IMAGINATION, LANGUAGE AND AUTISM: INSIGHTS FROM EYE MOVEMENTS

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Pragmatic anomalies

The peanut was in love

The peanut was salted
The role of context

A woman saw a dancing peanut who had a big smile on his face. The peanut was singing about a girl he had just met. And judging from the song, the peanut was totally crazy about her. The woman thought it was really cute to see the peanut singing and dancing like that.

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The role of context

The angry man picked up the lorry and carried on down the road.
The role of context

The Incredible Hulk was annoyed that there was a lot of traffic in his way.

The angry man picked up the lorry and carried on down the road.

*Filik (2008)*
Linguistic context and autism

- People with ASD have equivalent lexical and semantic access to TD people (e.g. Caruana & Brock, 2014; Howard et al., in press)

- Contextual processing of language is intact in ASD (e.g. Brock et al., 2008; Hahn et al., 2015)
Counterfactuals

• Describe events that are true in a hypothetical model, but false in actuality

I _should_ have eaten less over Christmas

I _wish_ I had won the lottery

If I had wings, _then_ I could fly
Counterfactuals serve important social functions.
How are counterfactuals understood?

• Dual representations
  • Two mental spaces are created for counterfactuals: reality & hypothetical (Fauconnier, 1994; 2002)
  • Mental models represent logically equivalent possibilities: the true possibilities and the contrary-to-fact possibilities (Byrne & Tasso, 1999)
How are counterfactuals understood?

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  • Mental models represent logically equivalent possibilities: the true possibilities and the contrary-to-fact possibilities (Byrne & Tasso, 1999)

• Empirical research supports dual representations
  • Rapid access to the implied factual world (deVega et al., 2007; Ferguson, 2012)
  • Rapid access to the explicit counterfactual world (e.g. Ferguson et al., 2010; Nieuwland & Martin, 2012)
Counterfactuals and social cognition

- Counterfactual thought engages the same network of specialized cognitive processes as Theory of Mind (ToM) reasoning (Perner, 2000; Riggs et al., 1998)

Van Hoek et al. (2014)
Counterfactuals and social cognition

- Counterfactual thought engages the same network of specialized cognitive processes as Theory of Mind (ToM) reasoning (Perner, 2000; Riggs et al., 1998)
  - The same set of executive functions mediates successful counterfactual and ToM reasoning in children (Drayton et al., 2011)

- Children who are better at counterfactual thinking are also better at the false belief task (Peterson & Bowler, 2000)
Counterfactuals, social cognition and autism

• Children with autism show deficits in counterfactual reasoning, but perform well in all other reasoning tasks
  • Impairments not as great as ToM (Grant et al., 2004)

• Most studies have focused on production of counterfactuals, or syllogistic reasoning based on counterfactual statements

• Distinct counterfactual reasoning strategies between TD and ASD children
Imagination and autism

• Distinguishing reality from fiction develops early in TD children

• Children with ASD struggle with reality/fiction distinction
  • Less likely to identify ‘which is silly’
  • Less imaginative elements in made up stories

• Being prompted to ‘imagine’ counterfactual events impairs ASD understanding even further
  • Are people with ASD less able to suspend reality than TD people?
Increasing demands on counterfactual imagination

- Known fictional worlds
- Novel fictional worlds
- Valid alternatives to historical facts
- Realistic counterfactuals
Anomaly detection and eye-tracking

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• Ease or difficulty processing a word is reflected in the amount of time readers spend looking at it

• Reading times are increased on an anomalous word, and readers jump back to revisit earlier parts of the sentence

Rayner (1998)
Experiment 1 – everyday hypothetical counterfactuals

“If Joanne had remembered her umbrella, her hair would have been dry/wet when she arrived home.”

“Because Joanne had remembered her umbrella, her hair was dry/wet when she arrived home.”

• Materials modified from Ferguson (2012)
• These counterfactuals involve no change from reality, the critical word is consistent/inconsistent with the local discourse
Analyses

Four regions for analysis:

| If Joanne had remembered her umbrella, | her hair would have been | when she arrived home. |
| REGION 1 | REGION 2 | CRITICAL REGION 4 |

N = 25 TD/25 ASD adults, 32 Experimental items, plus fillers

Data analysed using LMER for each region and measure
First-pass reading time

- Sum duration of fixations on first entering a region
- Indicates initial processing difficulties

...would have been | *dry* | when she...
Regression path reading time

- Sum duration of fixations from first entering that region until moving past it to the right
- Indicates early difficulty integrating a word with context

...would have been | dry | when she...
Total reading time

- Sum duration of all fixations within a region (includes initial reading time and any re-reads)
- Indicates overall difficulty to process text in that region

...would have been | dry | when she...

1 → 2 → 3 → 4 → 5

6 → 7 → 8
## Additional measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autism Diagnostic Observation Schedule (ADOS)</td>
<td>Severity of autism symptomology</td>
</tr>
<tr>
<td>Autism Spectrum Quotient (AQ)</td>
<td>Self report autism trait ***</td>
</tr>
<tr>
<td>Wechsler Abbreviated Scale of Intelligence (WASI)</td>
<td>Verbal, performance and overall IQ</td>
</tr>
<tr>
<td>Operation Span task (OSPAN)</td>
<td>Working memory capacity</td>
</tr>
<tr>
<td>Wisconsin Card Sorting Task (WCST)</td>
<td>Cognitive flexibility</td>
</tr>
<tr>
<td>Stroop task</td>
<td>Inhibitory control ***</td>
</tr>
<tr>
<td>Imagination task (adapted from Hassabis et al, 2007)</td>
<td>Imagination ability ***</td>
</tr>
<tr>
<td>General knowledge questions</td>
<td>Knowledge of facts described in Experiment 2</td>
</tr>
<tr>
<td>Fictional knowledge questions</td>
<td>Knowledge of fiction described in Experiment 4</td>
</tr>
</tbody>
</table>
Results

If Joanne had remembered her umbrella, her hair would have been dry/wet when she arrived home.
Results

- Rapid accommodation of the counterfactual world - clear effects of inconsistency detection throughout in both groups

If Joanne had remembered her umbrella, her hair would have been dry/wet when she arrived home.

Total reading time (msec)

<table>
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- Consistent
- Inconsistent
Results

• Earlier detection of inconsistencies in ASD group compared to TD group
Results

• Greater disruption for a factual inconsistency than counterfactual inconsistency (post-critical region)
Experiment 2 – alternative versions of real world knowledge

“If the Titanic had not hit an iceberg, it would have sunk/survived along with all the passengers.”

“Because the Titanic hit an iceberg, it sunk/survived along with all the passengers.”

• Materials translated and adapted from Nieuwland & Martin (2012)

• These counterfactuals require the reader to inhibit their knowledge of the real world in order to generate the alternative counterfactual world
Results

- Clear effects of inconsistency detection throughout, and in both groups.
Results

• Rapid accommodation of the counterfactual world (on critical word, “sunk/survived”)
Results

- Different patterns of responding to the counterfactual inconsistency between groups
Experiment 3 – novel scenarios that violate reality

“If margarine contained soap, Mum could use margarine in her baking/washing and impress her friends.”

“Because margarine contains oil, Mum can use margarine in her baking/washing and impress her friends.”

• Materials adapted from Ferguson & Sanford (2008)
• These counterfactuals rely on readers suspending their knowledge of what is true in reality (as in Experiment 2), but here they must also imagine a fantasy world where usually implausible events can occur
Results

- Readers initially relate critical word to reality; effects of counterfactual world emerge later
Results

- Reality continues to interfere even within a counterfactual context

![Graph showing total reading time (msec) for factual and counterfactual contexts, with bars for consistent and inconsistent critical words. The graph illustrates that counterfactual contexts have a higher reading time compared to factual contexts.]
Results

- Slower total RTs throughout for ASD versus TD
- ASD group spend longer re-reading counterfactual than factual statements, TDs show no difference (reg path r4)
Discussion

• People with ASD can rapidly imagine events in a counterfactual world
  • Faster detection of discourse inconsistencies than TDs

• TD people show faster integration when related to known facts than temporary context

• Some interference from alternative model of the world

• People with ASD are more sensitive to counterfactuals that require reader to inhibit reality and infer an imagined world
Increasing demands on counterfactual imagination

- Known fictional worlds
- Novel fictional worlds
- Valid alternatives to historical facts
- Realistic counterfactuals
Discussion

• What do these results mean for theories of weak central coherence, or complex information processing?
  • ASD participants have maintained global coherence
    • Expt 1- accurate anomaly detection based on discourse (in fact, faster than TDs)
    • Expt 2- reversed ‘factual’ anomaly detection based on the counterfactual discourse
    • Expt 3- reversed ‘reality’ anomaly detection based on the counterfactual discourse
  • Perhaps global coherence is not limited within a single sentences?
THANK YOU

All our participants
Jo Black
David Williams
Experiment 4 – counterfactual events in known fictional worlds

“If Harry Potter did not have magic powers, he would use his broom to fly/sweep around the castle.”

“Because Harry Potter has magic powers, he uses his broom to fly/sweep around the castle.”

• These counterfactuals depict events in known fictional worlds that are stored in long-term knowledge
• The counterfactual restores real-world contraints