Resolution of Ambiguous Homographs in Individuals with Autism: An ERP Study

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Introduction

Homographs and Autism

Autism spectrum disorder (ASD) is partly characterized by deficits in communication and pragmatic language use. Previous studies have shown that one aspect of these deficits is a difficulty determining the meaning of ambiguous words in context. For example, when reading sentences aloud, individuals with ASD are more likely than typically developing (TD) individuals to mispronounce ambiguous homographs like “lead” and “tear” (Jolliffe & Baron-Cohen, 1999). Traditionally this difficulty has been interpreted within the “weak-central coherence” theory (Frith, 1989), which suggests that individuals with ASD have a tendency toward enhanced local processing at the expense of global integration.

The N400

The N400 event-related potential (ERP) component has been linked to contextual meaning during reading. When a word violates a reader’s semantic expectations (“He spread butter on his *socks*”), this violation causes an electrical negativity over posterior scalp, peaking 400ms after word-onset. Previous studies have shown reduced or absent N400 effects for individuals with ASD compared to TD individuals (Pijnaker et al., 2010), suggesting impaired use of sentence context during sentence reading.

Current Study

We compared the electrophysiological effects of local vs. global processing during lexical ambiguity resolution in individuals with ASD and TD individuals. Our sentences (adapted from Sitnikova et al., 2002) consisted of an initial clause that biased the dominant or subordinate meaning of a homograph (e.g. ‘ruler’). A second clause contained a **critical word** (e.g. ‘length’) that was always congruent with the local context (i.e. the homograph's dominant meaning) but was either congruent [1-2] or incongruent [3-4] with the global context of the initial biasing clause. A *control word* was either congruent (e.g. ‘line’) [1] or incongruent (e.g. ‘couple’) [2] with both local and global sentence context.

[1] The designer used a ruler because the **length** of the *line* was critical.
[2] The designer used a ruler because the **length** of the *couple* was critical.
[3] The king was a mean ruler because the **length** of the *line* was critical.
[4] The king was a mean ruler because the **length** of the *couple* was critical.

Predictions

- A local processing bias would predict no N400 effect at the critical word, since the critical word is always congruent with the homograph’s dominant meaning.
- A global processing bias would predict enhanced N400 amplitudes at the critical word for [3] and [4] compared to [1] and [2] (i.e. an N400 effect), since the critical word is incongruent with the global interpretation of the homograph set up by the preceding clause.
- Weak central coherence would predict greater local processing in the ASD group (i.e. no N400 effect at the critical word) and greater global processing in the TD group (i.e. a significant N400 effect at the critical word).
- Both groups should show N400 effects in response to the control word.

Methods

Participants

- 20 ASD; mean age 34 years (range 18-68); 16 male, 4 female. 20 TD; mean age 33 years (range 19-68); 16 male, 4 female. All right-handed native English speakers
- Groups matched on age (p = 0.91), verbal IQ (K-BIT; p = 0.24) and non-verbal IQ (K-BIT; p = 0.32). Lower receptive vocabulary (PPVT) in ASD group than TD group (p < 0.05)

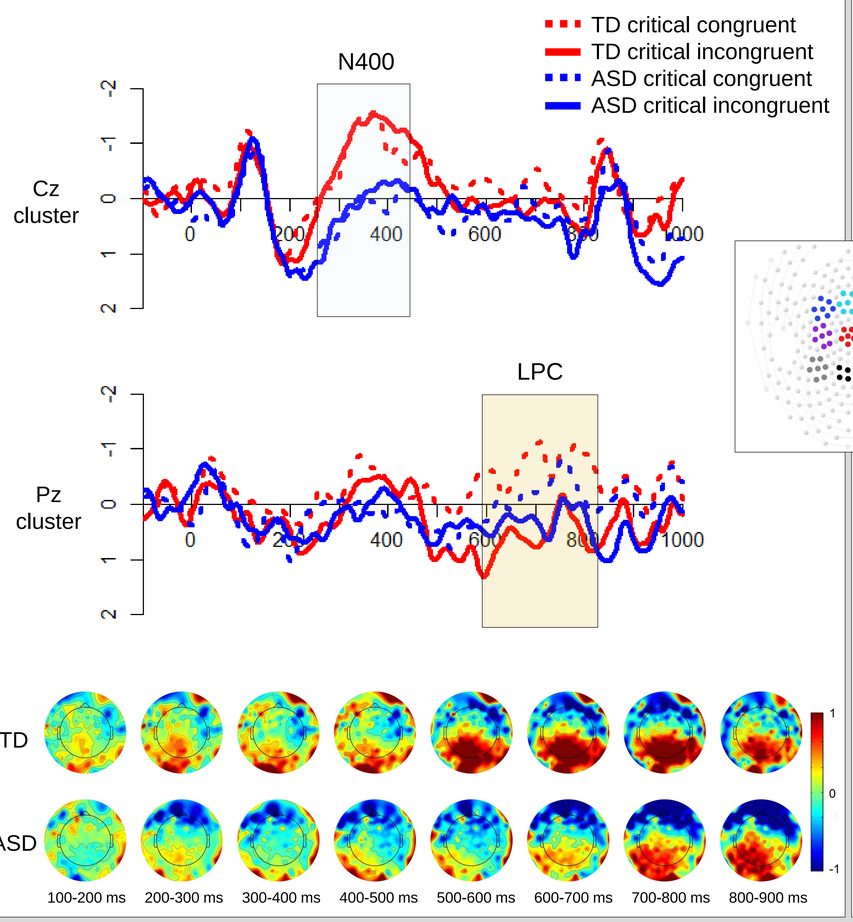
Stimuli and Procedure

- 120 sentences, 30 of each sentence type [1-4], presented in 4 blocks
- Words presented in rapid serial visual presentation (RSVP) format; 600 ms, 100 ms ISI
- Relatedness probes presented after every sentence: participants judged whether a word was related to the sentence

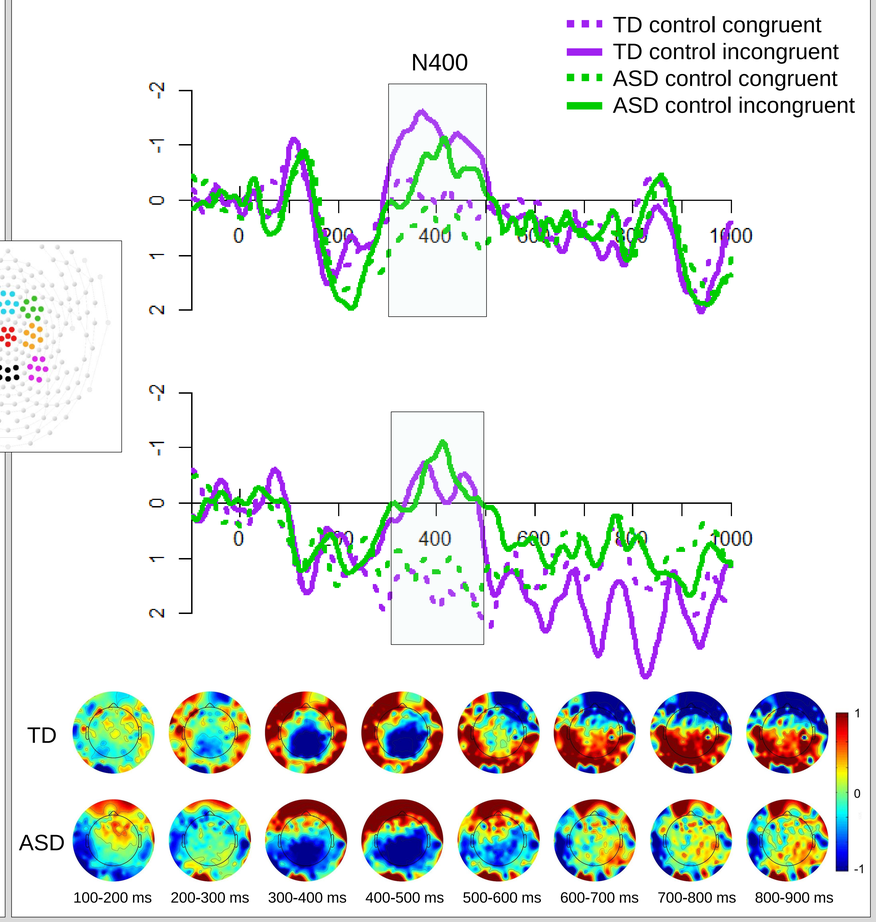
EEG Data Acquisition and Preprocessing

- EEG recorded at 250 Hz using an EGI GES 300 EEG System; NetStation 4.3; 256-channel Hydrocel Geodesic Sensor Net
- Bandpass filtering 0.1-30 Hz; average reference transform

Results: Critical Word



Results: Control Word



Results

Critical word

- N400 component
  - No significant N400 congruency effects in either the TD or ASD groups.
  - Overall larger N400 amplitudes for both conditions in TD compared to ASD from 250-450 ms.
- Late positive component (LPC)
  - LPC congruency effect (incongruent more positive than congruent) from 500-800 ms for TD, and from 600-1000 ms for ASD.
  - No differences in LPC effect magnitude between groups from 600-800 ms.
  - Trend towards a significantly later LPC effect in ASD compared to TD at the P3 cluster (p = 0.07; TD group latency = 665 ms, ASD group latency = 748 ms), but no significant difference at the Pz cluster (p = 0.69).

Control word

- N400 component
  - Significant N400 congruency effect (incongruent more negative than congruent) for both groups from 300-500 ms.
  - No significant differences between groups in N400 effect size.
- Late positive component (LPC)
  - Trend of an LPC effect from 600-900 ms in TD group, but this did not reach statistical significance.
  - The ASD group showed no LPC congruency effect.
  - No group differences in the LPC effect.

Discussion

In response to the control word, both groups showed an N400, suggesting that individuals with ASD can successfully detect semantic anomalies.

In response to the critical word, neither group showed a significant N400 effect, suggesting a lack of global context effects for both groups. However, both groups showed an LPC effect, which suggests that ambiguity resolution may have been shifted to later re-analysis processes. The LPC effect was slightly later in the ASD group, which may suggest delayed ambiguity resolution.

Interestingly, the TD group showed larger N400 responses than the ASD group for both congruent and incongruent critical words. This could indicate that TD participants keep both meanings of the homograph in mind to later evaluate congruity. The fact that the ASD group did not show this congruity-independent N400 response suggests that they process semantic ambiguity in a fundamentally different way than TD participants.

References

Frith, U. (1989). *Autism: Explaining the enigma.* Oxford: Blackwell.

Jolliffe, T., & Baron-Cohen, S. (1999). A test of central coherence theory: linguistic processing in high-functioning adults with autism or Asperger syndrome: is local coherence impaired? *Cognition, 71*, 149–185.

Pijnacker, J., Geurts, B., van Lambalgen, M., Buitelaar, J., & Hagoort, P. (2010). Exceptions and anomalies: An ERP study on context sensitivity in autism. *Neuropsychologia, 48*(10), 2940–2951.

Sitnikova, T., Salisbury, D. F., Kuperberg, G., & Holcomb, P. I. (2002). Electrophysiological insights into language processing in schizophrenia. *Psychophysiology, 39*(6), 851–860.

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