th></th>
<th>synchronized attention</th>
<th>sustained coordinated attention</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Proportion (% of time)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>42.56 (11.35)</td>
<td>51.35 (5.41)</td>
</tr>
<tr>
<td>mutual gaze</td>
<td>9.76 (5.85)</td>
<td>9.45 (3.23)</td>
</tr>
<tr>
<td>Object</td>
<td>32.80 (7.63)</td>
<td>41.55 (6.46)</td>
</tr>
<tr>
<td><strong>Frequency (rate/min)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>22.58 (5.06)</td>
<td>9.29 (1.63)</td>
</tr>
<tr>
<td>mutual gaze</td>
<td>4.85 (2.37)</td>
<td>2.24 (1.38)</td>
</tr>
<tr>
<td>object</td>
<td>17.73 (4.19)</td>
<td>7.05 (1.63)</td>
</tr>
<tr>
<td><strong>mean duration (in second)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>0.85 (0.30)</td>
<td>2.45 (0.95)</td>
</tr>
<tr>
<td>mutual gaze</td>
<td>0.86 (0.28)</td>
<td>1.85 (0.41)</td>
</tr>
<tr>
<td>object</td>
<td>0.82 (0.31)</td>
<td>2.53 (1.02)</td>
</tr>
</tbody>
</table>
Dyadic Head-Mounted Eye Tracking: Tracking Visual Engagement and Play

(a) child-led JA pathways

(b) parent-led JA pathways

pathway (a)  child  child  child
pathway (b)  no one  child  child
pathway (c)  no one  no one  child
pathway (d)  parent  parent  parent
pathway (e)  no one  parent  parent
pathway (f)  child  child  parent
Dyadic Head-Mounted Eye Tracking: Tracking Visual Engagement During Play

### Graphs

1. **(a) child leading/parent following**
   - Graph showing gaze distribution with time to joint attention (JT) onset.

2. **(b) parent leading/child following**
   - Graph showing gaze distribution with time to JT onset.

### Diagrams

- **(a) child gaze**
  - Diagram showing gaze patterns for child.

- **(b) parent gaze**
  - Diagram showing gaze patterns for parent.

- **(c) Synchronized joint attention**
  - Diagram illustrating synchronized attention.

- **(d) Sustained joint attention**
  - Diagram illustrating sustained attention.

### Child-led JA

- **Child eye ROI**
- **Parent eye ROI**
- **Parent ROI**

### Parent-led JA

- **Child’s onset**
- **Parent’s onset**
- **Coordinated attention**

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Dyadic Head-Mounted Eye Tracking: Tracking Visual Engagement and Play

Yu & Smith, Current Biology, 2016

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Dyadic Head-Mounted Eye Tracking: Tracking Visual Engagement and Play

A. First test

\[ M_{\text{long-lag}} = 5,231 \, \text{ms}; M_{\text{short-lag}} = 4,876 \, \text{ms} \]
\[ b = 0.07, \, \text{SE} = 0.17, \, \text{not significant} \]

B. Second test

\[ M_{\text{long-JA}} = 6,540 \, \text{ms}; M_{\text{short-JA}} = 4,293 \, \text{ms} \]
\[ b = 0.87, \, \text{SE} = 0.17, \, p < 0.001 \]

C. Third test

\[ M_{\text{long-JA}} = 2,146 \, \text{ms}; M_{\text{short-JA}} = 959 \, \text{ms} \]
\[ b = 0.82, \, \text{SE} = 0.09, \, p < 0.001 \]
Dyadic Head-Mounted Eye Tracking: Tracking Visual Engagement and Play

N=6; ~18.5 months old

Yu & Smith, Cognition, 2012
Dyadic Head-Mounted Eye Tracking: Tracking Visual Engagement and Play
Summary

- ASD interferes with joint engagement
- NDBI current best practice for infant ASD
- Egocentric vision techniques would likely provide new insights into therapeutic targets and mechanisms of change in NDBI
  - Inform treatment strategies
  - Inform treatment progress and outcome
  - Inform how paths toward engagement could be used synergistically
    - Scaffolding
    - Alternative
Future Directions

• Currently using DHMET to investigate visual joint engagement and play in 12-24 month olds with and without ASD

• Planning launch of pilot RCT of NDBI using DHMET and data from other related eye-tracking techniques as measures of outcome and to predict treatment response

• Intriguing potential for synergy with other approaches
  • Neuroimaging
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