



ELSEVIER

available at www.sciencedirect.comjournal homepage: www.elsevier.com/locate/cortex

Research report

Neural correlates of morphosyntactic and verb-argument structure processing: An fMRI study

Tim Raettig^{a,*}, Stefan Frisch^b, Angela D. Friederici^a and Sonja A. Kotz^{a,b}

^aMax-Planck-Institute for Human Cognitive and Brain Sciences, Leipzig, Germany

^bDay Care Clinic of Cognitive Neurology, University of Leipzig, Germany

ARTICLE INFO

Article history:

Received 29 April 2008

Reviewed 29 July 2008

Revised 30 January 2009

Accepted 4 June 2009

Action editor Stefano Cappa

Published online 12 June 2009

Keywords:

Morphosyntax

Verb-argument structure

Language processing

Superior temporal gyrus

Inferior frontal gyrus

ABSTRACT

In the current study, we investigated the processing of ungrammatical sentences containing morphosyntactic and verb-argument structure violations in an fMRI paradigm. In the morphosyntactic condition, participants listened to German perfect tense sentences with morphosyntactic violations which were neither related to finiteness nor to agreement but which were based on a syntactic feature mismatch between two verbal elements. When compared to correct sentences, morphosyntactically ungrammatical sentences elicited an increase in brain activity in the left middle to posterior superior temporal gyrus (STG). In the verb-argument structure condition, sentences were either correct or contained an intransitive verb with an unlicensed direct object. Ungrammatical sentences of this type elicited brain activations in the left inferior frontal gyrus (IFG) (BA 44). Thus, we found evidence for different brain activity patterns as a function of violation type. The left posterior STG, an area known to support lexical-syntactic integration was strongly implicated in morphosyntactic processing whereas the left dorsal IFG (BA 44) was seen to be involved in the processing of verb-argument structure. Our results suggest that lexical, syntactic and semantic features of verbal stimuli interact in a complex fashion during language comprehension.

© 2009 Elsevier Srl. All rights reserved.

1. Introduction

The neural correlates of syntactic processing have been investigated in a large number of imaging studies (for comprehensive reviews, see Kaan and Swaab, 2002; Friederici and Kotz, 2003; Heim, 2005; Frisch et al., 2008). However, while there is an extensive body of literature on the effects of syntactic complexity (Just et al., 1996; Stromswold et al., 1996; Cooke et al., 2001; Roeder et al., 2002; Mason et al., 2003; Constable et al., 2004; Peelle et al., 2004; Friederici et al., 2006b) and syntactic violations related to phrase structure and

subject-verb or article-noun agreement (Kang et al., 1999; Friederici et al., 2003; Rueschemeyer et al., 2005), the processing of exclusively inter-verbal morphosyntactic relations (for example, between auxiliaries and main verbs) has not received much attention yet. In addition, while there is imaging evidence on the interactions between verb-argument structure and case marking, animacy and word order (Bornkessel et al., 2005; Grewe et al., 2007), the effects of outright violations of a verb's subcategorization frame remain to be investigated. The present study will focus on these two aspects of language comprehension.

* Corresponding author. Max-Planck-Institute for Human Cognitive and Brain Sciences, Stephanstrasse 1a, 04103 Leipzig, Germany.

E-mail address: raettig@cbs.mpg.de (T. Raettig).

0010-9452/\$ – see front matter © 2009 Elsevier Srl. All rights reserved.

doi:10.1016/j.cortex.2009.06.003

Morphosyntax as a general term refers to syntactic operations that affect the morphology of one or more elements of a sentence. Consider the following example¹ from German:

Example 1.

Peter hat den Apfel gegessen.
Peter has the apple eaten (Peter has eaten the apple.)

Three different, but related morphosyntactic phenomena can be observed here, article and noun agreeing in number, gender and case, the subject agreeing with the auxiliary in number, and finally the auxiliary forcing the past participle form on the following main verb. All three cases can be analyzed as instances of syntactic “feature checking” (Lasnik, 2002; Sternefeld, 2007), although the nature of the particular grammatical features that are checked does of course vary. In the current study, we investigated the impact of morphosyntactic mismatches between auxiliary and main verb (see Example 2).

Example 2.

* Peter hat den Apfel essen.
* Peter has the apple eat (*Peter has eat the apple.)

Importantly, the type of morphosyntactic violation that we want to implement here is neither related to finiteness (infinitives and participles are both nonfinite) nor to agreement (the subject agrees with the auxiliary, not with the main verb), and it does not involve a nominal element. The processing of nouns and verbs has been shown to differ in a number of previous studies (Perani et al., 1999; Davis et al., 2004; Tyler et al., 2004), and the small number of previous neuroimaging studies concerned with morphosyntactic processing (Ni et al., 2000; Indefrey et al., 2001; Moro et al., 2001; Kuperberg et al., 2003; Newman et al., 2003) is exclusively concerned with grammatical constructions that are either at least in part nominal or involve a manipulation of finiteness. Testing morphosyntactic violations in a purely verbal context and independently of the infinitival or inflected status of the relevant lexical items can therefore yield important insights into the fine-grained structure of the neural systems underlying morphosyntactic processing.

If verbal morphosyntax is processed differently from nominal morphosyntax, our experimental manipulation should induce brain activations in regions distinct from those reported for the processing of article-noun disagreement (Moro et al., 2001). Moro et al. (2001) investigated instances of article-noun disagreement in pseudo-word sentences, comparing the processing of blocks of correct and incorrect sentences in a grammaticality judgment task to the processing of blocks of phonotactically legal and illegal word lists in a phonological acceptability task. The authors report a stronger hemodynamic response to the sentence blocks than to the word list blocks in the bilateral inferior frontal gyrus (IFG) (BA 44, 45) and the cerebellar vermis.

Finiteness plays no prominent role in our study, but since finiteness violations are also restricted to verbal morphosyntax one might expect some overlap of our results with studies investigating this type of manipulation (Ni et al., 2000;

Indefrey et al., 2001; Kuperberg et al., 2003). Ni et al. (2000) report an increase in brain activity for morphosyntactically illegal sentences like “Trees can grew” in the left inferior, middle and superior frontal gyri (BA 44, 45, 46, 47, 6, 8), the bilateral postcentral gyrus, the right supramarginal gyrus and the head of the right caudate nucleus. Indefrey et al. (2001), testing finiteness violations in pseudo-word sentences, found a stronger hemodynamic response during blocks of syntactic processing than during blocks of phonological processing in the left middle frontal gyrus (BA 9). Finally, Kuperberg et al. (2003) compared the processing of real word sentences containing finiteness violations to the processing of correct sentences. Morphosyntactically illegal stimuli elicited an increase in brain activity in the bilateral inferior parietal lobule, intraparietal sulcus and precuneus.

Since subject-verb agreement involves both verbal and nominal elements, brain regions found to be active for this type of syntactic processing may at least in part overlap with areas relevant for the manipulation tested in the current study. Violations of subject-verb agreement were tested by Newman et al. (2003). Comparing blocks of stimuli containing a mismatch between a singular subject and a verb carrying a plural inflection and blocks of stimuli containing a phrase structure violation, they report a stronger hemodynamic response for the former in the left pars opercularis.

In sum, the picture that emerges when looking at imaging studies on morphosyntactic processing is diverse, as are the particular methodologies that are employed. Activation of the left inferior and middle frontal lobe is often reported for morphosyntactic processing (Ni et al., 2000; Indefrey et al., 2001; Moro et al., 2001; Newman et al., 2003), but there are notable exceptions (Kuperberg et al., 2003). Three of the studies described above used blocked designs (Indefrey et al., 2001; Moro et al., 2001; Newman et al., 2003) and two relied on pseudo-word stimuli (Indefrey et al., 2001; Moro et al., 2001), making comparisons to the current study difficult.

Thus although results of earlier event-related fMRI studies with real word stimuli indicate that the left IFG plays a role in the processing of morphosyntactic violations (Ni et al., 2000), no strong hypotheses can be deduced from the available studies due to the methodological differences discussed in the paragraphs above. When taking models of speech comprehension into account (Friederici, 2002; Grodzinsky and Friederici, 2006), it is plausible to assume that a morphosyntactically illegal word cannot be readily incorporated into the sentence structure that is initially built up during parsing – this would entail increased difficulties in lexical-syntactic integration, suggesting a possible involvement of left posterior superior temporal areas (Grodzinsky and Friederici, 2006).

The second linguistic concept that was investigated in this paper is verb-argument structure. Again, consider the following example from German:

Example 3.

Peter hat den Apfel gegessen.
Peter has the apple eaten (Peter has eaten the apple.)

With regard to the argument structure of the sentence we can observe that the event described by the main verb (“to eat”) requires the presence of two participants: someone who is

¹ Throughout this text, both literal and non-literal translations (in brackets) will be given for all example sentences.

Download English Version:

<https://daneshyari.com/en/article/942456>

Download Persian Version:

<https://daneshyari.com/article/942456>

[Daneshyari.com](https://daneshyari.com)