New Directions in Eye Tracking Technology and ASD

December 8th
Attention

Sue Leekam and Georgie Powell

http://sites.cardiff.ac.uk/warc/
Our research project
Training Visual Attention Control in children with Neurodevelopmental Disorders

Professor Sue Leekam
Dr Georgina Powell
Dr Sam Wass & Prof Jon Erichsen
Who we are

Professor Sue Leekam
Chair in Autism
School of Psychology
Cardiff University

Dr Georgina Powell
Research Associate
School of Psychology
Cardiff University

Dr Sam Wass
Research Fellow
MRC Brain and Cognition Unit, Cambridge

Professor Jonathan Erichsen
School of Optometry and Vision Sciences
Cardiff University

Professor Angus Clarke
School of Medical Genetics
Cardiff University
Our research project on training attention

Why a project on attention training?

• previous research indicates that visual attention difficulties may disrupt skill acquisition

• currently no targeted interventions exist for improving attention skills in individuals with neurodevelopmental disorders such as ASD, especially for those with extreme intellectual disability.

• a novel eye tracking intervention offers an opportunity to target skills and improve learning

• not possible before modern eye tracking techniques were introduced.
Our project on training attention in ASD

Goals of the project

• To explore the feasibility of the method
  • Identify suitability of techniques, materials, presentation
  • e.g. do children engage with the task? how best to measure change?

• To run preliminary findings
  • Are there indications of training effects?
Outline

• Introduction to attention in ASD
• Introduction to eye tracking technology
• Training attention control
• Introduction: Attention in ASD

• Introduction to eye tracking technology

• Training attention control
Attention in ASD – Why is it important?

Clinical description: DSM-5

• Social and communication impairments
  • Includes non verbal communication (joint attention) and socio-emotional reciprocity
• Restricted and repetitive behaviour
  • Includes and hypo and hyper reactivity to sensory input and restricted interests/routine (flexibility)

• Summary: Attention impairment is not a specific clinical symptom of ASD and causal links to symptoms are not clear, but has been proposed by some as contributing to the core ASD impairments (see Keehn et al., 2013)
Attention in ASD: Why is it important?

Arousal/attention orienting difficulties have been proposed across many years

older accounts: Ornitz & Ritvo, 1968
newer accounts: Keehn, 2013; Orekhova & Stroganova, 2014

Different approaches taken to attention

• Bottom up explanations: - Physiological - overarousal, underarousal, modulation

• Top down: Cognitive - integration of information, top-down control
Social and non-social attention

• Same types of explanation associated with different symptom domains.
• Attention capture/ control

• Social attention
  – orienting to faces – different stimulus salience
  - joint attention – poor at coordinating social interaction

• Non-social attention
  • disengaging and shifting
  • Inhibition
  • prediction
Example of social attention - free viewing

Eye tracking results indicate mouth vs eye bias and difficulty in first eye movement (temporal)

Jones et al., 2009
Social attention

Social attention

“Have a look at the picture”

Results

- No difference in looking time
- Social image (both preferred)
- Face, eyes

Difference in first eye-movement
- fewer first eye movements made to body and face

Following gaze
- Less likely to fixate the gazed-at object.

Non social attention

Visual search: evidence of difference (superior visual search) in autism in some tasks, and difficulties in other tasks – O’Riordan et al., 2001, Kaldy et al., 2011.
Example of attention control difficulties

2. Disengagement – Overlap task

No overlap

Overlap
Disengagement – other factors

- Disengagement difficulties – not always worse in ASD (Leekam et al., 2000; van der Geest, 2001)

- Factors influencing disengagement (Marshall, 2010, PhD)
  - stimulus interest
  - dynamic/static stimulus presentation
  - form/colour

  Dynamic abstract stimuli were preferred by ASD children in a preferential looking task and children were slower to disengage from these than other stimuli

- Children with ASD were not slow to disengage from human faces compared with TD children (Charwaska, 2010)
Summary: Stimuli characteristics can affect attentional disengagement

Disengagement difficulties for those with ASD may

• be stimulus specific

• include stimulus interest (low level sensory qualities of stimulus)

• not include faces
Attention control- difficulty in suppression of reflexive eye movements

**New 2012/2013 eye-tracking findings:**

- No problem with basic disengagement in overlap condition but high errors in ‘don’t look’/look to other side condition task – anti-saccade task (Kelly, et al 2013)

- Also similar problems in face task (don’t look eyes vs mouth) (Laidlaw, 2012; Thompson PhD Cardiff).

**Summary of findings:** “Look elsewhere” instruction results in differences.

NB. Kelly also found problems in language impaired children as well as ASD.
Non-social attention - Is there evidence for learning? Yes

There is evidence for implicit learning of context

However, novelty learning less efficient when learning confined to local context

Eye tracking results indicate that have longer fixation durations overall and also slower to launch first saccade

Social attention – is there evidence for learning in ASD? Yes

• Joint attention can be trained

Summary: attention, eye tracking and learning in ASD

• Differences in social orienting and attentional ‘capture’ of social stimuli
  • Orienting: reduced social bias (look to face/eyes)
  • Impaired coordination of attention (following another’s gaze or point)

• Non-social attention differences
  • E.g. Visual search, disengaging and shifting

• Some evidence of problems with attention control in particular tasks

• Also some evidence that attentional learning can occur

• Use of eye tracking technique can circumvent problems with communication, social interaction and fine motor control

• Capacity for improvement by training attention?
• Attention in ASD

• Introduction to eye tracking technology

• Training attention control
Eye tracking - Eye movements

- Fixations
- Saccades
- Pursuit
Eye tracking - Eye movements

- Head movements

- Pupil size
Eye tracking - How does it work?
Eye tracking - How does it work?

Gaze position on screen

Coordinates x (horizontal), y (vertical)
Eye tracking - Applications

Research

Advertising and commercial research

Communication aids

Assessment and intervention?
Eye tracking - Advantages

• Non invasive

• Improving ease of use

• Relatively cheap

• Circumvent barriers of communication problems and motor control

• Particularly good for visual attention
• Attention in ASD

• Introduction to eye tracking technology

• Training attention control
Current project – Can you train attention?

Sam Wass et al., 2012

Developed a set of attention training games that improved some areas of attention in 11 month old typically developing infants.

ASD and Rett Syndrome?
Areas to train

1. Sustained attention
2. Disengagement
3. Anticipation/learning sequences
Areas to train

1. Sustained attention – length of time spent looking at an object

• Atypical attention patterns and narrow interests.

• Mixed results from sustained attention tasks (e.g. Continuous performance)

• May not be condition specific – comorbidity of autism with ADHD and developmental delay.
Areas to train

2. Disengagement – Overlap task

No overlap

Overlap

Faster to saccade

Slower to saccade

Some evidence for problems in autism..

e.g. Landry and Bryson 2004, Kawakubo el al, 2007, Elsabbagh et al., 2009, 2013.

Some evidence against..


Stimuli preferences? – Leekam et al., unpublished data.
Areas to train

3. Anticipation/learning sequences - Can we predict when to look at an object that moves in a certain sequence or pattern?

Goldberg et al., 2002
Study design

Pre tests
30 min
1-2 sessions
- Sustained attention
- Disengagement
- Prediction/anticipation

Training games
2 hours
5-8 sessions

Control videos
2 hours
5-8 sessions

What types of games could train attention?

Post tests
30 min
1-2 sessions
- Sustained attention
- Disengagement
- Prediction/anticipation
Training games - Butterfly
Sustaining attention, ignoring distractors
Training games - Butterfly

Sustaining attention, ignoring distractors
Training games - Stars

Disengagement, ignoring distractors

Game increases in difficulty level adaptively.

Visual rewards
Training games - Stars

Disengagement, ignoring distractors
Study design

**Pre tests**
30 min
1-2 sessions
- Sustained attention
- Disengagement
- Prediction/anticipation

**Training games**
2 hours
5-8 sessions

**Control videos**
2 hours
5-8 sessions

**Post tests**
30 min
1-2 sessions
- Sustained attention
- Disengagement
- Prediction/anticipation
Study predictions

Longer sustained attention, Faster disengagement, Faster prediction/anticipation

Mean post test scores on..

Sustained attention

Disengagement

Prediction/anticipation

Trained Controls
Study predictions

Individual Pre & Post test scores on:

- Sustained attention
- Disengagement
- Prediction/anticipation

### Trained group

<table>
<thead>
<tr>
<th></th>
<th>Pre tests</th>
<th>Post tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustained</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disengagement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prediction/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>anticipation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Control group

<table>
<thead>
<tr>
<th></th>
<th>Pre tests</th>
<th>Post tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustained</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disengagement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prediction/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>anticipation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average across participants
Study predictions

Individual Pre & Post test scores on..

- Sustained attention
- Disengagement
- Prediction/ anticipation

Control group

Trained group

Average across participants
Participant sample

- Recruited and tested at local schools
- All had a diagnosis of ASD.
- No exclusion criteria.
- 8/27 children recruited failed to engage (30%).
- Average session about 20 minutes.

<table>
<thead>
<tr>
<th>Group</th>
<th>No.</th>
<th>Age Mean (STD)</th>
<th>Age Range</th>
<th>Gender</th>
<th>BAS (n = 14) Median (IQR)</th>
<th>Mullens (n = 2) Age equivalent</th>
<th>N Completed two hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trained</td>
<td>10</td>
<td>6.1 (1.5)</td>
<td>5-10</td>
<td>8 M, 2 F</td>
<td>70 (18)</td>
<td>18m</td>
<td>9</td>
</tr>
<tr>
<td>Controls</td>
<td>9</td>
<td>6.3 (1.4)</td>
<td>5-9</td>
<td>7 M, 1 F</td>
<td>72 (27)</td>
<td>5m</td>
<td>8</td>
</tr>
</tbody>
</table>
Pre-post tests — **Sustained attention**

- **Duration of first presentation**

- Photo presented until child looks away.
Pre/post tests – **Sustained attention**

Boring

Interesting
Sustained attention – First presentation duration

• ANCOVA controlling for pre-test scores - significant difference in post-test first look duration to interesting images, $F(1, 14) = 5.2, p < 0.05, d = 0.67$.

• No difference in post-test first look duration for the boring images, $F(1, 14) = 1.2, p > 0.05$. 
Sustained attention – comparison to infant study

Current study

Wass et al., 2011

* Change in looking duration

Interesting | Boring

Trained
Controls

Interesting | Boring

Current study

Wass et al., 2011
Pre-post tests – Disengagement

No overlap

Overlap
Pre-post tests – **Disengagement**

- **Eye gaze position on screen**
  - Right screen
  - Centre screen
  - Left screen

**TIME (eye tracker frames)**
- Target onset
- Response time
- Participant starts eye movement to target
Pre-post tests – **Disengagement**

Disengagement effect = Overlap RT – No Overlap RT

Positive disengagement effect = slower eye movement to the target in the overlap condition than the no overlap condition.
Disengagement

• Eye movement quality on this task was often low.

• Data excluded completely for 6/17 participants.

• Exclusion criteria – less than 8 valid trials.
Disengagement

Disengagement effect = Overlap RT – No overlap RT

POST TEST SCORES (marginal means)

Overall, disengagement improves in trained group relative to control group.
Disengagement

Disengagement effect = Overlap RT – Baseline RT

Average across participants
Disengagement—relation to infant study

Current study

Wass et al., 2011

Change in disengagement effect

Disengagement

Δ reaction time (ms)

Disengagement

Trained

Controls

*
Pre-post tests – Prediction/anticipation
Anticipation/Prediction

Response time = faster is better

![Graph showing POST TEST SCORES (marginal means)]
Pre/post tests summary

1. **Sustained attention**: Significant improvement in first look duration.

2. **Disengagement**: Problems with data quality, potentially promising but need larger sample.

3. **Prediction/anticipation**: Some participants seem to improve, but need more for it to reach significance.
Improvement over training sessions?

Average score across participants = 0

Above average scores

Below average scores

Average score per session on all training games.
All but two participants show a trend upwards over sessions. This suggests that most participants improved on the training games. Some participants are consistently better at games than others.
Early days – future analysis

Background info

Ability scores

Response to training
Future Directions

1. Larger sample and younger children

Our sample

Trained group

Control group

Trained group

Ideal sample

Control group
Future Directions

2. Finland study (Forssman, Wass & Leppanen) – improvements in social attention?

- Control group
- Trained group
Future Directions

3. Tailor games to individual ability profiles and interests of each child

4. Portable technology – tablets with eye trackers built in.
Acknowledgements

• Project collaborators

Professor Sue Leekam
Chair in Autism
School of Psychology
Cardiff University

Dr Sam Wass
Research Fellow
MRC Brain and Cognition Unit, Cambridge

Professor Jonathan Erichsen
School of Optometry and Vision Sciences
Cardiff University

Professor Angus Clarke
School of Medical Genetics
Cardiff University

• Participants and families

• Teachers and support staff

• Sarah Carrington
Contact us for more information

We are preparing the results of this study for publication. We also have results from 3 children with Rett Syndrome not presented here.

Please contact us if you would like to received the article or if you want to cite anything from this presentation or if you have any queries!

Dr Georgie Powell: PowellG7@cardiff.ac.uk and Prof Sue Leekam LeekamSR@cardiff.ac.uk

You can also find more details of our work at WARC at http://sites.cardiff.ac.uk/warc/research/
Further Reading


Further reading


