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Monitoring in language perception in high-functioning adults with autism spectrum disorder: Evidence from event-related potentials

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HIGHLIGHTS

- We studied language problems in autism spectrum disorder (ASD) in light of monitoring, an aspect of cognitive control, using event-related potentials.
- Participants with ASD monitored language in simple and complex conditions, whereas control participants monitored language mainly in complex conditions.
- As atypical monitoring might play a role in language impairments in ASD, it seems important to study language perception in ASD in interaction with other cognitive processes rather than as an isolated (in)ability.

ABSTRACT

Objectives: Autism spectrum disorder (ASD) is characterized by impaired global language processing, whereas local language processing often appears intact. Recent psycholinguistic research suggests that the quality of language perception relies on monitoring, an aspect of executive control. The aim of the study was to examine monitoring in people with ASD of (a) local, orthographic violations, and (b) global, syntactic violations, when provided with single level versus dual level task instructions.
Methods: We recorded event-related potentials and compared P600 effects to the linguistic violations relative to correct words in 14 adults with ASD and 14 matched controls.
Results: In control participants, local errors elicited a monitoring response as tapped by the P600 effect in both conditions. For global errors, the P600 effect was present only at one centroposterior site in the single level condition, whereas in the dual level condition a broadly distributed effect was obtained. People with ASD, however, showed a monitoring response to local and global errors both in the single and dual level condition.
Conclusions: The main ERP finding suggests that when instructed people with ASD monitor global aspects of language already under simple circumstances, whereas people without ASD mainly do so under more complex circumstances.
Significance: Results suggest that language problems in ASD should not be studied in terms of a linguistic dysfunction as such, but in light of the use of executive resources during language comprehension.

1. Introduction

Impairments in language and communication are among the key characteristics of autism spectrum disorders (ASD) (DSM-IV-TR, American Psychiatric Association, 2000). Individuals with ASD generally show difficulties processing higher-level aspects of language, e.g. aspects that require integration of verbal material for comprehension such as complex syntactic structures, semantics and pragmatics, resulting in impaired understanding of the meaning of language. On the other hand, lower-level processes often are found to be relatively spared or even enhanced compared to typical individuals (for an overview see Kelley, 2011). It is still unclear, however, what mechanisms underlie general findings of spared or even superior local processing abilities and impaired global processing. Recently, claims of involvement of executive control mechanisms in typical language processing have been made (for a review see Ye and Zhou, 2009). In line with this, in the present study it was examined how executive control, specifically monitoring, was employed by people with ASD during local and global language perception. To this aim, we used event-related

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potentials (ERPs), which, given their excellent temporal resolution, provide good insight in the time course of cognitive processes during language processing.

1.1. Local and global processing in ASD

Information processing in ASD often is described in terms of a detail-focused cognitive style, referring to a bias towards simple, low-level stimuli and local features, and an impaired ability to process global information (Frith, 1989; Happé, 1999; Happé and Frith, 2006). In language processing, such a local bias is said to lead to a stronger focus on individual linguistic features, supported by studies showing relatively strong literal-semantic performance on for instance standardized vocabulary tests (Kjelgaard and Tager-Flusberg, 2001), and enhanced discrimination of isolated acoustic features of speech sounds, such as pitch (Heaton et al., 2008; Jarvinen-Pasley et al., 2008). Evidence for impaired global processing comes from studies revealing reduced use of context for comprehension. For instance, in a homograph task, participants with ASD appear less able to use sentence context to derive the appropriate pronunciation of the homograph (Frith and Snowling, 1983; Jolliffe and Baron-Cohen, 1999; Snowling and Frith, 1986). Although the aforementioned results would suggest a clear-cut distinction between intact local and impaired global abilities, there is also evidence of people with ASD having difficulties at local language tasks that require more elaborate integrative processes. For instance, individuals with ASD are less likely than controls to be primed by semantically related words in a lexical decision task (Kamio et al., 2006), and tend to show reduced performance on speech perception tasks in which multiple acoustic features need to be integrated (e.g., words; Alcantara et al., 2004; Groen et al., 2009).

Moreover, the 'impairment' in global processing observed in ASD appears to be sensitive to task demands and (attentional) instructions. For instance, when in a homograph task people with ASD are provided with explicit instructions to focus on sentence context, sentences can be processed for meaning (Snowling and Frith, 1986). In line with this, people with ASD show 'typical' processing speed of local, orthographic and global, syntactic information when instructed to focus their attention singly on one of them (Koolen et al., 2012). However, when attention needs to be focused on local and global information simultaneously, processing speed reduces for both levels of information. This overall processing delay suggests that these dual level task instructions have attentional costs for both local and global processing.

Taken together, the results on local and global processing are not straightforward in terms of intact or impaired processing abilities. Generally, the more linguistic input requires complex, integrative processes, the more people with ASD seem to experience difficulties processing the input. Moreover, the fact that local and global processing in ASD can be modulated by attentional instructions, gives rise to the idea that language problems in ASD should be studied in light of cognitive control operations, rather than in terms of linguistic functions as such. After all, the suggested local bias can be overcome and global processing can take place, but this needs specific instructions, suggesting that it may cost more effort for individuals with ASD. We propose that the general language processing pattern in ASD of increasing problems with increasing linguistic complexity could be explained in terms of increased use of executive control, specifically monitoring. We will explain this hypothesis based on the monitoring process observed in typical language function.

1.2. Monitoring in language perception

Monitoring is one of several executive functions that are distinguished in the literature (Stuss and Knight, 2002). It is an aspect of executive control that evaluates the demands for control, and by evoking changes in control consequently, ensures the quality of our thoughts and behavior. According to monitoring theory of language perception, monitoring plays an important role in the optimization of language comprehension (for a review see Van de Meerendonk et al., 2009). In case of processing uncertainty resulting from for instance incorrect or complex linguistic input, a cognitive control process is needed to come to a correct interpretation and hence understanding of the input.

The idea that the quality of language perception depends on cognitive control (monitoring) is based on ERP studies, which showed a so-called P600 effect to different types of (non)linguistic violations and complexities. The P600 is a late positive-voltage effect with a centro-posterior scalp distribution, starting approximately 600 milliseconds after occurrence of conflicting input. The P600 was initially found to be elicited by various syntactic anomalies (e.g., Friederici, 1995; Hagoort et al., 1993; Kaan et al., 2000). Therefore, the component was thought to reflect syntactic reanalysis or repair processes (e.g., Friederici, 1995; Friederici, et al., 2001). However, contrary to what would be expected based on a purely syntactic interpretation of the P600, the effect was also found to sentences that were syntactically correct and unambiguous but that contained semantic violations (e.g., Kolk et al., 2003; Kuperberg et al., 2003). In order to account for these nonsyntactic effects, Kuperberg (2007) proposed that the effect reflects (the consequences of) a clash between a prediction of the input based on evolving representations and semantic memory and a representation of the input based on integration of the incoming word with the context based on rule-like constraints. This conflict between these two outputs would then result in reanalysis to obtain a new parse or a new set of thematic roles, reflected by the P600 effect. Although this framework can account for the P600 effects found in case of syntactic and semantic violations, an increasing number of studies also found the component to other violations. For instance, P600 effects have been observed at various linguistic (e.g., to orthographic violations, Vissers et al., 2006) and nonlinguistic (e.g., to conceptual, Vissers et al., 2008, or musical violations, Patel et al., 1998) levels. These findings cannot be explained in terms of syntactic or semantic reanalysis. Kolk et al. (2003) suggested that, instead, the P600 effect reflects a broader cognitive control process; monitoring. Monitoring theory is similar to the accounts described above in that all propose reanalysis of unexpected input. However, the accounts differ in their explanation of the *function* of this reanalysis. Whereas other accounts provide a linguistic explanation, monitoring theory implies a more general cognitive control process in terms of error monitoring, thereby accounting for repair processes in case of various linguistic and nonlinguistic violations that would otherwise interfere with comprehension.

Monitoring theory in language perception is based on dual-route models of language comprehension. According to these models, the construction of sentence meaning occurs along two parallel routes; simple processing heuristics and systematic, compositional algorithms (e.g., Ferreira, 2003; Ferreira et al., 2002). Heuristics are mental shortcuts that are top-down; they rely on knowledge and expectations, providing a basis for the most plausible interpretation of the sentence. On the other hand, systematic algorithms involve a bottom-up analysis of the incoming information. It has been shown that the two routes – perceptual, bottom-up algorithms and expectancy based, top-down heuristics – run in parallel and are largely independent (e.g., Friederici, 1995; Van Herten et al., 2006; Vissers et al., 2007). In most sentences, expectations and perception will provide similar thematic interpretations. In some cases, however, the parallel processing of heuristic-based and algorithmic-based sentence interpretations leads to conflicting outcomes. For instance, in the sentence 'The cat that fled from the mouse ran through the room.', the plausibility heuristic leads to the interpretation that 'the mouse fled from the cat', while the parser suggests that