Journal of Neurolinguistics xxx (2010) 1–18

Contents lists available at ScienceDirect

Journal of Neurolinguistics

journal homepage: www.elsevier.com/locate/jneuroling

Exhaustiveness effects in clefts are not truth-functional

Heiner Drenhaus [a,*], Malte Zimmermann [b], Shravan Vasishth [b]

[a] Department of Computational Linguistics & Phonetics, Saarland University, 66123 Saarbrücken, Germany
[b] Department of Linguistics, Universität Potsdam, Haus 24/35, Karl-Liebknecht-Str. 24-25, 14476 Potsdam, Germany

ARTICLE INFO

Article history:
Received 25 May 2010
Received in revised form 26 October 2010
Accepted 28 October 2010

Keywords:
ERP
It- clefts
Only-foci
Information structure
German

ABSTRACT

While it is widely acknowledged in the formal semantic literature that both the truth-functional focus particle *only* and *it*-clefts convey exhaustiveness, the nature and source of exhaustiveness effects with *it*-clefts remain contested. We describe a questionnaire study ($n = 80$) and an event-related brain potentials (ERP) study ($n = 16$) that investigated the violation of exhaustiveness in German *only*-foci versus *it*-clefts. The offline study showed that a violation of exhaustivity with *only* is less acceptable than the violation with *it*-clefts, suggesting a difference in the nature of exhaustivity interpretation in the two environments. The ERP-results confirm that this difference can be seen in online processing as well: a violation of exhaustiveness in *only*-foci elicited a centro-posterior positivity (600–800ms), whereas a violation in *it*-clefts induced a globally distributed N400 pattern (400–600ms). The positivity can be interpreted as a reanalysis process and more generally as a process of context updating. The N400 effect in *it*-clefts is interpreted as indexing a cancelation process that is functionally distinct from the *only* case. The ERP study is, to our knowledge, the first evidence from an online experimental paradigm which shows that the violation of exhaustiveness involves different underlying processes in the two structural environments.

* Corresponding author. Tel.: +49 681 302 6597; fax: +49 681 302 6560.
E-mail addresses: h.drenhaus@gmail.com (H. Drenhaus), mazimmer@uni-potsdam.de (M. Zimmermann), vasishth@uni-potsdam.de (S. Vasishth).

0911-6044/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jneuroling.2010.10.004

1. Introduction

There is a general consensus in the semantic literature that not only sentences with the exclusive focus particle *only* (1 a), but also *it*-cleft sentences (1 b) come with an exhaustive interpretation; see, for instance, Halvorsen (1978; 1976), Atlas and Levinson (1981), Horn (1981), Declerck (1988), Delin and Oberlander (1995), É. Kiss (1999; 1998), Hedberg (2000), Krifka (2008):

(1) (a) Only **[John]** FOC stole a cookie.
(b) It's **[John]** FOC that stole a cookie.

As in the *only*-focus sentence in (1 a), the cleft sentence in (1 b) seems to say that nobody else but John stole a cookie. Due to their exhaustive interpretation, both *only*-foci and focus *it*-clefts have been argued to be incompatible with certain additive particles, such as postposed *too*, cf. (2):

(2) (a) *Only **[John]** FOC, too, stole a cookie.
(b) *It's **[John]** FOC, too, that stole a cookie.

While the existence of an exhaustiveness effect in (1a) and (1b) is beyond doubt, it is not so clear that the effect arises for the same semantic or pragmatic reasons. Specifically, while it is generally acknowledged that the exhaustiveness effect in (1a) forms part of the asserted truth-functional content of the utterance (Beaver & Clark, 2008; Horn, 1969; König, 1991; Rooth, 1985), various semantic and pragmatic explanations have been proposed in order to account for exhaustiveness in *it*-clefts. While some of the proposed solutions have been rejected on theoretical grounds, others remain viable options, with the result that the issue has not been conclusively settled among theoretical linguists.

The present contribution aims at shedding light on the ongoing theoretical debate from an experimental perspective. We provide experimental evidence that the violation or cancelation of exhaustiveness effects induce distinct processing costs in different structural contexts. We do so by presenting the results of a comparison of ERP patterns in the processing of (marked) violations of exhaustiveness in semantically exhaustive *only*-foci, on the one hand, and in the processing of (marked) violations of exhaustiveness with German *it*-clefts, on the other. Our findings pertain to the larger question of how the human language processor responds to the different types of demands initiated by the tested structures.

2. Theoretical background

This section briefly lays out the theoretical background assumptions for our study. Section 2.1 gives a brief overview of semantic analyses of exhaustiveness effects with *only*-foci and *it*-clefts, pointing out which analyses remain viable options.Section 2.2 summarizes some of the major eyetracking studies on focus and *it*-clefts, and Section 2.3 introduces some relevant background information on ERP-studies. Following this, we present the experimental design and hypothesize on some possible outcomes in section 2.4.

2.1. The analysis of exhaustiveness in *only*-foci and *it*-clefts

There is a general consensus that exhaustiveness with *only*-foci enters the semantic representation as part of the asserted truth-functional content. This can be seen, for instance, by the fact that exhaustiveness can be targeted by negation, cf. (3a). Given this, the truth-conditions of ~~(1 a)~~ in terms of universal quantification are given (in simplified form) in (3b):

(3) (a) [[Not only Bill stole a cookie]] = 1 iff Bill is not the only one that stole a cookie. = somebody besides Bill stole a cookie.
(b) **stole_ a_cookie(john)** $\wedge$ $\forall$**z [stole a cookie(z)** $\rightarrow$ **z = john]**

Please cite this article in press as: Drenhaus, H., et al., Exhaustiveness effects in clefts are not truth-functional, Journal of Neurolinguistics (2010), doi:10.1016/j.jneuroling.2010.10.004

For *it*-clefts, by contrast, the situation is not as simple. Based on empirical results and theoretical considerations, the semantic literature offers four positions on the semantic or pragmatic nature of the exhaustiveness effect in (English) *it*-clefts. It has been alternatively analyzed as a

(4) (i) truth-functional effect (on par with *only*-foci) (Atlas & Levinson, 1981; É. Kiss, 1999; 1998);
(ii) conventional exhaustiveness implicature of the form *nobody but*, which is added to the asserted content (Halvorsen, 1978; 1976);
(iii) uniqueness or maximality presupposition ((Delin & Oberlander, 1995; Percus, 1997; Wedgwood, Pethö, & Cann, 2006; von Fintel & Matthewson, 2008); or a
(iv) (generalized) conversational implicature (Horn, 1981).

The different analyses make different empirical predictions concerning the behavior of *it*-clefts. For instance, we would expect *it*-clefts and their corresponding *only*-focus constructions to be synonymous on the truth-functional account (4i), cf. (1a and 1b). Conversely, we would expect *it*-clefts and their corresponding *only*-focus constructions to behave very differently on the conversational implicature account in ~~(4 iv)~~.[1] For instance, we would predict the exhaustiveness effect to be cancelable with the *it*-cleft in (1b), but not with the *only*-focus in (1a).

Horn (1981) provides strong arguments against an analysis of the exhaustiveness in *it*-clefts in terms of (4i) (truth-functional) or (4ii) (conventional implicature). First, Horn demonstrates that *it*-clefts and *only*-foci are in fact not synonymous, effectively ruling out (4i). Second, he shows that the exhaustiveness effect in *it*-clefts does not show the expected projection behavior of conventional implicatures (see, e.g. Karttunen & Peters, 1979) in negative, question, and conditional contexts, thus ruling out (4ii).

The remaining candidates (4iii) (presupposition) and (4iv) (conversational implicature) fare equally well with respect to a standard test for non-asserted (i.e. non truth-functional) content, the 'Hey, wait a minute!'-test (von Fintel, 2001). In (5a), the exhaustive meaning component in A's *it*-cleft can be questioned or suspended by B's 'Hey, wait a minute!'-response, whereas the same is not possible for the exhaustive component in *only*-foci (5b).

(5) (a) A: It's Peter that took part in the contest.
B: Hey, wait a minute! I thought there were many participants.
(b) A: Only Peter took part in the contest.
B: #Hey, wait a minute! I thought there were many participants.

However, the presupposition account and the conversational implicature account differ in other respects. An account of exhaustiveness in *it*-clefts in terms of uniqueness presuppositions is very much in line with a prominent syntactic analysis of *it*-clefts as involving a covert definite determiner (Akmajian, 1970; Percus, 1997). On this account, then, the exhaustiveness effect is effectively reduced to a uniqueness/maximality presupposition triggered by the lexical meaning of the covert determiner (Frege, 1879; Heim, 1991). Conversely, a pragmatic account of exhaustiveness in *it*-clefts in terms of a generalized conversational implicature can explain the fact that exhaustiveness effects with *it*-clefts can sometimes be absent (Horn, 1981; Prince, 1978). On the pragmatic view, the observed exhaustiveness effect would result from default pragmatic strengthening procedures on par with the default exhaustive interpretation of answers to wh-questions (Schulz & van Rooij, 2006; Spector, 2007).

In this contribution, we will not take a direct stand on the precise nature of the exhaustiveness effects in *it*-clefts as presuppositional (4iii) or as (generalized) conversational implicatures (4iv), except for a few tentative remarks in the discussion. Instead, we pursue the more modest goal of presenting experimental results which show that the violation of exhaustiveness in German *it*-clefts differs from the violation of exhaustiveness in the German *only*-focus construction, which seems to constitute a genuine semantic violation in form of a logical contradiction. By contrast, we show that the exhaustiveness effect in German *it*-clefts is not truth-functional in nature, which is in agreement with, and hence in support of, the theoretical literature.

Please cite this article in press as: Drenhaus, H., et al., Exhaustiveness effects in clefts are not truth-functional, Journal of Neurolinguistics (2010), doi:10.1016/j.jneuroling.2010.10.004

2.2. Eye-tracking research on *focus* and *it*-clefts

It is well-known that listeners detect focused information more quickly than non-focused information (Cutler & Fodor, 1979), and can also remember it better than non-focused information (Singer, 1976). Like other types of focus, *it*-clefts also facilitate processing in online sentence comprehension tasks. This fact about focus has been confirmed in numerous studies. In a probe recognition and naming task, Birch and Garnsey (1995) observed that clefted nouns are named faster and more accurately than non-clefted nouns, suggesting that it is easier to access the clefted material. Similarly, in an eyetracking study on pronoun resolution, Foraker and McElree (2007) found that clefted noun phrases were more available as antecedents for anaphoric pronouns than their non-clefted counterparts.

In related work, Sedivy, Carlson, Tanenhaus, Spivey-Knowlton, and Eberhard (1994) explored contrastive focus in the auditory modality in conjunction with visual processing. When contrastive stress was placed on an object in the visual display (the *small* blue circle) eye movements to the object were faster. When the contrast member (the *large* blue circle) was referred to in a later utterance, eye movements to the contrast member were faster in the contrastive focus condition. Thus, the main finding was that reference resolution of the focused object and the contrast member were facilitated by the presence of contrastive stress.

Similarly, in an eye-movement study of reading, Carpenter and Just (1977) found that when one of two referents was focused by a cleft or pseudocleft, and an ambiguous pronoun was present in a subsequent sentence, readers tended to make a larger proportion of regressions to the focused antecedent. The main finding was that readers are less likely to fixate on a non-focused antecedent, and this finding extends to clefts as well.

One reason that the clefted noun might have greater accessibility in memory may be that the focused item achieves a higher activation in memory because the clefted item ends up being encoded more richly. In a clefted structure like *It was John who bought a book*, an exhaustiveness interpretation must be computed: no-one but John bought a book. Processing the clefted noun would at least involve generating the exhaustiveness interpretation and associating it with the noun; these are probably the underlying processing steps that result in a richer encoding of the clefted noun in memory. Indeed, recent work by Hofmeister (2009) shows that this extra processing increases the activation of the clefted noun in memory, which in turn results in easier retrieval of the noun at a subsequent stage.

In summary, the evidence shows that clefting a noun makes it more accessible in memory once the noun has been encoded. Interestingly, evidence also exists for increased encoding cost due to clefting; this comes from an eyetracking study conducted by Birch and Rayner (1997). They compared clefted sentences such as (6a) with a non-clefted sentence (6b).

(6) (a) It was the *suburb* that received the most damage from the ice storm.
(b) Workers in the *suburb* hurried to restore power after the ice storm.

They found twice as many regressive eye movements (regressions, or leftward eye-movements while reading have been associated with increased processing effort; see, e.g., Frazier and Rayner (1982)) to the first three words of the sentence in the clefted condition compared to the non-clefted one. In addition, the probability of regressing out of the clefted word was higher (but the effect did not reach significance; in subsequent work they did find a significant effect, see Experiment 3B in Birch and Rayner (2010)). Finally, longer reading times were seen on the clefted versus non-clefted word. Birch and Rayner (1997) suggest that this is evidence for the encoding cost arising from the processing events triggered by a cleft structure (although in Birch and Rayner (2010) they found the opposite pattern, shorter first-pass reading times in the clefted versus non-clefted noun).

Thus, evidence exists for increased encoding cost of clefting—which is probably due to the cost of generating the exhaustiveness reading— and for greater accessibility of the clefted noun after it has been encoded. The presence of both effects—increased encoding cost followed by facilitation during subsequent processing—has been found in a self-paced reading study conducted by Hofmeister (2009). Further, a Hindi eyetracking study involving clefts (Vasishth et al., 2010) also showed similar results:

Please cite this article in press as: Drenhaus, H., et al., Exhaustiveness effects in clefts are not truth-functional, Journal of Neurolinguistics (2010), doi:10.1016/j.jneuroling.2010.10.004

increased encoding cost in clefted nouns, expressed as higher regression probability (similar to the result in Experiment 3B of Birch and Rayner (2010)), and easier processing of the clefted noun in re-reading time.

For the purposes of this paper, the central insight to take away from the work on focus in the eyetracking paradigm is that focused constituents in general and *it*-clefts in particular involve some processing cost initially (e.g., the higher regression probability on clefts found in Birch and Rayner (2010) and Vasishth et al. (2010)), and in *it*-clefts this increased processing cost is probably due to the comprehension mechanisms computing the exhaustiveness interpretation as soon as the clefted noun is processed.

2.3. Event-related brain potential studies on focus-marking

Event-related potentials (ERPs) provide an excellent means for investigating language processing online because ERPs have a very high temporal resolution Kutas and van Petten (1994). ERP effects (components) are characterized by a set of quantitative (peak latency) and qualitative parameters (polarity, topography, experimental sensitivity). Distinct ERP patterns have been found in response to linguistically distinct experimental manipulations. They are identified by a nomenclature which refers to their polarity (N/negativity versus P/positivity), post-stimulus peak latency and topographic distribution. Four main markers of language processing have been identified in the literature: the early left anterior negativity (ELAN), the left anterior negativity (LAN), the N400 and the P600. However, in the following we will only discuss the N400 and the P600 component because of their relevance for the interpretation of our experimental findings.

N400: The N400 is a negativity with a latency peaking typically around 400 ms after the onset of a critical element. It has a centro-parietal bilateral (sometimes also global) distribution often with a slight right hemisphere focus. It has been shown that this component reflects the cost of (semantic) integration of non-stereotypical events and/or elements which do not fit with the (extra) linguistic context-expectancy (e.g. Kutas & Hillyard, 1980; 1983; Nieuwland & Kuperberg, 2008). Compare (7a) and (7b).

(7) (a) He drank a glass of **coke**.
(b) He drank a glass of **rocks**.

Additionally, Kutas and Hillyard (1984) and Kutas and Federmeier (2000) showed that the N400 is modulated by the structure of semantic memory. In other studies, N400 effects were elicited by lexico-semantic factors as well as thematic role assignment (e.g. Hoeks, Stowe, & Doedens, 2004; Friederici & Frisch, 2000). Semantic integration and expectancy N400s were also reported at discourse level (e.g. van Berkum, Hagoort, & Brown, 1999).

Crucially for the discussion to come, the N400 cannot be taken as an indicator of truth-value violations. Fischler, Bloom Childers, Roucos, and Perry (1983) showed that sentences that differ in truth value but that contain semantically related words do not generate an N400. For instance, no differences in N400 amplitude were found for the false (8a) versus the correct (8b). Compare this with the N400 effects in (9a) versus (9b).

(8) (a) #A robin is not a bird.
(b) A robin is a bird.

→ no difference in the N400 amplitude

(9) (a) A robin is not a tree.
(b) #A robin is not a bird.

→ an enlarged N400 amplitude for the false and non-fitting (a) compared to (b)

Please cite this article in press as: Drenhaus, H., et al., Exhaustiveness effects in clefts are not truth-functional, Journal of Neurolinguistics (2010), doi:10.1016/j.jneuroling.2010.10.004

P600: The so-called P600 (late Positivity) is a positivity peaking between 600 and 900 ms with a centro-parietal distribution and has been associated with (syntactic) reanalysis and repair (e.g. Osterhout & Holcomb, 1992). Additionally, this component has been found in response to enhanced syntactic complexity (e.g. Kaan, Harris, Gibson, & Holcomb, 2000; Friederici, Hahne, & Saddy, 2002). However, in recent work the idea of a purely syntactically related component has been questioned. Some studies showed the P600 component can also be induced when a semantic anomaly or violation ~~(2.3)~~ was detected (e.g. van Herten, Kolk, & Chwilla, 2005); see also Kolk, Chwilla, van Herten, and Oor (2003). However, the interpretation of a semantic P600 is not without controversy—for example, Bornkessel-Schlesewsky and Schlesewsky (2008) argued that the phenomenon of semantic P600s is language-specific and is only found in languages with fixed word order (English and Dutch). Similar manipulations elicit N400 effects in languages with a free word order (e.g. German).

(10)*De kat die voor de muizen vluchtte rende door de kamer
'The cat that fled from the mice ran across the room (paraphrase)'

Additionally, a P600 effect/Positivity was found in licensing violations of German negative polarity items in (11a) versus (11b) (Drenhaus, Saddy, & Frisch, 2005; 2006). The (semantic/pragmatic) P600 follows directly under the assumption of semantic/pragmatic licensing of negative polarity items (e.g. Ladusaw, 1980).

(11)(a) **Kein** Mann, der einen Bart hatte, war jemals glücklich.
'No man who had a beard was ever happy'

(b) ***Ein** Mann, der **keinen** Bart hatte, war jemals glücklich.
'A man who had a beard was ever happy'

→ P600 on the unlicensed negative polarity jemals 'ever' in (11b) compared to the grammatical licensing environment (11a).

Since a logical contradiction constitutes a semantic violation one might therefore expect a P600/Positivity to show with exhaustiveness violations with *only*-foci and *it*-clefts if the exhausted meaning component were to constitute a conventionalized part of the meaning of these structures.

Focus structure, it-clefts and the violation of information structure: With regard to the topic of our paper, we will highlight only some of the studies which are relevant for the discussion of our data later.

Cowles, Kluender, Kutas, and Polinsky (2007) tested in an ERP study whether readers made use of focus structure to resolve the information structure of sentences (see also, Cowles, 2003). They presented participants with contexts followed by congruent target sentences (12a) or incongruent target sentences (12b), respectively.

(12) Context: A queen, an advisor, and a banker were arguing over taxes. Who did the queen silence with a word, the banker or the advisor?
(a) It was the banker that the queen silenced.
(b) It was the queen that silenced the banker.

They found a lateralized negativity between 200 ms and 500 ms on the noun *queen* (12b) compared to *banker* (12a) which the authors interpreted as an N400. Additionally, the authors reported a large positivity (P3b) for all words in the focus-marking (cleft) position. This positivity was interpreted as a marker for integration which was triggered by the focused elements in the question-context. In general, the authors highlight with their results that readers are using restrictions of the discourse and structural focus information online to process sentences.

Bornkessel, Schlesewsky, and Friederici (2003) tested the processing of clause-medial word order variations in German question answer-pairs. They observed a negativity for object-initial sentences in

Please cite this article in press as: Drenhaus, H., et al., Exhaustiveness effects in clefts are not truth-functional, Journal of Neurolinguistics (2010), doi:10.1016/j.jneuroling.2010.10.004

a neutral context which was explained as a reflex of local processing difficulty. Additionally, they found a parietal positivity (280–480ms) on the focused (questioned) initial objects and initial subjects, respectively. Bornkessel et al. (2003) suggested that the elicited positivity can be interpreted as an effect of structural focus processing or rather focus integration.

Stolterfoht and Bader (2004) studied word order variations in German. The structures in (13) are ambiguous. Until the parser reaches the auxiliary, the subject of the canonical structure (13a) or of the non-canonical structure (13b) can either be die neue Lehrerin 'the new teacher' or einige der Kollegen 'some the colleagues'. Additionally, the sentences in (13) have a different focus structural representation. (13a) has a wide focus reading, whereas a narrow focus on the second NP and the verb is required for (13b). In other words, the disambiguation in structures like (13b) would not only involve a reanalysis process but also an adjustment of the focus structure (under the assumption that the focus structure in (13a) is the default structure (Bader, 1998)).

(13) (a) …, das [die neue Lehrerin$_{subject}$ einige der Kollegen$_{object}$ angerufen hat]FOC
… that the new teacher some the colleagues phoned has.
… that the new teacher phoned some of the colleagues.

(b) …, das die neue Lehrerin$_{object}$ [einige der Kollegen$_{subject}$ angerufen haben]FOC
… that the new teacher some the colleagues phoned have.
… that some of the colleagues phoned the new teacher.

The authors found a positivity and a right central negativity (500–600ms) for structures like (13b) at the disambiguation point (auxiliary). They interpreted the positivity as the reflex of syntactic reanalysis and the negativity as a focus structural revision process. Finally, Stolterfoht, Friederici, Alter, and Steube (2007) investigated the processing of contrastive ellipsis (replacives) with the focus particle *nur* 'only' in German. In their ERP study, they found on the contrasted constituent a positivity (350–1300ms) and a negativity between 450 ms and 650 ms. The positivity was interpreted as a correlate of focus structural processing and the negativity as a reflection of implicit prosodic processing.

The above overview of focus, *it*-clefts and the violation of information structure does not give a conclusive picture of the interpretive properties of the focus-clefted constituent. While some studies reported positivities; others found negativities. The reason for these differences might be that these studies tested and compared different types of structures (e.g. complement clauses versus *it*-clefts). Additionally, some studies examined sentences with context and other studies tested sentences without context.

2.4. Predictions

In order to test for the nature of the exhaustiveness effect with *it*-clefts and *only*-foci in German, we compare the ERP patterns in the processing of (marked) non-exhaustive German *it*-clefts (14b) versus their (unmarked) exhaustive counterparts (14a); we also compare the processing of (marked) violations of exhaustiveness in German *only*-foci (15b) versus the processing of their (unmarked) exhaustive counterparts(15a).

(14) (a) Es ist Maria, die das Klavier spielen kann und auβerdem noch die Geige, sagte…
[*it* -cleft, [+exh]: unmarked]

(b) Es ist Maria, die das Klavier spielen kann und auβerdem noch Luise und Jana, sagte…
[*it* -cleft, [-exh]: marked]
It is Mary that plays the piano and, besides, the violin [+exh]/Luise and Jana [- exh], said …

(15) (a) Nur Maria kann das Klavier spielen und auβerdem noch die Geige, sagte…
[*only* -focus, [+exh]: unmarked]

Please cite this article in press as: Drenhaus, H., et al., Exhaustiveness effects in clefts are not truth-functional, Journal of Neurolinguistics (2010), doi:10.1016/j.jneuroling.2010.10.004

(b) Nur Maria kann das Klavier spielen und auβerdem noch Luise und Jana, sagte…
[*only* -focus, [-exh]: marked]
Only Mary can play the piano and, besides, the violin [+exh]/Luise and Jana [-exh], said …

If *it*-clefts and *only*-foci have an identical truth-functional interpretation, we would expect the (a) and (b) sentences in the pairs in (11) and (12) to pattern alike. If, on the other hand, the two structures were to involve different processes, we would expect distinct ERP patterns to arise.

3. Experimental investigations

3.1. Questionnaire

As a pretest we carried out a questionnaire study. The goal was to investigate the acceptability of violations of exhaustiveness in German *it*-clefts and *only*-foci structures (14 b and 15 b) compared to their unmarked counterparts (~~14 a and 15 a~~).

3.1.1. Participants

80 students of the university of Potsdam (mean age 23 years, 17 male) participated in this experiment after giving informed consent. They were all monolingual speakers of German and received course credits for their participation. 14 participants were excluded from the analysis because they did not fill in the questionnaire, or because they judged semantically or syntactically ungrammatical filler sentences as grammatical.

3.1.2. Methods and design

Participants rated the acceptability of 40 sentences on a six point scale, with 1 representing the highest and 6 representing the lowest degree of acceptability (German school marking system). Participants were instructed to judge the acceptability of the sentences. The extreme values of the scale were illustrated in the instruction section of the questionnaire. We designed 32 sets of critical sentences (*it*-clefts and *only*-foci). The sentences were split into 8 different versions of the questionnaire. Each version contained 4 marked and 4 unmarked *it*-clefts (14a and 14b) and 4 marked and 4 unmarked *only*-foci (15a and 15b). Additionally, there were 24 unrelated filler sentences (50% grammatical and 50% ungrammatical).

3.1.3. Results

On the scale from 1 (best) to 6 (worst) the marked (non-exhaustive) *it*-cleft condition got a mean rating of 2.8 (se 0.0756) compared to their unmarked (exhaustive) counterparts 2.4 (se 0.0723). In the *only*-foci condition we find a mean rating score of 3.7 (se 0.0844) for the marked (non-exhaustive) condition and a mean rating score of 2.6 (se 0.0797) for unmarked (exhaustive) condition, respectively (cf. Fig. 1).

The statistical analysis on participants' ratings was done by fitting a linear mixed model (LMM) ~~Bates and Sarkar (2007)~~.[1] We used participants and items as random factors. The exhaustiveness violation in *it*-clefts and in *only*-foci were used as fixed factor (contrast coding in each case: -0.5 for the (marked) non-exhaustive condition, and $+0.5$ for the (unmarked) exhaustive condition). Additionally, we calculated the the interaction in order to test whether the exhaustiveness violation has a different impact in *it*-clefts compared to *only*-foci. In LMMs, the degrees of freedom are difficult to compute due to partial pooling; however, an absolute t-value of 2 or greater corresponds to significance at the α level 0.05 (Gelman & Hill, 2007).

The analysis revealed that there is a significant effect for the exhaustiveness violation in *it*-clefts (coefficient 0.3552, se 0.0938, $t = 3.786$)) and for the exhaustiveness violation in *only*-foci (coefficient 1.0543, se 0.1299, $t = 8.115$). Additionally, we found an interaction (coefficient -0.34937, se 0.06596, $t = -5.297$). The results show that, on the one hand, participants rated an exhaustiveness violation less acceptable in *it*-clefts and in *only*-foci respectively. On the other hand, the interaction suggest that the violation of exhaustiveness in *only*-foci is less acceptable than in *it*-clefts. In other words,

Please cite this article in press as: Drenhaus, H., et al., Exhaustiveness effects in clefts are not truth-functional, Journal of Neurolinguistics (2010), doi:10.1016/j.jneuroling.2010.10.004

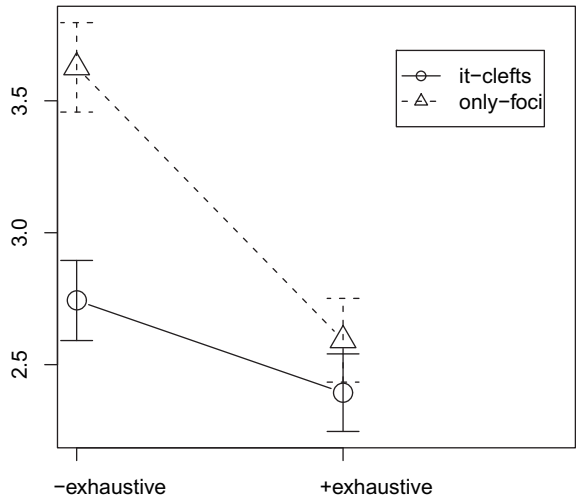

Fig. 1. Questionnaire: *it*-clefts and *only*-foci (Means with confidence intervals (95%))

exhaustiveness or rather the violation of exhaustiveness may have a different status in the tested structures[1].

3.2. The ERP study on *it*-clefts and *only*-foci

3.2.1. Participants

16 undergraduate students (mean age 24 years, 2 male) from the University of Potsdam participated in this experiment towards fulfilling curricular requirements; participants gave informed consent. All participants were monolingual, right-handed and had normal or corrected-to-normal vision.

3.2.2. Material

We constructed 4 versions with 92 critical sentences each (23 per condition) like those in (7) and (8) intermixed with 92 unrelated filler sentences from other experiments.

3.2.3. Procedure

Participants were seated around 100 cm in front of a 17" computer screen in a separately grounded SIEMENS pure-iron shielding cabin. Sentences were presented in grey letters on a blue background in a 28-point Times font. Each sentence was preceded by a fixation cross. The sentences were presented in a pseudorandomized order. EEG recording was performed on an IBM-compatible Pentium I using the recording software Xrefa (Novagk, 1998). ERTS (Experimental Run Time System, Beringer (1996)) was used to present the stimuli and to mark the relevant points (setting triggers). ERTS was installed on an IBM-compatible Pentium PC connected to the EEG recording computer. Responses were recorded with

[1] An anonymous reviewer points out that the *only*-violation received only a mean rating of 3.7 compared to the mean rating of 2.8 in *it*-clefts violations. It may be surprising to the reader that the ratings do not have more extreme values. It is possible that the ungrammatical filler sentences (violation of negative polarity licensing, violation of the word order in subordinated sentences as well as phrase structure violations) had an impact on the judgment in the questionnaire; the *only*-violation and the *it*-cleft violation may have received a better score had these fillers not been present. However, the important point here is that we are interested in relative differences between the two sets of conditions; absolute scores are not central to the discussion.

Please cite this article in press as: Drenhaus, H., et al., Exhaustiveness effects in clefts are not truth-functional, Journal of Neurolinguistics (2010), doi:10.1016/j.jneuroling.2010.10.004

the ERTS ExKey Keyboard Logic System (BeriSoft Corporation, Beringer, 1996). First, 12 training sentences were presented. After this training set, the 92 critical sentences and the 92 filler sentences were randomly presented in the center of a screen, with 400 ms (plus 100 ms interstimulus interval) for each unit (indicated by brackets in (16)).

(16) ***it*-cleft [+exh]**: [Es ist Maria,] [die] [das Klavier] [spielen kann] und [auβerdem noch] [die Geige,] [sagte] [der Lehrer.]

***it*-cleft [-exh]**: [Es ist Maria,] [die] [das Klavier] [spielen kann] und [auβerdem noch] [Luise und Jana,] [sagte] [der Lehrer.]

***only*-focus [+exh]**: [Nur Maria] [kann] [das Klavier] [spielen] [und] [auβerdem noch] [die Geige,] [sagte] [der Lehrer.]

***only*-focus [-exh]**: [Nur Maria] [kann] [das Klavier] [spielen] [und] [auβerdem noch] [Luise und Jana,] [sagte] [der Lehrer.]

500 ms after the last phrase of each sentence a single noun was presented on the screen for 400 ms (Probe detection). The task was to judge within a maximal interval of 3000 ms by pressing one of two buttons whether this noun was part of the sentence the participant had read before (probe detection). The distribution of probes was balanced over the conditions (50% correct probes and 50% incorrect probes, respectively). 1000 ms after their response, the next trial began. The EEG was recorded by means of 16 AgACl shielded electrodes fixed in elastic caps (EasyCap) with a sampling rate of 250 Hz (with impedances $<$ 5k Ohm) and were referenced to the left mastoid (re-referenced to linked mastoids offline). Following the nomenclature proposed by the American Electroencephalographic Society (Sharbrough et al., 1995) the electrodes were placed on the scalp. The horizontal electrooculogram (EOG) was monitored with two electrodes placed at the outer canthus of each eye and the vertical EOG with two electrodes above and below the right eye. The data from all channels was recorded with a 32-channel PORTI-32/MREFA TMS-Amplifier. During recording no online filters were used.

3.3. Behavioral data—probe detection

Accuracy percentages and response latencies of the probe detection task (cf., Table 1 and Figures 2, 3) were analyzed, even though there was no specific hypothesis for this data. It is important to mention that the probe detection task was a measure that was intended to ensure that participants really attended to words in the experimental sentences.

We performed a statistical analysis for accuracy and log-transformed reaction times by fitting a linear mixed model (LMM) Bates and Sarkar (2007). For analyzing accuracy we used a generalized linear mixed model with a logistic link function. The violation of exhaustiveness in *it*-clefts was used as fixed factor (contrast coding: -0.5 for the (marked) non-exhaustive condition, and $+0.5$ for the (unmarked) exhaustive condition) and *only*-focus conditions (contrast coding: -0.5 for the (marked) non-exhaustive condition, and $+0.5$ for the (unmarked) exhaustive condition). Participants and items were used as random factors. In the *it*-clefts, no effect was found in the accuracy measure of (marked) exhaustiveness violation. However, there was an effect in the reaction time data (coefficient 0.0693, se 0.0255, $t = 2.71$). In the *only*-foci analysis we found an effect for (marked) exhaustiveness in accuracies (coefficient -1.2365, se 0.3826, $z = -3.232$) and reaction times (coefficient 0.0687, se 0.0254, $t = 2.7$)[2].

[2] An anonymous reviewer pointed out that in these types of tasks participants might not read normally for comprehension, but instead build a set of possible probes. It might be that probe detection induces a strategy of some sort. However, the results are replicated across methods. Our results are in line with the results of an offline study by Onea and Beaver (2009). Hence, we think that participants are not just doing probe monitoring in our experiment. Crucially, if participants were following probe-monitoring strategies it is is hard to explain why we find different pattern for *it*-clefts and *only*-focus in our ERP-results.

Please cite this article in press as: Drenhaus, H., et al., Exhaustiveness effects in clefts are not truth-functional, Journal of Neurolinguistics (2010), doi:10.1016/j.jneuroling.2010.10.004

Table 1
Mean accuracies (percentages) and reaction times (ms) for all four conditions.

	accuracy in %	reaction times (log-transformed)
it-**cleft [+exh]**	93.21	6.69
it-**cleft [-exh]**	91.92	6.76
only-**foci [+exh]**	98.12	6.67
only-**foci [-exh]**	91.25	6.74

3.4. The ERP data

Only trials without artifacts were selected for the ERP analysis. The ERP data were filtered with 0.2 Hz (high pass) to compensate for drifts. Single-participant averages were computed in a 1200 ms window relative to the onset of the critical item (*die Geige* 'the violin' and *Luise und Jana* 'Luise and Jana') and aligned to a 200 ms pre-stimulus baseline. Two time windows were analyzed: 400–600ms for the N400 and 600–800ms for the P600 effects. Additionally, we conducted a third analysis (300–800ms) in order to investigate the differences between *it*-clefts and *only*-foci in the same time window.

3.4.1. Descriptive results

The ERP patterns from the onset of the critical element (*die Geige* 'the violin', onset at 0 ms up to 1200 ms thereafter) are displayed in Figs. 4 and 5. As can be seen from Fig. 3 (*it*-cleft conditions), ERPs in the (marked) non-exhaustive (14b) condition show a negativity that is broadly distributed compared to the (unmarked) exhaustive condition (14a). The negativity starts at around 400 ms and has a time window between 400 and 600 ms. From the ERP literature this effect can be interpreted as an N400 effect (see, section 2.3 and section 3.4.2 for the statistical analysis). By contrast, the ERPs in the *only*-foci conditions reveal a centro-parietal distributed positivity at between 600 and 800 ms for the (marked) non-exhaustive ~~(15 b)~~ condition compared to the (unmarked) exhaustive condition ~~(15 a)~~, see Fig. 4. This positivity can be interpreted as an P600 effect (see, section 2.3 and section 3.4.2 for the statistical analysis).

3.4.2. Statistical analyses

We fit a linear mixed model (LMM) Bates and Sarkar (2007) with ERP values averaged over items for each participant as dependent measure. Fixed factors were the exhaustiveness violation in clefts

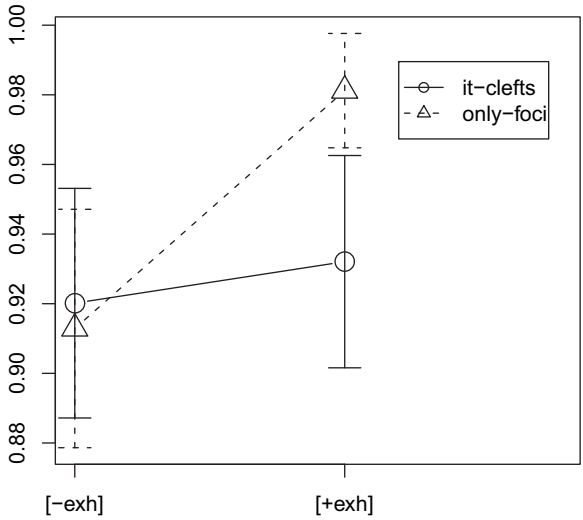

Fig. 2. Probe detection (Accuracies).

Please cite this article in press as: Drenhaus, H., et al., Exhaustiveness effects in clefts are not truth-functional, Journal of Neurolinguistics (2010), doi:10.1016/j.jneuroling.2010.10.004

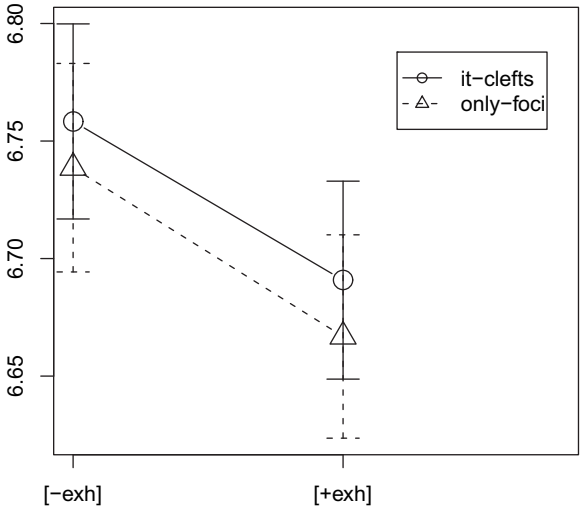

Fig. 3. Reaction times (log-transformed).

(contrast coding: −0.5 for the non-exhaustive condition, and +0.5 for the exhaustive condition) and only-focus conditions (contrast coding: −0.5 for the non-exhaustive condition, and +0.5 for the exhaustive condition). Participants were used as a random factor.

As mentioned above, in the *it*-cleft conditions, visual inspection revealed a globally distributed N400 pattern in the 400–600 ms window. The LMM analysis, collapsing over the nine channels (F3, FZ, F4, C3, CZ, C4, P3, PZ, P4), showed that this effect was significant (coefficient −1.9544, se 0.6964, $t = -2.8$). The centro-posterior positivity in the 600–800 ms window did not reach significance ($t < 1$). In the *only*-focus conditions, the observed centro-parietal positivity in the 600–800 window was statistically significant (coefficient 4.5810, se 1.1131, $t = 4.12$); this positivity was unaffected even when the three frontal electrodes were included in the analysis.

In order to compare the ERP response in *it*-clefts and *only*-foci within the same time window, we carried out a further analysis over a longer time window (300–800 ms); all nine electrodes were collapsed together. Here, we compared statistical models that either had only participants as random effects, or also had a separate slope term for each participant for the *it*-clefts and *only*-foci conditions (the so-called random intercepts and slopes model (Gelman & Hill, 2007)). The model with random slopes and intercepts was the best-fitting model, and showed no effect of exhaustiveness violations in clefting, whereas in the *only*-focus condition a positivity was found (*it*-clefts coefficient −0.6050, se 0.5781, $t = -1.047$; only coefficient 3.0463, se 0.6546, $t = 4.654$).

4. Discussion

In the present study, we found a globally distributed negativity (400–600 ms window) when an exhaustiveness violation occurred in *it*-clefts, but a centro-parietal positivity (600–800 ms window) when an exhaustiveness violation occurred in *only*-foci. The negativity observed with *it*-clefts can be interpreted as an N400 effect (compare, Kutas & Hillyard, 1980; 1983; Nieuwland & Kuperberg, 2008). As mentioned in section 2.3, this effect can be taken as an indicator of a semantic/pragmatic integration process which is typically triggered by the processing of non-stereotypical events. In the case of non-exhaustive *it*-clefts, we contend that the non-stereotypical event is constituted by the violation of exhaustiveness itself. In this connection, it is important to keep in mind that truth-value violations do not generate an N400 effect (Fischler et al., 1983). This suggests that the violation of exhaustiveness with *it*-clefts does not constitute a semantic violation.

Please cite this article in press as: Drenhaus, H., et al., Exhaustiveness effects in clefts are not truth-functional, Journal of Neurolinguistics (2010), doi:10.1016/j.jneuroling.2010.10.004

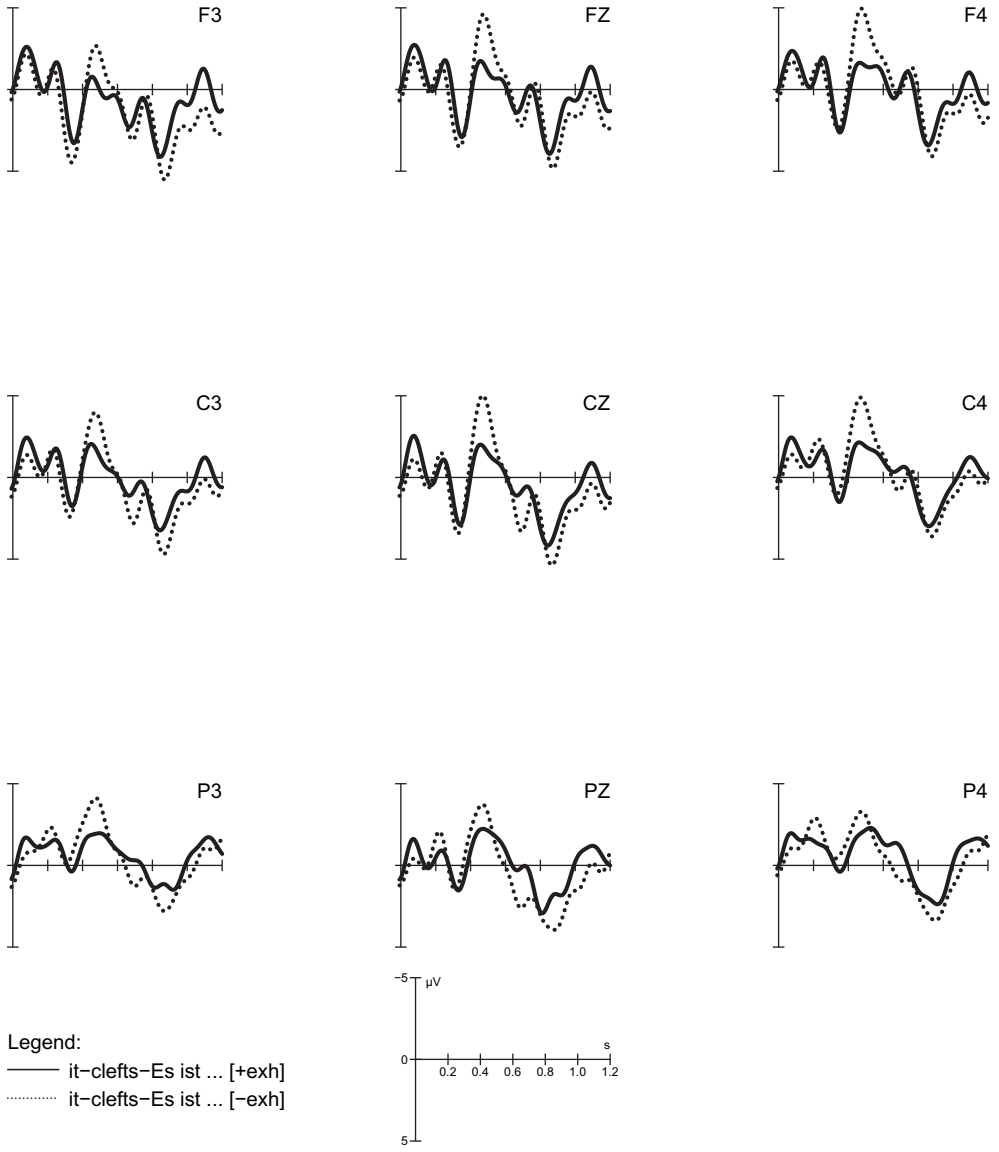

Fig. 4. *It*-**clefts**: ERP effects on the critical element(s) *die Geige* 'the violin' and *Luise und Jana* 'Luise und Jana' from the onset at 0 ms up to 1200 ms at a subset of nine electrodes. Negativity is plotted upwards. The solid line displays the unmarked (exhaustive) condition and the dotted line displays the marked (non-exhaustive) condition. For presentation purpose only, ERPs were filtered offline with 8 Hz low pass.

Bornkessel et al. (2003) and Cowles (2003); Cowles et al. (2007) reported increased positivities for clefts and interpret this as an attempt to integrate information. Cowles et al. (2007) observed an increased negativity (or less positivity) for an incongruent clefted noun compared to the congruent clefted noun. The authors interpreted their effect as an N400. They suggested two alternative ways to interpret their findings; namely, incongruence between focus assignment and preceding context or as a disruption of thematic processing. As they pointed out, both suggestions are compatible with a semantic interpretation of the N400 effect. However, none of the studies mentioned directly

Please cite this article in press as: Drenhaus, H., et al., Exhaustiveness effects in clefts are not truth-functional, Journal of Neurolinguistics (2010), doi:10.1016/j.jneuroling.2010.10.004

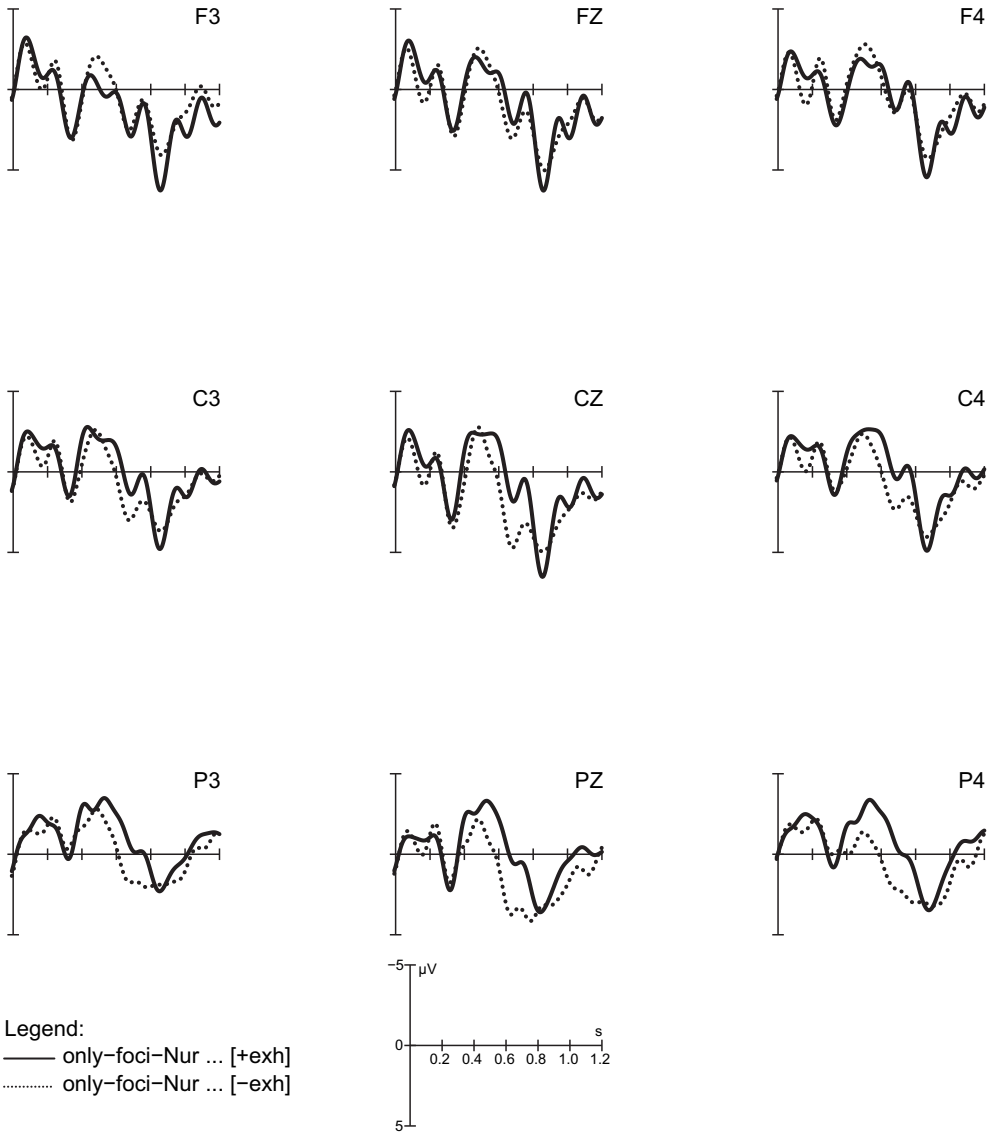

Fig. 5. *Only*-**foci**: ERP effects on the critical element(s) die Geige 'the violin' and Luise und Jana from the onset at 0 ms up to 1200 ms at a subset of nine electrodes. Negativity is plotted upwards. The solid line displays the unmarked (exhaustive) condition and the dotted line displays the marked (non-exhaustive) condition. For presentation purpose only, ERPs were filtered offline with 8 Hz low pass.

considers the consequences of violating the exhaustiveness interpretation generated by *it*-clefts and *only*; this makes it difficult to directly relate their findings to ours.

The negativity associated with *it*-clefts in our study can be interpreted as a reflex of integrating an unexpected element pragmatically (since truth-value violations do not generate an N400 Fischler et al. (1983)). Specifically, the mechanism of exhaustiveness cancelation is hypothesized to operate as follows: when the parser reaches the critical region of the exhaustiveness violation (*Luise and Jana*) it expects a different grammatical role/different animacy information (Bornkessel & Schlesewsky, 2006; Friederici & Frisch, 2000; Frisch & Schlesewsky, 2001, 2005; Hoeks et al., 2004), and therefore attempts to delete

Please cite this article in press as: Drenhaus, H., et al., Exhaustiveness effects in clefts are not truth-functional, Journal of Neurolinguistics (2010), doi:10.1016/j.jneuroling.2010.10.004

the exhaustiveness interpretation generated when the cleft was processed (recall that the eyetracking evidence discussed in Section 2.2 suggests that such an exhaustiveness interpretation is generated at the cleft). This cancelation process is presumably reflected in the negativity seen in *it*-clefts.

There are other reasons to believe that the negativity we find is of a different nature than that observed by Cowles et al. (2007). The negativity reported in our study shows a stronger peak compared to the study of Cowles et al. (2007). Additionally, Cowles et al. negativity started earlier and lasted longer (200–800ms) compared to our negativity (400–600ms). In addition, compared to our study, a smaller amplitude was elicited in Cowles' study; this was perhaps a result of the experimental design (context sentence followed by the target sentence). Evidence for this comes from van Berkum et al. (1999) and van Berkum, Zwitserlood, Hagoort, and Brown (2003), who showed that the amplitude of the N400 is reduced when a context sentence precedes the critical element in a certain sentence context.

Regarding the *only*-foci exhaustiveness violation, if the underlying mechanism for exhaustiveness cancelation were identical to that of *it*-clefts, we would have expected to see a negativity on the critical element, analogous to the *it*-cleft case. However, a positivity was found with *only*-foci. This can be interpreted either as an indicator of general reanalysis, or even as an indicator of a semantic violation (van Herten et al., 2005, see section 2.3). The positivity might be related to the results of Stolterfoht et al. (2007) (compare section 2.3) who interpreted their positivity as a reanalysis process and the mapping of different linguistic information (following the model of sentence processing by Friederici et al., 2002).

There is another possible interpretation for the positivity found in our study. For example, Coulson, King, and Kutas (1998) and Gunter, Stowe, and Mulder (1997) argued that a late positivity can be related to another component, namely the P3b (Donchin & Coles, 1988). This component is sensitive to expectancy. The less an event is expected, the more chance there is that the event is due to erroneous processing. Hence, it is seen as an indication for the actualisation and updating of a mental model (see also, Polich, 2007). In this sense, the findings for *only*-foci suggest that the underlying mechanism for exhaustiveness is qualitatively different from *it*-clefts, and may require the processor to check the veridicality of the exhaustiveness violation in *only*-foci.

Finally, the comparison of the observed patterns with exhaustiveness violations in *it*-clefts and *only*-foci in the larger 300–800 ms window showed no effect in the *it*-cleft condition, but a positivity in the *only*-focus condition. Taken together, these results suggest that the exhaustiveness violations in *it*-clefts versus *only*-foci involve qualitatively different processing mechanisms and can hence be seen as involving different generators. This is consistent with claims in the theoretical literature that exhaustiveness violations in *it*-clefts are not on par with those *only*-foci. They may constitute either a presupposition failure or a cancelation of a conversational implicature.

From a cross-linguistic perspective, these findings tie in with the results of an experimental study on the well-known exhaustiveness effect in the Hungarian preverbal focus position. Based on an offline text completion task, Onea and Beaver (2009) show that there is indeed an exhaustiveness effect observed with preverbal foci in Hungarian. However, this exhaustiveness effect is not as strong as the one observed with the truth-functional exclusive particle *csak* 'only', contra claims in the literature by É. Kiss (1998; 1999), among others.

Turning back to the primary focus of our study, observe, again, that the choice between the two remaining options for the source of exhaustiveness, namely presupposition and conversational implicature, is not simply a choice between two otherwise equal semanto-pragmatic analyses. Rather, it has far-reaching consequences for our conception of the syntax–semantics interface with *it*-clefts. If the exhaustiveness effect indeed turned out to be presuppositional in nature, it would seem to be hard-wired in the linguistic form of the cleft, possibly in form of a covert definite description (as argued in Percus (1997), see section 2.1). On its alternative analysis as a (generalized) conversational implicature (Horn, 1981), by contrast, the exhaustiveness effect would not be coded in the structure of the *it*-cleft. Instead, it would be the result of a default pragmatic strengthening procedure that hearers apply, presumably in order to justify the use of a non-canonical, and uneconomical, cleft-structure by the speaker.

Given this central difference in terms of structural coding, the two analyses make a number of different predictions that can be empirically evaluated. We are currently pursuing these questions in ongoing work.

Please cite this article in press as: Drenhaus, H., et al., Exhaustiveness effects in clefts are not truth-functional, Journal of Neurolinguistics (2010), doi:10.1016/j.jneuroling.2010.10.004

5. Conclusion

This study is, to our knowledge, the first online study that demonstrates the difference between exhaustiveness cancelation in *it*-clefts versus *only*-foci that has been proposed in the theoretical literature (e.g., Horn (1981)). The comparison of ERP patterns in these two conditions suggests that the exhaustiveness effect is triggered by different factors in the two structural environments. In particular, the differences found with *only*-foci and *it*-clefts suggest strongly that the exhaustiveness effect in *it*-clefts is not a truth-functional effect; this is consistent with proposals in the linguistic literature on the topic. It remains unclear whether exhaustiveness is a conventional meaning component of *it*-clefts, or whether its frequent occurrence with *it*-clefts is merely due to (default) pragmatic strengthening; this is an issue we intend to address in future research.

References

Akmajian, A. (1970). On deriving cleft sentences from pseudo-cleft sentences. *Linguistic Inquiry, 1*, 149–168.

Atlas, J., & Levinson, S. (1981). It-clefts, informativeness, and logical form. In P. Cole (Ed.), Radical Pragmatics., *pages 1–62*. New York: Academic Press.

Bader, M. (1998). Prosodic influences on reading syntactically ambiguous sentences. *Reanalysis in Sentence Processing* 1–46.

Bates, D. and Sarkar, D. (2007). lme4: Linear mixed-effects models using S4 classes. R package version 0.9975-11.

Beaver, D., & Clark, B. (2008). *Sense and Sensitivity: How focus Determines meaning*. Malden, MA: Wiley-Blackwell.

Beringer, J. (1996). Experimental runtime system (erts). Technical report, TH Darmstadt.,

Birch, S., & Rayner, K. (2010). Effects of syntactic prominence on eye movements during reading. *Memory & Cognition, 38*(6), 740.

Birch, S. L., & Garnsey, S. M. (1995). The effect of focus on memory for words in sentences. *Journal of Memory and Language, 34*(2), 232–267.

Birch, S. L., & Rayner, K. (1997). Linguistic focus affects eye movements during reading. *Memory and Cognition, 25*(5), 653–660.

Bornkessel, I., & Schlesewsky, M. (2006). The extended argument dependency model: a neurocognitive approach to sentence comprehension across languages. *Psychological Review, 113*(4), 787–821.

Bornkessel, I., Schlesewsky, M., & Friederici, A. (2003). Contextual information modulates initial processes of syntactic integration: the role of inter-versus intrasentential predictions. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29*(5), 871.

Bornkessel-Schlesewsky, I., & Schlesewsky, M. (2008). An alternative perspective on. *Brain Research Reviews, 59*(1), 55–73.

Carpenter, P. A., & Just, M. A. (1977). Reading comprehension as the eyes see it. In M. A. Just, & P. A. Carpenter (Eds.), *Cognitive processes in comprehension* (pp. 109–139). Hillsdale, NJ: Erlbaum.

Coulson, S., King, J., & Kutas, M. (1998). Expect the unexpected: event-related brain response to morphosyntactic violations. *Language and Cognitive Processes, 13*(1), 21–58.

Cowles, H. (2003). Processing information structure: Evidence from comprehension and production. PhD thesis, University of California, San Diego.

Cowles, H., Kluender, R., Kutas, M., & Polinsky, M. (2007). Violations of information structure: an electrophysiological study of answers to wh-questions. *Brain and Language, 102*(3), 228–242.

Cutler, E. A., & Fodor, J. A. (1979). Semantic focus and sentence comprehension. *Cognition, 7*, 49.

Declerck, R. (1988). *Studies on copular sentences, clefts, and pseudo-clefts Leuven. Symbolae Facultatis Litterarum et Philosophiae Lovaniensis*. In *Series C, Linguistica, vol. 5*. Belgium, Leuven: Leuven University Press, Foris Publications Series.

Delin, J., & Oberlander, J. (1995). Syntactic constraints on discourse structure: the case of it-clefts. *Linguistics, 33*(3).

Donchin, E., & Coles, M. (1988). Is the P300 component a manifestation of context updating? *Behavioral and Brain Sciences, 11*(3), 357–427.

Drenhaus, H., beim Graben, P., Saddy, D., & Frisch, S. (2006). Diagnosis and repair of negative polarity constructions in the light of symbolic resonance analysis. *Brain and Language* 255–268.

Drenhaus, H., Saddy, D., & Frisch, S. (2005). Processing negative polarity items: when negation comes through the backdoor. In S. Kepser, & M. Reis (Eds.), *Linguistic Evidence: Empirical, theoretical, and Computational Perspectives* (pp. 145–165). Berlin: Mouton de Gruyter (Studies in Generative Grammar 85).

Kiss, K. É (1998). Identificational focus vs. information focus. *Language, 74*(2), 245–273.

Kiss, K. É (1999). The English cleft-construction as a focus phrase. In L. Mereu (Ed.), *Boundaries of Morphology and syntax* (pp. 217–229). Amsterdam: Benjamins.

Fischler, P., Bloom Childers, D., Roucos, S., & Perry, N. (1983). Brain potentials related to stages of sentence verification. *Psychophysiology, 20*, 400–409.

Foraker, S., & McElree, B. (2007). The role of prominence in pronoun resolution: active versus passive representations. *Journal of Memory and Language, 56*(3), 357–383.

Frazier, L., & Rayner, K. (1982). Making and correcting errors during sentence comprehension: eye movements in the analysis of structurally ambiguous sentences. *Cognitive Psychology, 14*, 178–210.

Frege, G. (1879). *Begriffsschrift, eine der arithmetischen nachgebildete Formelsprache des reinen Denkens*. (L. Nebert, Halle a.S).

Friederici, A., & Frisch, S. (2000). Verb argument structure processing: the role of verb-specific and argument-specific information. *Journal of Memory and Language, 43*(3), 476–507.

Friederici, A., Hahne, A., & Saddy, D. (2002). Distinct neurophysiological patterns reflecting aspects of syntactic complexity and syntactic repair. *Journal of Psycholinguistic Reseach, 31*(1), 45–63.

Frisch, S., & Schlesewsky, M. (2001). The N400 reflects problems of thematic hierarchizing. *NeuroReport, 12*(15), 3391.

Please cite this article in press as: Drenhaus, H., et al., Exhaustiveness effects in clefts are not truth-functional, Journal of Neurolinguistics (2010), doi:10.1016/j.jneuroling.2010.10.004

Frisch, S., & Schlesewsky, M. (2005). The resolution of case conflicts from a neurophysiological perspective. *Cognitive Brain Research, 25*(2), 484–498.
Gelman, A., & Hill, J. (2007). *Data analysis using regression and multilevel/hierarchical models*. Cambridge, UK: Cambridge University Press.
Gunter, T., Stowe, L., & Mulder, G. (1997). When syntax meets semantics. *Psychophysiology, 34*(6), 660–676.
Halvorsen, P.-K. (1976). Syntax and semantics of cleft sentences. In *Proceedings from the 12th Chicago linguistic Society*.
Halvorsen, P.-K. (1978). The Syntax and Semantics of Cleft Constructions. PhD thesis, University of Texas, Austin.
Hedberg, N. (2000). The referential status of clefts. *Language, 76*, 891–920.
Heim, I. (1991). Articles and definiteness. In A. Stechow, & D. Wunderlich (Eds.), Handbook of Semantics. An international handbook of contemporary research, *chapter Published in German as "Artikel und Definitheit"* (pp. 487–535). Berlin: W. de Gruyter.
Hoeks, J., Stowe, L., & Doedens, G. (2004). Seeing words in context: the interaction of lexical and sentence level information during reading. *Cognitive Brain Research, 19*(1), 59–73.
Hofmeister, P. (2009). Encoding effects on memory retrieval in language comprehension. In *Proceedings of CUNY conference*. Davis, CA: University of Davis.
Horn, L. (1981). Exhaustiveness and the semantics of clefts. In V. Burke, & J. Pustejovsky (Eds.), *Papers from the 11th Annual Meeting of NELS* (pp. 124–142). Amherst, (GLSA).
Horn, L. R. (1969). A presuppositional analysis of *only* and *even*. In *Proceedings of the Chicago linguistics Society, Vol. 5* (pp. 98–108).
Kaan, E., Harris, A., Gibson, E., & Holcomb, P. (2000). The P600 as an index of syntactic integration difficulty. *Language and Cognitive Processes, 15*, 159–201.
Karttunen, L., & Peters, S. (1979). Conventional implicature. In C.-K. Oh, & D. A. Dinneen (Eds.), *Syntax and semantics, presupposition, Vol. 11*. New York: Academic Press.
Kolk, H., Chwilla, D., van Herten, M., & Oor, P. (2003). Structure and limited capacity in verbal working memory: a study with event-related potentials. *Brain and Language, 85*(1), 1–36.
König, E. (1991). *The meaning of focus particles. A comparative perspective*. London: Routledge.
Krifka, M. (2008). Basic notions of information structure. *Acta Linguistica Hungarica, 55*.
Kutas, M., & Federmeier, K. (2000). Electrophysiology reveals semantic memory use in language comprehension. *Trends in Cognitive Sciences, 4*(12), 463–470.
Kutas, M., & Hillyard, S. (1980). Reading senseless sentences: brain potentials reflect semantic incongruity. *Science, 207*, 203–205.
Kutas, M., & Hillyard, S. (1983). Event-related potentials to grammatical errors and semantic anomalies. *Memory and Cognition, 11*, 539–550.
Kutas, M., & Hillyard, S. (1984). Brain potentials during reading reflect word expectancy and semantic association. *Nature, 307* (5947), 161–163.
Kutas, M., & van Petten, C. K. (1994). Psycholinguistics electrified. Event–related brain potential investigations. In M. A. Gernsbacher (Ed.), Handbook of Psycholinguistics (pp. 83–133). San Diego: Academic Press.
Ladusaw, W. (1980). *Polarity Sensitivity as Inherent Scope Relations*. Garland: New York & London.
Nieuwland, M. S., & Kuperberg, G. (2008). When the truth is not too hard to handle: an event-related potential study on the pragmatics of negation. *Psychological Science, 19*, 1213–1218.
Novagk, R. (1998). Xrefa. tms porti-32/mrefa frontended data acquisition. Technical report, Max-Planck Institute of Cognitive Neuroscience Leipzig.
Onea, E., & Beaver, D. (2009). *Hungarian focus is not exhausted*. In *Proceedings of SALT, 19*.
Osterhout, L., & Holcomb, P. J. (1992). Event-related brain potentials elicited by syntactic anomaly. *Journal of Memory and Language, 31*, 785–806.
Percus, O. (1997). Prying open the cleft. In *Proceedings of NELS, Vol. 37* (pp. 337–351).
Polich, J. (2007). Updating P300: an integrative theory of P3a and P3b. *Clinical Neurophysiology, 118*(10), 2128–2148.
Prince, E. F. (1978). A comparison of wh-clefts and it-clefts in discourse. *Language, 54*, 883–906.
Rooth, M. (1985). Association with Focus. PhD thesis, University of Massachusetts, Amherst.
Schulz, K., & van Rooij, R. (2006). Pragmatic meaning and non-monotonic reasoning: the case of exhaustive interpretation. *Linguistics & Philosophy, 29*, 205–250.
Sedivy, J., Carlson, G., Tanenhaus, M., Spivey-Knowlton, M., & Eberhard, K. (1994). The cognitive function of contrast sets in processing focus constructions. In P. Bosch, R. van der Sandt, P.e.t.e.r. Bosch, & R.o.b. van der Sandt (Eds.), *IBM working papers of the Institute for Logic and Linguistics*. Heidelberg.
Sharbrough, F., Chartrian, G.-E., Lesser, R. P., Lüders, H., Nuwer, M., & Picton, T. W. (1995). American Electroencephalographic Society guidelines for standard electrode position nomenclature. *Journal of Clinical Neurophysiology, 8*, 200–202.
Singer, M. (1976). Thematic structure and the integration of linguistic information. *Journal of Verbal Learning and Verbal Behavior, 15*(5), 549–558.
Spector, B. (2007). Scalar implicatures: exhaustivity and Gricean reasoning. In M. Aloni, A. Butler, & P. Dekker (Eds.), *Questions in Dynamic semantics* (pp. 225–250). Elsevier.
Stolterfoht, B., & Bader, M. (2004). Focus structure and the processing of word order variations in German. *Information Structure: Theoretical and Empirical Aspects* 259–275.
Stolterfoht, B., Friederici, A., Alter, K., & Steube, A. (2007). Processing focus structure and implicit prosody during reading: Differential ERP effects. *Cognition, 104*(3), 565–590.
van Berkum, J., Hagoort, P., & Brown, C. (1999). Semantic integration in sentences and discourse: evidence from the N400. *Journal of Cognitive Neuroscience, 11*(6), 657–671.
van Berkum, J., Zwitserlood, P., Hagoort, P., & Brown, C. (2003). When and how do listeners relate a sentence to the wider discourse? Evidence from the N400 effect. *Cognitive Brain Research, 17*(3), 701–718.
van Herten, M., Kolk, H., & Chwilla, D. (2005). An ERP study of P600 effects elicited by semantic anomalies. *Cognitive Brain Research, 22*(2), 241–255.

Please cite this article in press as: Drenhaus, H., et al., Exhaustiveness effects in clefts are not truth-functional, Journal of Neurolinguistics (2010), doi:10.1016/j.jneuroling.2010.10.004

Vasishth, S., Shaher, R., and Srinivasan, N. (2010). The role of clefting, word order and given-new ordering in sentence comprehension: Evidence from Hindi. accepted pending revisions by Journal of South Asian Linguistics.

von Fintel, K. (2001). Would You believe it? The king of France is back! (Presuppositions and truth-value Intuitions). In A. Bezuidenhout, & M. Reimer (Eds.), *Descriptions and beyond: An Interdisciplinary Collection of Essays on definite and Indefinite descriptions and other related Phenomena*. Oxford University Press.

von Fintel, K., & Matthewson, L. (2008). Universals in semantics. *The Linguistic Review.*

Wedgwood, D., Pethö, G., & Cann, R. (2006). *Hungarian 'focus position' and English it-clefts: The semantic underspecification of 'focus' readings*.

Please cite this article in press as: Drenhaus, H., et al., Exhaustiveness effects in clefts are not truth-functional, Journal of Neurolinguistics (2010), doi:10.1016/j.jneuroling.2010.10.004