Brain & Language 137 (2014) 62–76

Contents lists available at ScienceDirect

Brain & Language

journal homepage: www.elsevier.com/locate/b&l

Context updating during sentence comprehension: The effect of aboutness topic

Juliane Burmester [a], Katharina Spalek [b], Isabell Wartenburger [a,*]

[a] Department of Linguistics, Center of Excellence Cognitive Science, University of Potsdam, Karl-Liebknecht-Straße 24-25, 14476 Potsdam, Germany
[b] Department of German Language and Linguistics, Humboldt-Universität Berlin, Unter den Linden 6, 10099 Berlin, Germany

ARTICLE INFO

Article history:
Accepted 1 August 2014
Available online 24 August 2014

Keywords:
Information structure
Discourse context
Aboutness topic
Sentence processing
Word order variation
ERP
Late positivity
Syntax-Discourse Model

ABSTRACT

To communicate efficiently, speakers typically link their utterances to the discourse environment and adapt their utterances to the listener's discourse representation. Information structure describes how linguistic information is packaged within a discourse to optimize information transfer. The present study investigates the nature and time course of context integration (i.e., aboutness topic vs. neutral context) on the comprehension of German declarative sentences with either subject-before-object (SO) or object-before-subject (OS) word order using offline comprehensibility judgments and online event-related potentials (ERPs). Comprehensibility judgments revealed that the topic context selectively facilitated comprehension of stories containing OS (i.e., non-canonical) sentences. In the ERPs, the topic context effect was reflected in a less pronounced late positivity at the sentence-initial object. In line with the Syntax-Discourse Model, we argue that these context-induced effects are attributable to reduced processing costs for updating the current discourse model. The results support recent approaches of neurocognitive models of discourse processing.

1. Introduction

In everyday communication, we typically link our utterances to the discourse environment of the interlocutor in order to efficiently achieve our communicative objectives. Besides other factors, the speaker considers background information and feedback of the listener. Linguistic (e.g., information structure, stress) as well as extra-linguistic features (e.g., gestures, eye-gaze) are dynamically used to clarify what the utterance is about and ultimately guide the cooperative listener to the communicative intention of the speaker. It has been proposed that the listener structurally represents all relevant aspects of information (e.g., participants, events) delivered via language and perception within a mental model in which further incoming discourse information is integrated (e.g., Cowles, 2003; Johnson-Laird, 1980).

Information structure (cf. *information packaging*) is concerned with how information is packaged within a discourse to optimize information transfer (Chafe, 1976). In this regard the idea of efficient communication was defined by Clark and Haviland (1977) as: "The speaker tries, to the best of his ability, to make the structure of his utterances congruent with his knowledge of the listener's mental world" (p. 4). Ordering of information at the sentence-level is thought to be influenced by information structural concepts, such as topic-comment, given-new, or focus-background (e.g., Büring, 2007; Halliday, 1967; Krifka, 2008; Lenerz, 1977). However, these information structural concepts lack a uniform definition and depend on the field of research and respective theoretical framework. For the purposes of our study, we use the following definitions: The TOPIC of a sentence is typically understood as the information that the speaker intends to increase the listener's knowledge (Gundel, 1985). Hence, topic is defined as what the sentence is about; COMMENT is what is said about the topic (Gundel, 1988; Reinhart, 1981; see Section 1.4 for a more detailed definition of topic). GIVEN INFORMATION constitutes information the speaker expects to be already known by the listener (e.g., Haviland & Clark, 1974); that is, information explicitly mentioned in the previous discourse or information that can be entailed by the context (e.g., Chafe, 1976; Schwarzschild, 1999). In contrast, NEW INFORMATION describes information the speaker expects to introduce to the listener in the sense of "newly activating" it in the listener's consciousness (Chafe, 1976). FOCUS refers to the new/informative or contrastive part of an utterance. Whereas, BACKGROUND denotes less relevant information (e.g., Vallduvi & Engdahl, 1996). Experimentally, focus is often induced as contrastive focus, where the newness of the information is emphasized by its contrast to

* Corresponding author.
E-mail addresses: juliane.burmester@uni-potsdam.de (J. Burmester), katharina.spalek@staff.hu-berlin.de (K. Spalek), isabell.wartenburger@uni-potsdam.de (I. Wartenburger).

http://dx.doi.org/10.1016/j.bandl.2014.08.001
0093-934X/

previously focused information (e.g., Jacobs, 1988). A special type of contrastive focus is corrective focus, where an assumption is explicitly corrected. These information structural concepts are thought to be realized by distinct prosodic (i.e., accenting) and/or syntactic (e.g., sentence position) phenomena (see e.g., Chafe, 1976; Féry & Krifka, 2008; Skopeteas & Fanselow, 2010; Steedman, 2000).

In the present study, we aim to investigate how a previously presented context, in particular a context introducing all characters of a fictitious scene with emphasis on one of them as the *aboutness topic*, affects the comprehension of a subsequent canonical (subject-before-object) or non-canonical (object-before-subject) declarative sentence in German. Before we present the two experiments (Experiment 1: offline comprehensibility judgments, Experiment 2: Event-related potentials (ERPs) during online sentence processing) we first give a brief overview of German word order, the underlying neurocognitive mechanisms of sentence and discourse processing, as well as previous findings concerning information structural concepts and sentence processing relevant to understanding the motivation and predictions of the present study design.

1.1. Word order in German

Word order in German is relatively flexible. Reordering of constituents within a sentence can be used to highlight the communicatively relevant part of the utterance. German has a strong subject-first preference (e.g., Gorrell, 2000), but reordering of constituents within a sentence is possible, because syntactic roles can still be assigned correctly due to morphological case marking at the respective determiner or determiner and noun. Case marking of the subject by nominative (NOM) and object by accusative (ACC) case is ambiguous for feminine, neuter, and plural noun phrases, but unambiguous for masculine singular noun phrases. The example sentences (1a, b) illustrate case marking for masculine subjects and objects in German with the finite, transitive verb in the second sentence position. (1a) depicts a canonical declarative sentence with typical subject-before-object (SO) word order. (1b) depicts a non-canonical sentence with object-before-subject (OS) word order.

(1a) Der Uhu malt den Igel.
[the$_{[NOM]}$ owl$_{[NOM]}$]$_{subject}$ [paints]$_{verb}$ [the$_{[ACC]}$ hedgehog$_{[ACC]}$]$_{object}$.
'*The owl paints the hedgehog.*'

(1b) Den Igel malt der Uhu.
[the$_{[ACC]}$ hedgehog$_{[ACC]}$]$_{object}$ [paints]$_{verb}$ [the$_{[NOM]}$ owl$_{[NOM]}$]$_{subject}$.
'*The hedgehog, the owl paints.*'

Sentences (1a) and (1b) differ in the manner of information packaging (SO vs. OS order). However, both sentences induce the same propositional representation. In isolation, the OS order (cf. example 1b) is assumed to be harder to process compared to SO (e.g., Schlesewsky, Fanselow, Kliegl, & Krems, 2000), but interestingly, context information (e.g., a preceding sentence or question) has been found to ease the processing of OS sentences (e.g., Meng, Bader, & Bayer, 1999) (see Section 1.3 for the effect of information structure on the processing of word order variation in German).

Thus, in German main clauses, subjects as well as objects can appear in the sentence-initial position before the finite verb (so called *prefield*). Similarly, if the verb is not in the second but in final sentence position, either the subject or object can follow the complementizer (so called *middlefield*)[1] (see e.g., Pittner & Berman, 2008, for an overview of the topological classification of German sentences). As commonly assumed, the OS order is derived from the basic order of SO; but, depending on the theoretical framework, different movement operations are assumed to underlie word order variation in the German pre- and middlefield (e.g., Haider & Rosengren, 1998; Lenerz, 2000; Müller, 1999; see Diedrichsen, 2008, for an alternative, movement-independent account of the German sentence topology). Bornkessel-Schlesewsky and colleagues substantiate the distinction of word order variation in the pre- and middlefield from the neuroanatomical perspective (Bornkessel-Schlesewsky, Grewe, & Schlesewsky, 2012): Whereas numerous studies reported an increased activation for OS opposed to SO within the left inferior frontal gyrus (lIFG), aboutness-based sequencing (prefield) activated anterior subregions of the lIFG, but prominence-based sequencing (middlefield) activated superior subregions of the lIFG (for a review, see Bornkessel-Schlesewsky & Schlesewsky, 2012).

Several semantic and discourse-related factors have been proposed to affect the linear order of sentential constituents (e.g., concerning the thematic role, actors should precede non-actors; for a review about incremental argument interpretation during processing of transitive sentences, see Bornkessel-Schlesewsky & Schlesewsky, 2009a). Numerous studies proposed factors that crucially affect word order in the German middlefield (e.g., Bornkessel-Schlesewsky & Schlesewsky, 2009b; Choi, 1996; Lenerz, 1977; Müller, 1999; Siewierska, 1993). For the purposes of our study, the most important are findings concerning the German prefield: As attested in written corpora, SO and OS sentences predominately occur with an accusative object (Bader & Häussler, 2010). SO sentences tend to contain active verbs, whereas OS order frequently occurs with verbs lacking an agent argument (i.e., passivized ditransitive and unaccusative verbs). Further, OS is more frequent if the object is animate and the subject inanimate (Bader & Häussler, 2010), which fits the previously proposed animacy-based ordering preferences of sentential constituents (Tomlin, 1986). In the present study, we aimed to exclude confounding effects of the listed linearization preferences in order to examine the effect of aboutness topic in the prefield of SO and OS sentences. Thus, we held the following factors constant: case of the object (accusative), verb type (active, transitive), thematic roles of subject (agent) and object (patient) as well as their animacy status (animate). Persisting differences between OS and SO word order we further considered by focusing on comparing contextual effects *within* the respective word order.

1.2. Neurocognitive models of sentence and discourse processing

Different neurocognitive models of sentence comprehension have been formulated to better understand the nature and time course of online sentence processing (e.g., the *extended Augmented Dependency Model* (*eADM*) by Bornkessel & Schlesewsky, 2006a; the *auditory sentence processing model* by Friederici, 2002). Basically, the architecture of these models is assumed to be hierarchically organized in phases that specify the steps of incremental sentence comprehension and correspond with functionally separable networks at the brain level. These processing steps have been linked to specific language-related ERP components. After the prosodic analysis, indexed by a negativity peaking around 100 ms (N100), the model of Friederici (2002) proposes three phases: Phase 1 is an initial phrase-structure-building process of the sentential constituents. In phase 2, morphosyntactic as well as semantic information is integrated (i.e., thematic role assignment), indexed for instance by the left anterior negativity (LAN) and the negativity around 400 ms (N400). Phase 3 is characterized by reanalysis and repair mechanisms as indexed by the positivity around 600 ms (P600) (Friederici, 2002). Similarly, the eADM proposes three phases

[1] The deviation of SO order in the German middlefield is termed *scrambling* (i.e., OS: ..., dass den Igel der Uhu malt. (..., [that]$_{[complementizer]}$ [the$_{[ACC]}$ hedgehog$_{[ACC]}$]$_{[object]}$ [the$_{[NOM]}$ owl$_{[NOM]}$]$_{[subject]}$ [paints]$_{[verb]}$.)).

of sentence comprehension: In phase 1, the phrase-structure representation is built via template-mapping. In phase 2, the arguments are interpreted with regard to their thematic and prominence relations, indexed by the N400, LAN, the P600 and/or the scrambling negativity – an ERP component that has been engendered by violations in sequencing arguments according to prominence based hierarchies in languages allowing word order variation (e.g., accusative object precedes subject in the German middlefield (Bornkessel & Schlesewsky, 2006b; Bornkessel, Schlesewsky, & Friederici, 2002; Bornkessel, Schlesewsky, & Friederici, 2003) or in Japanese (Wolff, Schlesewsky, Hirotani, & Bornkessel-Schlesewsky, 2008)). In phase 3 (''generalized mapping''), information structural mechanisms induced by the discourse context, world-knowledge and/or prosody are taken into account and trigger well-formedness evaluation and repair processes, indexed by late positivities (that have been suggested to belong to the P300 component). Hence, in this final phase, sentences are evaluated according to their acceptability with respect to the context environment (Bornkessel & Schlesewsky, 2006a). This is the processing step in which we also expect to see effects of contextual manipulation in the present study.

A more recent model of Bornkessel-Schlesewsky and Schlesewsky (2013) –the ''New dorsal–ventral stream model of sentence comprehension''– explicitly links the eADM to underlying brain structures. This model assumes two processing streams working in parallel: The ventral stream builds the sentence-level semantic representation by time-independent computations such as identification and unification of conceptual (actor-event) schemata. The dorsal stream combines time-dependent elements and establishes the syntactic (constituent) structure by time-dependent computations such as prosodic segmentation, combination of elements into category sequences, and actor identification. The two streams are integrated in the frontal cortex which subserves cognitive control and allows for top-down-feedback, pragmatic interpretation, conflict resolution, and builds the interface with motor cortices. Discourse linking processes are also assumed to be supported by parietal brain regions (Bornkessel-Schlesewsky & Schlesewsky, 2013).

In the present study, hypotheses are based on the *Syntax-Discourse Model* (*SDM*) (first introduced for pronominal-antecedent relations by Burkhardt, 2005, and extended to general discourse processing in a multi-stream-model by Schumacher & Hung, 2012 and Wang & Schumacher, 2013). The SDM focuses on mechanisms of information packaging during online sentence comprehension. Therein, currently processed information is assumed to be directly interpreted and integrated in relation to a previously established discourse representation which is built incrementally (see also the *Information Structure Processing Hypothesis* (*ISPH*), by Cowles, 2003). According to this model, the N400 response is related to expectation-based discourse linking, whereas the late positivity is evoked by discourse updating processes such as the adding of a new discourse referent, topic shift, inferential reasoning, enrichment, and/or the modification of the established discourse representation (see Wang & Schumacher, 2013, and Schumacher, 2014, for recent reviews).

1.3. The effect of information structure on sentence processing

Recent research in the field of information structure has raised the question how information packaging in terms of word order variation is affected by different types of context information (e.g., Büring, 2007; Fanselow & Lenertová, 2011). So far, studies on word order variation in German have mainly focused on SO and OS sentences in the absence of context information (e.g., Bader & Häussler, 2010; Bornkessel, Zysset, Friederici, von Cramon, & Schlesewsky, 2005; Hemforth, 1993; Kempen & Harbusch, 2005; Matzke, Mai, Nager, Rüsseler, & Münte, 2002; Rösler, Pechmann, Streb, Röder, & Henninghausen, 1998). However, context information plays an important role in licensing non-canonical word orders, as evidenced by occurrence frequency in corpora, behavioral and ERP findings.

In written corpora, OS is very rare in German main clauses (Bader & Häussler, 2010; Weber & Müller, 2004), but the frequency of OS significantly increases for certain discourse contexts: At first sight, the linear order of subject and object in German main clauses was determined by givenness (i.e., increased frequency of OS if the object was given in a previous context but the subject was discourse-new); however, more decisive are the factors definiteness and pronominalization – both highly correlated with givenness (e.g., pronouns and definite noun phrases predominantly represent given, indefinite noun phrases new information) (Weber & Müller, 2004). As these factors were not of interest in our study we ruled out any confounding effects by using given, definite, and full noun phrases.

Based on behavioral data (i.e., acceptability rating and reading time), strong contextual licensing effects for OS in German main clauses have been found if the object was in a contrastive whole-part relation to a contextually mentioned set (*partially ordered set relation* according to Prince, 1998) (Weskott, Hoernig, Fanselow, & Kliegl, 2011). Besides, a context question, which revealed the object as given and the subject as focused, improved judgments and reading times of scrambled OS in German embedded clauses (Meng et al., 1999).

How context information modulates underlying mechanisms of online sentence processing has previously been investigated by ERPs. ERP components commonly used to investigate language processing at the semantic and syntactic level, such as the well-established N400 (see e.g., Kutas & Federmeier, 2011; Lau, Phillips, & Poeppel, 2008 for a review) and P600 or late positivity (Frisch, Schlesewsky, Saddy, & Alpermann, 2002; Osterhout & Holcomb, 1992), have been found to be sensitive to discourse-level processing (e.g., Bornkessel et al., 2003; Burkhardt, 2007; Cowles, Kluender, Kutas, & Polinsky, 2007; Hung & Schumacher, 2012; van Berkum, 2012; Wang & Schumacher, 2013). Previous ERP studies examining context effects during sentence processing revealed an impact of givenness and focus. For instance, an early positivity around 300 ms for discourse-new focused initial objects in scrambled OS as well as subjects in SO was interpreted in terms of reflecting processes of focus integration (e.g., Bornkessel et al., 2003). Furthermore, the scrambling negativity for OS in the German middlefield was enhanced if the object was given opposed to a discourse-new object (Bornkessel et al., 2003); although-based on behavioral findings- givenness of the object would be expected to license OS (Meng et al., 1999). In a related study, Bornkessel and Schlesewsky (2006b) compared OS with SO sentences. Any processing difficulties in terms of the scrambling negativity for OS compared to SO disappeared if a preceding context induced a corrective focus.

Moreover, modulations of the N400 and late positivity have been proposed to index discourse integration processes (cf. SDM by Schumacher & Hung, 2012 and Wang & Schumacher, 2013, see also Section 1.2). The N400 –modulated by different degrees of givenness– has been attributed to processing difficulties in linking the current referent to the previous discourse: For instance, in German main clauses, the N400 was enhanced for inferable vs. given subjects in SO as well as objects in OS (Schumacher & Hung, 2012). Similarly, Wang and Schumacher (2013) investigated the influence of topic status on sentence processing. The authors were interested in how different types of discourse contexts (given vs. inferable topic vs. contrastive new) influence sentence processing in Japanese: New vs. given information revealed an N400, but the N400 was absent if the new information was expected, due to its sentential position and the respective context. This finding supports

the assumption that the N400 indicates expectation-based discourse linking rather than an effect of information status per se. Further, a late positivity (around 500–700 ms) has been proposed to reflect processing costs for updating and correcting the current discourse model, which was assumed to be more demanding for (contrastive) new vs. inferable vs. given (topic) referents (e.g., Schumacher & Hung, 2012; Wang & Schumacher, 2013). Similarly, in Chinese, the late positivity has been found to be sensitive to position-specific processing demands evoked by different types of topic (given topic/topic shift/new topic) (Hung & Schumacher, 2012): The preference that the topic position is filled by a given topic (i.e., topic continuation) or a non-conflicting novel topic over topic shift was reflected in a reduced late positivity. A biphasic N400-late positivity pattern with enhanced amplitudes for new opposing to given information was reported for subsequent non-topic positions. Hence, discourse linking and updating evoke a biphasic N400-late positivity pattern (e.g., Hung & Schumacher, 2012; Wang & Schumacher, 2013). But both components have also been found independent of each other: For instance, the N400 was modulated by different degrees of givenness in the German prefield (e.g., Schumacher & Hung, 2012), and the late positivity was modulated by different degrees of expectation in the German middlefield (Burkhardt, 2007). Hence, the SDM assumes two independent processing streams for discourse linking (N400) and updating (late positivity) (e.g., Wang & Schumacher, 2013). Taken together, the ERP studies support that the impact of discourse information on sentence processing is detectable in modulations of well-known ERP components, such as the N400 and late positivity. In this regard, the SDM strongly contributes to understanding discourse relevant processing demands modified by previously presented context information.

To sum up, word order in German has been found to be context-sensitive: As evidenced by high frequency in corpora, high acceptability ratings, low reading times and online processing measures, SO is felicitous even without a context; but OS is constrained by certain licensing contexts. Offline methods such as acceptability ratings have been used to decide whether a certain context licenses sentence processing on a global level, whereas online methods such as ERPs have been used to characterize the underlying mechanisms of context effects during incremental sentence processing. The relevance of using offline as well as online methods to characterize the level at which context information interacts with word order during sentence comprehension has been underlined by previous findings. As already mentioned, behavioral findings revealed given objects in scrambled OS felicitous (Meng et al., 1999), whereas ERPs still revealed a scrambling negativity during online processing (Bornkessel et al., 2003). Similarly, contrastively focused objects in scrambled OS improved offline acceptability ratings, but online a scrambling negativity reflected processing costs compared to SO (Bornkessel & Schlesewsky, 2006b). Most of the previous online and offline studies in German characterized the influence of givenness, focus or topic (operationalized by different degrees of givenness or inferability) on the processing of word order variation; but online studies on different types of topic in other languages (e.g., Hung & Schumacher, 2012; Wang & Schumacher, 2013) offer a useful starting point for the predictions of the present study (see Section 1.5). Importantly, in the present study, topic was operationalized as aboutness topic (see Section 1.4), while givenness was held constant (all referents given).

1.4. The information structural notion of aboutness topic

Topic or aboutness topic is an important information structural concept relevant for linguistic communication (for a review, see Frey, 2007 and Jacobs, 2001). As a pragmatic phenomenon, aboutness topic has been described as the entity the sentence is about (e.g., Reinhart, 1981). Topic has been assumed to perform "the anchoring role to the previous discourse or the hearer's mental world" (Vallduvi & Engdahl, 1996, p. 465). This is in line with the account that topic usually refers to information that is given due to a previous context (e.g., Givón, 1983; Gundel, 1988; Skopeteas et al., 2006). Accordingly, Reinhart (1981) pointed out that the sentence topic is identifiable by both the context of the utterance and the linguistic structure. At the sentence-level, Hockett (1958) differentiates between the topic as what the speaker announces first and the comment as what is said about the topic. The definition as well as the identification of topic via linguistic features has been controversially discussed (see e.g., Lambrecht, 1994 for a discussion on the "*topic-first principle*"). For German main clauses, topic has been argued to strongly tend to occur sentence-initially (e.g., Büring, 1999; Frey, 2004a; Jacobs, 2001; Rosengren, 1993; Vallduvi & Engdahl, 1996) if this position is not occupied by a competitor (i.e., a scene-setting or contrastive element) (Speyer, 2004, 2008). Besides, as in German the prefield can be occupied by non-topics, the middlefield has been argued to be designated for topic (e.g., Frey, 2004b).

Taking into consideration the properties of topic plus the relatively flexible word order, German offers a promising starting point to examine the impact of topic context on sentence processing, especially on OS sentences. It remains an open question if a context inducing an aboutness topic status of given referents crucially facilitates the overall comprehension of OS in the prefield; and especially if this effect is immediately reflected in the online processing of OS sentences in terms of discourse updating of the current mental model.

1.5. The present study

The goal of the present study was to characterize if and how a discourse context indicating the aboutness topic of the upcoming sentence eases the processing of the following canonical (i.e., SO) or non-canonical sentence (i.e., OS) in German. By using fictitious stories that introduced two relevant characters and the event of the scene (discourse-given), we compared the effect of two differential mini-discourse contexts: In one condition, a topic context indicated the aboutness topic status of one character of the scene; in the other condition, a neutral context indicated a wide scope of the scene. The context question used to establish the topic status is similar to previous studies investigating aboutness topic during online sentence comprehension in other languages. However, these studies modulated givenness (Hung & Schumacher, 2012, 2014) or animacy (Wang, Schlesewsky, Philipp, & Bornkessel-Schlesewsky, 2012) at the same time. Whereas all referents of the scene were discourse-given, we aimed to characterize the effect of these two discourse contexts (topic vs. neutral context) on unambiguously case marked German declaratives with either SO or OS word order. Therefore, two experimental methods were used: (1) An offline comprehensibility judgment task to test if the participants' judgment of overall understanding of the stories with either SO or OS target sentences is affected by the type of the preceding discourse context (Experiment 1), and (2) ERPs to test how the preceding discourse context incrementally modulates the online processing of the SO and OS target sentences (Experiment 2). Note that we compared the context effect within each word order, meaning that in both experiments the very same target sentences were compared to circumvent confounding effects of prominence-related sequencing preferences (such as grammatical or thematic role). These two methods provide crucial information about both the nature and time course of discourse organizational processes elicited by the two context types.

In German main clauses, a contextually induced aboutness topic is expected to be placed sentence-initially (e.g., Büring, 1999),

whereas the neutral context does not generate such an expectation. Due to the strong subject-first preference in German (e.g., Hemforth, 1993), context information revealing all sentential constituents as given should not play a crucial role for the processing of SO sentences. But as evidenced previously, for non-canonical word order, context information plays a licensing role (e.g., Bornkessel & Schlesewsky, 2006b; Weskott et al., 2011). Hence, for Experiment 1, we predicted that stories containing SO target sentences should be judged as easily comprehensible, independent of context type; whereas for stories containing OS target sentences, the preceding topic context was expected to improve comprehensibility judgments. Based on recent ERP studies, discourse organizational processes have arguably been reflected in modulations of ERPs around 400 and 600 ms during online sentence processing (see above). Similar to offline comprehensibility judgments, we do not expect any modulations by the preceding context type during online processing of SO sentences in Experiment 2. However, if the topic context creates a felicitous discourse environment for OS sentences as measured by offline comprehensibility judgments, we expect that in these sentences differential processing costs induced by the two discourse contexts should be visible during online processing. Therefore, due to direct contextual integration of the topic into the discourse model, processing costs for updating the current mental model should require less effort compared to the neutral context. This might be reflected in modulations of the late positivity as this ERP component has been proposed to reflect processing costs for updating and correcting the current discourse model (e.g., Bornkessel & Schlesewsky, 2006a; Burkhardt, 2007; Hung & Schumacher, 2012; Schumacher & Hung, 2012; Wang & Schumacher, 2013). Note that we do not expect a modulation of the N400 due to the fact that all constituents are discourse-given, and hence, the linking of unexpected discourse referents is not required.

2. Experiment 1

In Experiment 1, participants were presented with short fictitious stories. We conducted an offline comprehensibility judgment task to detect if the participants' judgment concerning the overall comprehensibility of stories containing either an SO or OS target sentence was affected by the preceding discourse context, a topic vs. neutral context. The individual behavioral judgment of the comprehensibility of each story was recorded.

2.1. Materials and methods

2.1.1. Participants

Twenty-eight German native speakers (19 female, *M* age 24 years, age range 20–34 years) participated in Experiment 1. Twenty-six participants were right-handed and two ambidextrous as assessed by a German version of the Edinburgh Handedness Inventory (Oldfield, 1971). None reported any neurological disorder. All had normal or corrected-to-normal vision. Participants were reimbursed or received course credits for participation.

2.1.2. Material

The experiment used a 2×2 within-subject design with the factors CONTEXT TYPE (TOPIC vs. NEUTRAL) and WORD ORDER (SO vs. OS). In accordance with previous studies investigating the interaction of context and word order, we created short fictitious discourses by means of question–answer pairs (Bornkessel et al., 2003; Meng et al., 1999) that led to significantly increased acceptability ratings compared to non-question contexts (Bornkessel & Schlesewsky, 2006b). A set of 160 experimental trials (40 trials per condition) was constructed. Each trial consisted of a three-sentence discourse depicting a scene of two animals performing a transitive action in which both were equally plausible to be the agent or patient of the scene. All trials followed the structure shown in Table 1. (1) In the first sentence (lead-in) of each trial, the current scene with both animals and the instrument of the to-be-performed action was introduced. Thus, in terms of information structure, the relevant characters were discourse-given (Prince, 1981) and the action was inferable (Prince, 1992) from the instrument mentioned. The same lead-in was used for all conditions. (2) The following wh-question (i.e., context question) differed with regard to the factor CONTEXT TYPE: The context question either induced a wide scope of the scene (NEUTRAL CONTEXT) or indicated one of the two animals as the aboutness topic (TOPIC CONTEXT). (3) The third sentence (target sentence) provided a plausible answer to the preceding context question by describing the final action event of the two animals. The target sentence varied according to the factor WORD ORDER and was thus presented in SO or OS order.

The different scenes were created based on 40 animals (monomorphemic nouns, masculine gender, 1-syllabic ($n = 18$) to 2-syllabic ($n = 22$)) and 10 actions (monomorphemic verbs, transitive, accusative-assigning, 2-syllabic) with corresponding instruments and a scene-setting prepositional phrase (e.g., *in the park*). Note that both grammatical and thematic roles coincided (i.e., the grammatical subject was always the agent, the grammatical object was always the patient). The critical nouns and verbs were matched for written lemma frequency, type frequency and normalized $\log_{10}$ familiarity values, taken from the dlex database (Heister et al., 2011). To control for position effects, each noun occurred once in each of the four conditions at the first and second noun phrase position of the target sentence. Thus, each animal served four times as the agent and four times as the patient of the target sentence, respectively, always with a different action and co-animal. In the lead-in sentence, the first and second mention of the potential agent and patient was counterbalanced across conditions. Both animals of a scene always differed in the initial phoneme. To minimize possible effects of structural priming (Scheepers & Crocker, 2004), all trials were pseudo-randomized such that maximally two consecutive trials were of the same condition or had the same word order in the target sentence. To avoid any preferences of thematic role or topic continuity (Givón, 1983) caused by the previous trial, at least five trials separated the repetition of an animal, and at least two trials the repetition of an action. Four lists of 160 trials were created such that each list contained each item only once, and across all lists each item occurred once in each condition. Each participant was presented with one of the four lists.

2.1.3. Procedure

Similar to judgments on acceptability (Bornkessel & Schlesewsky, 2006b) or felicity (Meng et al., 1999) of paired question–answers, we used a speeded comprehensibility judgment task, in which participants were explicitly asked to intuitively judge the comprehensibility of stories within a 2000 ms time window.

Participants were tested individually, seated in a sound-attenuated booth 90 cm away from the computer screen with a button box (Cedrus response pad model RB-830) on their lap. Written instructions about the experimental procedure were given to participants. Participants were asked to read each story attentively and silently and judge each story as fast as possible with regard to its comprehensibility. The trials were displayed visually in the center of the screen by means of the Presentation software (version 14.1, www.neurobs.com). Each trial began by presenting a red asterisk for 1000 ms to indicate the beginning of a new scene. Before and after the lead-in, a blank screen was displayed for 200 ms. Lead-in and context question were presented as a whole in a self-paced reading manner with a minimum reading time of 3350 ms and 1400 ms, respectively. The participant had to press

Table 1
Sample experimental trial for each condition (vertical bars in target sentence indicate phrase-wise presentation, approximate English translation written in inverted comma).

Lead-in	Context question	Target sentence	Condition
Der Uhu und der Igel haben eine Staffelei im Park aufgebaut. 'The owl and the hedgehog have set up an easel in the park.'	Was ist denn genau los? 'What exactly is going on?'	Der Uhu | malt | den Igel | im Park	NEUTRAL SO
		$[\text{the}_{[NOM]}\ \text{owl}_{[NOM]}]_{DP1}\ [\text{paints}]_{V}\ [\text{the}_{[ACC]}\ \text{hedgehog}_{[ACC]}]_{DP2}\ [\text{in the park}]_{PP}$.	
	Was ist mit dem Uhu? 'What about the owl?'	'The owl paints the hedgehog in the park.'	TOPIC SO
	Was ist denn genau los? 'What exactly is going on?'	Den Uhu | malt | der Igel | im Park	NEUTRAL OS
		$[\text{the}_{[ACC]}\ \text{owl}_{[ACC]}]_{DP1}\ [\text{paints}]_{V}\ [\text{the}_{[NOM]}\ \text{hedgehog}_{[NOM]}]_{DP2}\ [\text{in the park}]_{PP}$.	
	Was ist mit dem Uhu? 'What about the owl?'	'The owl, the hedgehog paints in the park.'	TOPIC OS

Abbreviations: NOM = nominative case, ACC = accusative case, DP1 = first determiner phrase, V = verb, DP2 = second determiner phrase, PP = prepositional phrase, SO = subject-before-object, OS = object-before-subject.

a button with the left thumb for further reading. Then the target sentence was presented phrase-wise (as indicated in Table 1) with 500 ms for each determiner phrase (DP) and prepositional phrase (PP) and 450 ms for the verb with an ISI of 100 ms (as used in previous studies, e.g., Bornkessel et al., 2003).

After the presentation of the target sentence, the participant had to perform a binary judgment on the comprehensibility of the whole preceding story by pressing a button. The participant either pressed the right index or middle finger on the respective "thumb-up" or "thumb-down" button: Thumb-up for stories that were easily comprehensible or thumb-down for stories that were less easy to comprehend. The assignment of the response buttons to the participants' right index and middle finger was counterbalanced across participants. Before the experiment started, finger positions on the respective buttons were checked by the experimenter. The response option was depicted for 2000 ms. Participants performed three practice trials to become familiar with the procedure. The experiment was split into four blocks of 40 experimental trials. No filler trials were presented to keep the experimentation time within acceptable limits for the participant (i.e., to preserve motivation and concentration, and to prohibit movement artifacts or alpha waves in the signal of the electroencephalography (EEG) in Experiment 2). The whole experimental session lasted approximately 40 min including self-adjusted pauses after each block.

2.1.4. Data analysis

For statistical data analysis of the comprehensibility judgment task, we computed logit mixed models for the categorical judgments (easily vs. less easily comprehensible), following Jaeger (2008). We used the statistical software R (version 2.15.2, R Core Team., 2013) with the supplied *lme4* package (Bates, Maechler, & Dai, 2009) for the mixed models analysis and the *ggplot2* package (Wickham, 2009) for the display of the results. To analyze the categorical judgments using logit mixed models, CONTEXT TYPE, WORD ORDER and the interaction of both were defined as fixed effects, while participants and items were defined as random effects. Fixed effects were coded as +.5/−.5 contrasts resembling traditional ANOVA analyses. Model fitting started with the most complex model (Barr, Levy, Scheepers, & Tily, 2013); that is, with the full factorial set of random effects (random slope adjustments for all fixed effects for both participants and items). In a step-wise manner, the complex model was reduced by model comparisons via log-likelihood tests (e.g., Baayen, 2008; Baayen, Davidson, & Bates, 2008). Slope adjustments were excluded if they did not improve the explanatory power of the model in comparison to the simpler model without that slope adjustment. Logit mixed models were fitted by the Laplace approximation. Estimates (b), standard errors (SE), z-values and the level of significance (p) of the final logit mixed model are reported.

2.2. Results

Participants showed the following mean (M) proportion for stories judged as easily comprehensible per condition: NEUTRAL SO: $M = 0.93$ ($SE = 0.04$), TOPIC SO: $M = 0.92$ ($SE = 0.04$), NEUTRAL OS: $M = 0.37$ ($SE = 0.05$), TOPIC OS: $M = 0.54$ ($SE = 0.05$) (see Fig. 1).

The statistical analysis of the participants' categorical judgments of the stories revealed significant main effects of CONTEXT TYPE and WORD ORDER, and a significant interaction of CONTEXT TYPE × WORD ORDER (see Table 2 for statistics of the final logit mixed models).[2] Post hoc logit mixed models to resolve the interaction within each WORD ORDER revealed a significant effect of CONTEXT TYPE for stories containing OS sentences, but not for stories containing SO sentences. Thus, stories containing the OS target sentence were more likely to be judged as easily comprehensible if presented together with the TOPIC CONTEXT. For stories containing the SO target sentence, the probability to be judged as easily comprehensible was equally high independent of the preceding CONTEXT TYPE and significantly higher than for stories with the OS target sentence.

3. Experiment 2

In Experiment 2, participants were presented with the same stories as in Experiment 1, while ERPs were used to investigate the effect of the preceding discourse context (CONTEXT TYPE: TOPIC vs. NEUTRAL) during online processing of German SO and OS sentences. Simultaneously, the behavioral performance of the participants was monitored in the form of a sentence-picture-verification task administered in 20% of the trials.

3.1. Materials and methods

3.1.1. Participants

Twenty-one German native speakers (13 female, mean age 25 years, age range 19–30 years) participated after giving informed consent. None of the participants took part in Experiment 1. All participants were right-handed as assessed by a German version of the Edinburgh Handedness Inventory (Oldfield, 1971). All had normal or corrected-to-normal vision and did not report any neurological disorder. Participants were reimbursed or received course credits for participation. Two participants were excluded from the analysis due to response accuracy scores below 60% in the sentence-picture-verification task (see Section 3.1.3). Data analysis was thus based on the remaining 19 participants (11 female, M age 25 years, age range 19–30 years).

[2] Additional statistical analyses using a 2 × 2 ANOVA for the proportions of easily comprehensible judgments revealed the same result pattern as the logit mixed models analysis on the raw data of the categorical judgments.

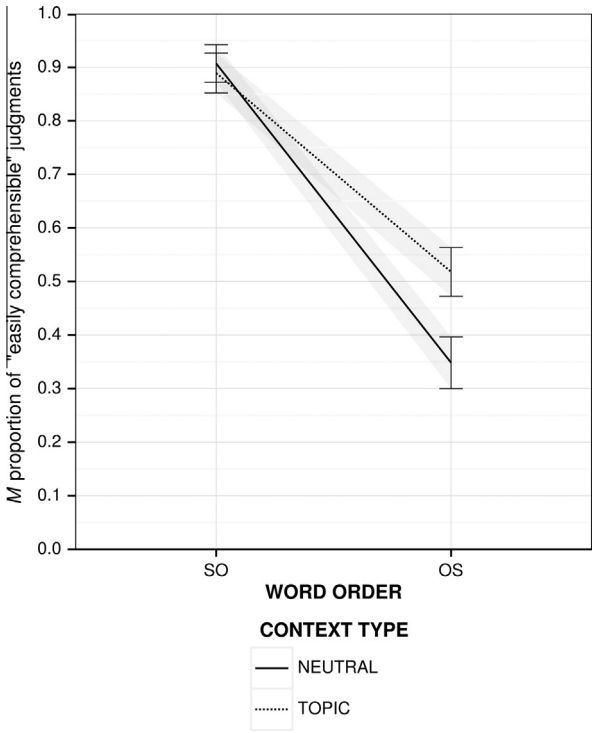

Fig. 1. Mean (*M*) proportion of stories judged as easily comprehensible showing the effect of CONTEXT TYPE (TOPIC [dotted line] vs. NEUTRAL [solid line]) within each word order (SO vs. OS) in Experiment 1. Error bars represent the standard error of the mean.

3.1.2. Material

Material for Experiment 2 was identical to Experiment 1. Additionally, 32 colored drawings depicting the scene of the preceding target sentence with correct (matching) or exchanged (mismatching) thematic roles (e.g., *The owl paints the hedgehog.* vs. *The hedgehog paints the owl.*) were created for the sentence-picture-verification task. For each of the four experimental conditions (NEUTRAL SO/OS, TOPIC SO/OS) the same number of matching/mismatching pictures was constructed.

3.1.3. Procedure

The procedure was identical to that of Experiment 1 except for the following three methodological adjustments: First, the participant was prepared for EEG recording prior to the experiment. Second, presentation of the target sentence was preceded and followed by a fixation cross for 500 ms in the center of the screen to reduce vertical eye movements of the participant. Third, instead of the behavioral judgment task on story comprehensibility, the participants performed a sentence-picture-verification task that followed the target sentence in 20% of the trials: After offset of the fixation cross, which followed the target sentence, the matching/mismatching picture was presented for 2 s before the participant had to press the corresponding button (yes vs. no) within a time window of 2 s. The assignment of the response buttons to the right index and middle fingers was counterbalanced across participants. A written instruction informed participants to read each scene attentively and silently and to answer the sentence-picture-verification task as accurately and fast as possible. Participants were asked to sit in a relaxed manner and to avoid blinks as well as other movements during sentence reading. The whole experimental session including three practice trials and pauses after each of the 40 trials lasted approximately 30 min plus electrode preparation.

3.1.4. EEG Recording

The EEG was recorded through a 32 channel active electrode system (Brain Products, Gilching, Germany) fixed at the scalp by means of a soft cap (Easycap, Inning, Germany). The electrode configuration included the following 29 scalp sites according to the international 10–20 system (American Electroencephalographic Society., 2006): F7/8, F5/6, F3/4, FC3/4, C5/6, C3/4, CP5/6, P3/4, P7/8, PO3/4, FPz, AFz, Fz, FCz, Cz, CPz, Pz, POz, Oz. To detect blinks and vertical eye movements, an electrooculogram (EOG) was monitored by one electrode under and one electrode above the right eye. The ground electrode was placed at FP1. EEG data were acquired with a sampling rate of 1000 Hz. Impedances were kept below 5 kOhm. The left mastoid served as the reference electrode online, but the recording was re-referenced to bilateral mastoids offline.

3.1.5. ERP data analysis

For ERP data analysis, Brain Vision Analyzer software (version 2.0.2; Brain Products, Gilching, Germany) was used. EEG raw data were filtered by applying the Butterworth zero phase filter (low cutoff: 0.3 Hz; high cutoff: 70 Hz; slope: 12 dB/oct) to exclude slow signal drifts and muscle artifacts, and a notch filter of 50 Hz. Artifacts caused by vertical eye movements were corrected by the algorithm of Gratton, Coles, and Donchin (1983). An automatic artifact rejection was used to reject blinks and drifts in the time window of −200 to 1500 ms relative to the onset of the critical stimuli in the target sentence: first determiner phrase (DP1), verb (V) and second determiner phrase (DP2) (rejection criteria: max. voltage step of 30 μV/ms, max. 200 μV difference of values in interval, lowest activity of 0.5 μV in intervals). Relative to the onset of DP1, V, and DP2, on average 5.71% of trials were rejected with an equal distribution across onsets of critical stimuli and experimental conditions [$F(2, 36)$, $p > .1$]. ERPs were averaged for each participant and each condition within a 1500 ms time window time-locked to the onset of the critical stimuli with a 200 ms pre-stimulus onset baseline.

Based on visual inspection of the ERPs and according to the literature on language-related ERP components (i.e., P200, N400, late

Table 2
Statistical results for the fixed effects of the final logit mixed model analyses of the comprehensibility judgment data (Experiment 1).

Fixed effects	*b*	*SE*	*z*-Value	Slope adjustments
Full factorial logit mixed model				
Intercept	−1.56	0.22	−6.97***	
CONTEXT TYPE (TOPIC vs. NEUTRAL)	0.60	0.20	3.05**	Participants
WORD ORDER (SO vs. OS)	4.00	0.54	7.45***	Participants, items
CONTEXT TYPE × WORD ORDER	0.53	0.20	2.64**	Participants
Post hoc logit mixed models				
OS CONTEXT TYPE (TOPIC vs. NEUTRAL)	1.10	0.34	3.20***	Participants
SO CONTEXT TYPE (TOPIC vs. NEUTRAL)	−0.20	0.18	−1.09	

Note: Significance levels: ** $p \leqslant .01$, *** $p \leqslant .001$. *b* = estimate, *SE* = standard error.

positivity), mean amplitude values of the ERPs per condition were statistically analyzed in the time windows 100–300 ms (P200), 300–500 ms (N400) and 500–700 ms (late positivity). The following nine regions of interest (ROIs) were computed via mean amplitudes of the three corresponding electrodes: left frontal (F7, F5, F3), left fronto-central (FC3, C5, C3), left centro-parietal (CP5, P3, P7), right frontal (F8, F6, F4), right fronto-central (FC4, C6, C4), right centro-parietal (CP6, P4, P8), frontal-midline (FPz, AFz, Fz), central midline (FCz, Cz, CPz), parietal midline (Pz, POz, Oz). The statistical ERP analysis followed a hierarchical schema (e.g., Bornkessel et al., 2003; Rossi et al., 2011) using IBM SPSS Statistics (version 21.0). Firstly, a fully crossed repeated measures analysis of variance (ANOVA) with the factors CONTEXT TYPE (TOPIC, NEUTRAL), WORD ORDER (SO, OS), and ROI (nine levels) was computed separately for the three time windows post onset DP1, V, and DP2. We applied the correction of Greenhouse and Geisser (1959) and report the corrected *F*- and *p*-values but with the original degrees of freedom. Only statistically significant ($p \leqslant .05$) and marginally significant ($p \leqslant .06$) main effects and interactions including the factors CONTEXT TYPE and/or WORD ORDER were resolved in post hoc comparisons. Significant three-way interactions were resolved by computing ANOVAs on the next level. Whenever the ANOVA revealed a significant interaction of CONTEXT TYPE or WORD ORDER with ROI, paired *t*-tests were calculated to report the topographical distribution of the effect. As our study is concerned with the effect of CONTEXT TYPE within each WORD ORDER, a significant interaction of both factors would be resolved by WORD ORDER. With this procedure, we ensure to compare ERPs of identical DPs with regard to morphosyntax and thematic role. For presentation purposes only, the grand average ERPs displayed in Figs. 2 and 3 were 7 Hz low-pass filtered (Butterworth zero phase filter: high cutoff: 7 Hz; slope: 12 dB/oct).

3.1.6. Behavioral data analysis

For statistical data analysis of the sentence-picture-verification task, logit mixed models for analysis of the binary distributed response accuracy data (correct vs. incorrect answers) were calculated. This statistical analysis followed the same procedure as described in Experiment 1.

3.2. Results

3.2.1. ERP results

Fig. 2 displays the grand average ERPs at selected electrode positions of the respective ROIs time-locked to the onset of DP1. For complete statistical details of the ERP analysis at DP1 see Table 3. Fig. 3 shows the grand average ERPs of one selected exemplary electrode time-locked to the onset of the verb and DP2, respectively.

3.2.1.1. ERP results time-locked to onset of DP1. For ERPs in the time window 100–300 ms post onset DP1, the ANOVA including the factors CONTEXT TYPE (TOPIC vs. NEUTRAL) and WORD ORDER (SO vs. OS) and ROI revealed a significant main effect of CONTEXT TYPE [$F(1, 18) = 5.48$, $p \leqslant .05$]: If DP1 was preceded by the topic context, the positivity around 200 ms was reduced (compared to the neutral context).

The ANOVA in the 300–500 ms time window yielded neither any statistically significant main effects nor interactions [$p > .1$].

For the 500–700 ms time window, the ANOVA revealed a significant interaction of WORD ORDER × ROI [$F(8, 144) = 4.14$, $p \leqslant .01$] as well as WORD ORDER × CONTEXT TYPE × ROI [$F(8, 144) = 4.15$, $p \leqslant .05$].[3] Separate post hoc analyses to resolve the three-way interaction of WORD ORDER × CONTEXT TYPE × ROI by WORD ORDER revealed a significant interaction of CONTEXT TYPE × ROI in sentences with OS order [$F(8, 144) = 2.99$, $p \leqslant .05$] (see Fig. 2, lower panel). Follow-up *t*-tests showed a significantly reduced positivity from 500 to 700 ms for OS sentences preceded by the topic context relative to the neutral context in the right-frontal and frontal-midline ROI [$t(18) = -2.53/-2.28$, $p \leqslant .05$]. For SO sentences, the post hoc ANOVA did not show any significant differences in the ERPs with regard to the factor CONTEXT TYPE [$p > .1$] (see Fig. 2, upper panel).

3.2.1.2. ERP results time-locked to onset of the verb. The ERPs in the three different time windows 100–300 ms, 300–500 ms and 500–700 ms post verb onset neither revealed any statistically significant main effects nor interactions with regard to the factors CONTEXT TYPE, WORD ORDER and/or ROI [$p > .1$]. As suggested by one anonymous reviewer, we performed an additional ERP analysis without baseline correction to account for possible baseline correction effects during the course of sentence processing (see e.g., Friederici, Wang, Herrmann, Maess, and Oertel (2000) and Wolff et al. (2008) for a similar procedure). The results revealed a significant main effect of WORD ORDER in the 100–300 ms time window [$F(1, 18) = 5.89$, $p \leqslant .05$] (OS more positive than SO) and a significant interaction of WORD ORDER × ROI in the 300-500 ms time window [$F(8, 144) = 3.25$, $p \leqslant .05$]. The post hoc *t*-test analysis to resolve the WORD ORDER × ROI interaction in the 300–500 ms time window revealed an enhanced negativity for OS compared to SO sentences in the left central ROI [$t(18) = 2.64$, $p \leqslant .05$] (see Fig. 3 (left panel) for the grand average ERPs time-locked to the onset of the verb at an example electrode of the left central ROI).

3.2.1.3. ERP results time-locked to onset of DP2. Statistical analysis of the ERPs time-locked to the onset of DP2 revealed a significant interaction of WORD ORDER × ROI in the time windows 300–500 ms [$F(8, 144) = 3.09$, $p \leqslant .05$] and 500–700 ms [$F(8, 144) = 3.53$, $p \leqslant .01$]. Post hoc *t*-tests showed that ERPs at DP2 were significantly more positive for OS sentences compared to SO sentences in the left frontal ROI for the 300–500 ms [$t(18) = -3.45$, $p \leqslant .01$] as well as for the 500–700 ms time window [$t(18) = -2.24$, $p \leqslant .05$].

Similar to the analysis with baseline correction, ERPs without baseline correction time-locked to the onset of DP2 showed the same pattern, but only in the later time window: The ANOVA of ERPs without baseline correction resulted in a marginally significant interaction of WORD ORDER × ROI [$F(8, 144) = 2.46$, $p \leqslant .06$] in the time window of 500–700 ms. As revealed by post hoc *t*-tests in this time window, the ERPs of OS sentences were significantly more positive compared to SO sentences in the frontal midline ROI [$t(18) = -2.12$, $p \leqslant .05$] (see right panel in Fig. 3).

3.2.2. Behavioral results

Participants showed the following response accuracy for each condition (in 20% of the trials): NEUTRAL SO: $M = 0.92$ ($SE = 0.02$), TOPIC SO: $M = 0.86$ ($SE = 0.02$), NEUTRAL OS: $M = 0.84$ ($SE = 0.03$), TOPIC OS: $M = 0.88$ ($SE = 0.02$). The final logit mixed model analysis of the raw response accuracy data including by-participant and by-item random intercepts did not reveal any statistically significant differences concerning the fixed effects CONTEXT TYPE ($b = 0.03$, $SE = 0.65$, $z = 0.05$, $p > .1$), WORD ORDER ($b = 0.84$, $SE = 0.65$, $z = 1.28$, $p > .1$), or the interaction CONTEXT TYPE × WORD ORDER ($b = 0.29$, $SE = 0.65$, $z = 0.45$, $p > .1$).

4. Discussion

In the present study, we used an offline comprehensibility judgment task (Experiment 1) to determine if discourse context affects the judgments concerning the overall comprehension of stories

[3] Similar results were found for the analysis of the time window 500–900 ms.

Table 3
Results of analysis of variance (ANOVAs) of the ERPs for different time windows (TW) time-locked to onset of the first determiner phrase (DP1).

	df	*F*-values		
		TW 100–300 ms (P200)	TW 300–500 ms (N400)	TW 500–700 ms (P600)
CONTEXT TYPE	1, 18	5.48*	0.02	0.73
CONTEXT TYPE × ROI	8, 144	1.77	0.78	0.34
WORD ORDER	1, 18	1.99	1.04	0.67
WORD ORDER × ROI	8, 144	0.66	0.98	4.14**
WORD ORDER × CONTEXT TYPE	1, 18	2.56	0.47	3.07
WORD ORDER × CONTEXT TYPE × ROI	8, 144	1.68	2.09	4.15*

Note. Greenhouse and Geisser (1959) corrected significance levels: * $p \leqslant .05$, ** $p \leqslant .01$. *df* = degrees of freedom.

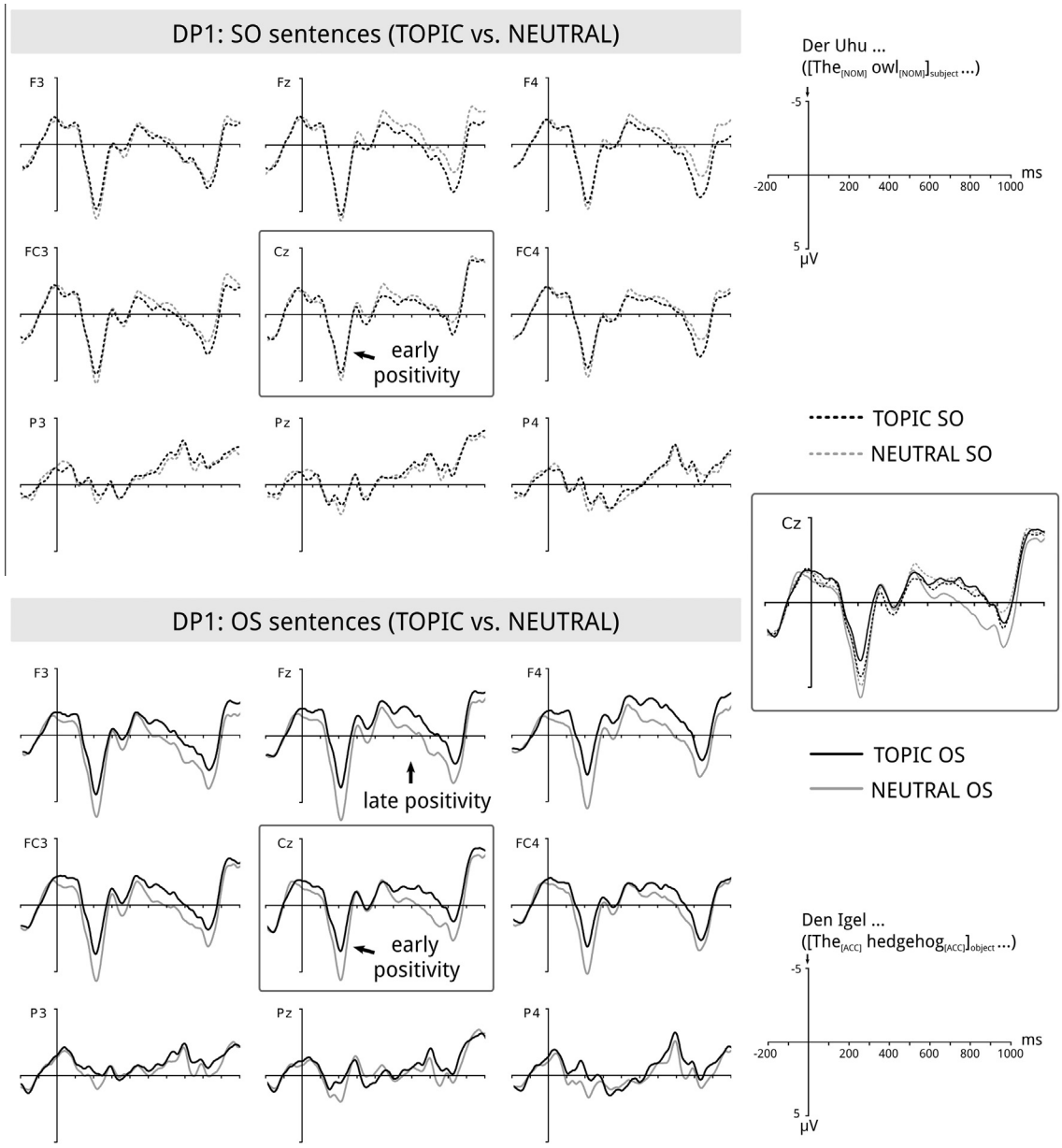

Fig. 2. Grand average ERPs (with baseline correction) at selected electrodes time-locked to the onset of the first determiner phrase (DP1) of the target sentence showing the effect of CONTEXT TYPE (TOPIC vs. NEUTRAL) within each word order (upper panel: TOPIC SO [dotted black] vs. NEUTRAL SO [dotted gray], lower panel: TOPIC OS [solid black] vs. NEUTRAL OS [solid gray]). Negativity is plotted upwards.

with German SO and OS sentences, and applied ERPs (Experiment 2) to characterize the time course of context-induced effects during online sentence comprehension. The discourse contexts depicted two characters in a fictitious scene and a context question related to either the topic status of one character (topic context) or a wide focus of the entire scene (neutral context).

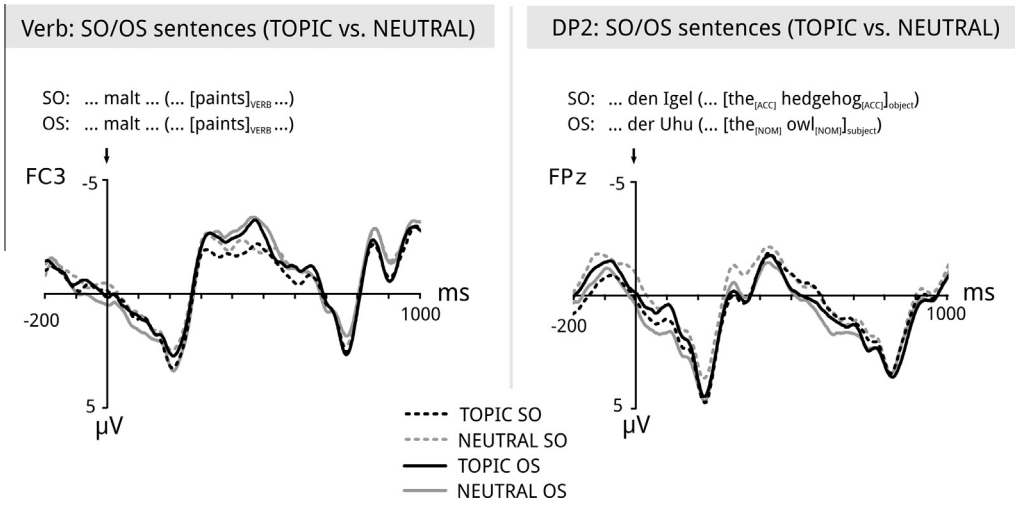

Fig. 3. Grand average ERPs (without baseline correction) at one selected electrode time-locked to the onset of verb (left panel) and second determiner phrase (DP2) (right panel) of the target sentence, respectively (TOPIC SO [dotted black] vs. NEUTRAL SO [dotted gray] vs. TOPIC OS [solid black] vs. NEUTRAL OS [solid gray]). Negativity is plotted upwards.

In summary, the results of both experiments clearly revealed a statistically significant interaction of the factors CONTEXT TYPE and WORD ORDER. The results of the comprehensibility judgment task (Experiment 1) demonstrate the participants' judgments on the comprehensibility of stories with OS target sentences were significantly improved if presented together with the topic context as compared to the neutral context. As predicted, no context effects were evident for the comprehensibility judgments of stories with SO target sentences. In line with the judgment data, during online comprehension of OS target sentences, ERPs (Experiment 2) were significantly modulated by the previous topic context: Compared to neutral context, the topic context elicited a less pronounced late positivity at the sentence-initial object position (DP1). Thus, for the OS sentences, the processing of identical sentence structures was significantly affected by the preceding context type. As expected, no effect of context was found during online processing of SO sentences; supporting the assumption that context information does not play a crucial role for processing of canonical word order. In addition, we observed a significant modulation of an early positivity peaking around 200 ms: Independent of word order, the early positive peak was reduced for target sentences following the topic relative to the neutral context. We interpret this finding as a perceptual mismatch response to repeated words (see below). Notably, in ERPs, the impact of context information during sentence processing was exclusively observable at the sentence-initial position (DP1) and did not elicit any further differential effects as the sentence unfolds (i.e., verb, DP2, for which we only found word order effects). In the following, we will discuss our results first in light of ERP components, before turning in more detail to word order effects and the impact of aboutness topic on the processing of non-canonical sentences.

4.1. Late positivity

ERP studies investigating discourse level processing attributed the late positivity to processing costs for updating the current discourse model (e.g., Burkhardt, 2006, 2007; Cowles, 2003; Hirotani & Schumacher, 2011; Hung & Schumacher, 2012; Kaan, Dallas, & Barkley, 2007; Schumacher & Hung, 2012; Wang & Schumacher, 2013). If the previously established discourse representation has to be updated by the listener, an increased late positivity has been induced. We suggest that establishing aboutness topic status of one of the two given characters by means of the context question increased the activation of this character in the present discourse model. Parallel to those recent ERP studies on discourse level processing and in line with the SDM, we interpret the late positivity in our study as an index for differential discourse updating costs of the established discourse model depending on whether the aboutness topic of the upcoming sentence has been announced previously.

In our study design, the topic context induced the expectation that the topic will be announced at the first position of the target sentence because the sentence-initial position is preferably filled by topic in German main clauses (e.g., Büring, 1999). If the first position of the target sentence is an object (i.e., OS sentence), fewer costs for updating the discourse model are induced if the sentence was preceded by a topic context as compared to a neutral context. Hung and Schumacher (2014) have observed that, for Mandarin Chinese at least, presenting a less prominent referent in topic position caused higher updating costs as reflected in a late positivity. While Hung and Schumacher manipulated prominence in terms of animacy, it could be argued for our study that the topic context increased the information structural prominence of one of the two previously given referents (both animate). Hence in OS, the prominent announcement of the topic referent led to reduced updating costs of the mental model as compared to the neutral context, in which both referents were equally prominent – rendering none of them plausible to be placed in the sentence-initial object position. If the first position of the target sentence is a subject (i.e., SO sentence), there are no differential discourse updating costs dependent on the preceding context. We might not see a comparable modulation of the late positivity at the sentence-initial position in SO sentences, as –due to the strong subject-first-preference in German (e.g., Hemforth, 1993)– the canonical word order is felicitous and hence easy to process even in the absence of context information (see Sections 1.1 and 1.3). The well-established interpretation of the late positivity in terms of the P600 (also syntactic positive shift, SPS) as reflecting syntax specific processing costs for structural reanalysis (e.g., Hagoort, 1993; Osterhout & Holcomb, 1992) and repair mechanisms (e.g., Friederici, Steinhauer, Mecklinger, & Meyer, 1998) is not sustainable for the late positivity in our study. In particular, the late positivity was elicited during processing of the very same non-canonical structures in which neither syntactic anomalies (i.e., ambiguity resolution) nor violations (e.g., of the phrase structure) were present. Thus, this late

positivity is in fact modulated by the preceding discourse level information and indexes discourse updating costs in line with the assumption of the SDM. The interpretation of the late positivity in our study is also compatible with the assumptions of the eADM: In the third phase of sentence processing late positivities indicate the integration of core-external (e.g., discourse) information and have been linked to the P300 family (Bornkessel & Schlesewsky, 2006a). P300 (or P3) responses are positive deflections of the ERP induced around 300 ms after stimulus onset (Sutton, Braren, Zubin, & John, 1965) typically evoked by infrequent stimuli in oddball paradigms (see Nieuwenhuis, Aston-Jones, & Cohen, 2005 for a review). In general, amplitude and latency of the component are considered to be influenced by (unconscious) expectancy,[4] task relevance, novelty, contextual constraints, and motivational significance (see e.g., Nieuwenhuis et al., 2005). Of most interest to our study, the P300 has been assumed to be related to domain-general context-updating processes and to reflect the revision of a mental model or the "conditions of the environment" (Donchin and Coles (1988, p. 367); but see Verleger (1988) and the following commentaries). Our design strictly followed a simple pattern of lead-in–context-question–target-sentence, revealing all referents given in the lead-in. The reduced late positivity in response to the sentence-initial object following the topic context could index a reduced need for general context updating, because the listener is less "surprised" about the object if previously announced as the topic of the scene compared to the neutral context. Thus, in line with Cowles (2003) who also reported a contextually modulated late positivity (i.e., the Late Positive Component (LPC)) during sentence comprehension, the late positivity in our study could reflect context-updating processes in terms of the P300. Notably, a number of authors argue against the context-updating interpretation of the P300 in favor of a general reflection of simple attentional, evaluative, or memory mechanisms (for a review, see Nieuwenhuis et al., 2005). Hence, it remains a matter of debate if late positivities/P600 responses elicited by sentences really belong to the P300 family or whether they should be considered an independent component (e.g., Coulson, King, & Kutas, 1998; Roehm et al., 2007; see Brouwer, Fitz, & Hoeks, 2012 for a related discussion of the P600 in response to semantic violations or illusions).

4.2. N400 component

The N400 has been described as another ERP component sensitive to discourse level information. It is thought to reflect processing costs for linking an entity to the current mental model (Burkhardt, 2006; Burkhardt & Roehm, 2007; Wang & Schumacher, 2013). The SDM assumes that discourse linking processes are driven by expectancy as indexed by a modulation of the N400 (see Sections 1.2 and 1.3). In these studies, the degree of inferability, expectancy, or accessibility of an entity in the mental model modulated the N400: The N400 for previously given, expected, or repeated noun phrases was reduced because those entities were easier to link to the current discourse. Importantly, due to the preceding lead-in context in our study which was identical for the neutral and the topic condition, both characters of the scene were discourse-given (Prince, 1981). Hence, we controlled for any processing advantages caused by the well-established given-before-new ordering principle (Clark & Haviland, 1977), or different degrees of inferability of an entity that might coincide with context effects (i.e., focus on subject or object) during processing of sentences with varying word order from previous studies (e.g., Bornkessel et al., 2003; Meng et al., 1999). Thus, absence of an N400 modulation in our study might be due to the fact that both characters of the scene were previously mentioned in the lead-in context, and thus equally expected and accessible in the mental model. This is in line with Burkhardt and Roehm (2007), who argue that both entities within a coordinated noun phrase –in our experimental design the two animals in the lead-in (e.g., *the owl and the hedgehog*)– evoke the same representational status in terms of accessibility or saliency in the mental model. In the framework of the SDM, our design was effective in the modulation of costs for updating the current discourse model (late positivity, see above) but not for expectancy-based discourse linking processes (N400).

4.3. Early positivity

Notably, in the topic condition, the topic of the context-question (e.g., *What about the owl?*) was directly repeated at the sentence initial position of the target sentence (SO and OS sentences), whereas such a repetition was not present in the target sentence following the neutral context (e.g., *What exactly is going on?*). Accordingly, the context type in our study revealed a broadly distributed early positive peak time-locked to the onset of the target sentence independent of its word order. As the topic context induced a reduction of this early positivity relative to the neutral context, we suggest that this context effect might be confounded with basic processes of information encoding due to word repetition in one but not the other context. The early positivity we found showed a similar peak and latency pattern as the positivity around 200 ms (c.f., P200) for which mixed results regarding its functional nature are reported in dependence on the experimental paradigm (e.g., Coulson, Federmeier, van Petten, & Kutas, 2005; Federmeier & Kutas, 2001; Friedrich & Kotz, 2007). As early modulations of ERPs, such as the P200, have commonly been associated with processes of basic information encoding (for visual stimuli see for instance Dunn, Dunn, Languis, & Andrews, 1998; Evans & Federmeier, 2007; Luck & Hillyard, 1994), we propose an interpretation of the reduced early positivity for repeated words in the topic condition in terms of a word repetition effect. Note that so far contradictory results have been reported with regard to amplitude and latency of ERPs elicited by word repetition: On the one hand side, some studies did not find a reduced but instead an enhanced early positivity for repeated words (see e.g., van Petten, Kutas, Kluender, Mitchiner, & McIsaac, 1991). However, in line with our data, a reduced early positivity for repeated words was found in word lists (e.g., Nagy & Rugg, 1989; Rugg, 1985). Most interestingly, Hung and Schumacher (2012) reported a similar discourse-related early P200-effect as our study (i.e., an enhanced P200 for novel-topic > topic-shift > topic-continuity; see also Hung & Schumacher (2014)). They interpreted the P200 –which was reduced for processing similar graphical forms– as an early perceptual mismatch response. This is in line with our interpretation of the present finding in terms of an early perceptual repetition effect in the topic condition.

4.4. Word order effects

Some ERP studies examining word order variation in German main clauses (i.e., prefield) without a preceding context demonstrated processing difficulties in terms of an enhanced LAN for OS compared to SO at the first DP (e.g., Matzke et al., 2002; Rösler et al., 1998), whereas other studies did not report such an effect of canonicity (e.g., Frisch et al., 2002; Knoeferle, Habets, Crocker, & Münte, 2007). For the German middlefield, robust processing difficulties in form of the scrambling negativity for OS vs. SO are reported even if preceded by context information (e.g., Bornkessel & Schlesewsky, 2006b; Bornkessel et al., 2003).

[4] Note, the P300 is not just simply evoked by unexpected stimuli but also present in response to highly expected words, depending on task demands and individual processing strategies (Roehm, Bornkessel-Schlesewsky, Rösler, & Schlesewsky, 2007).

As mentioned above, we did not focus on the direct comparison of the two word orders for the following reasons: First, SO is the canonical and more frequent word order in German; any differences could hence be confounded by those effects. Second, grammatical and thematic role coincided in our material. Thus, we would not only compare word order but also the order of thematic roles. Therefore, we prefer to interpret our context effects within each word order to assure we compare the same target sentences. However, the ERPs in our study indicate that word order immediately interacted with the preceding context during incremental sentence processing, as reflected by the late positivity at DP1 – the position that immediately followed the context question and revealed the crucial case marking of subject/object and the thematic role. Hence, it seems that similar to Schumacher and Hung (2012) no processing difficulties for OS vs. SO in terms of a negative deflection at the sentence-initial position of German main clauses was elicited – if embedded in a strong licensing context. At both subsequent sentence positions (i.e., verb, DP2) a significant word order effect was found. OS (vs. SO) sentences elicited an early positivity (100–300 ms) as well as a left central negativity 300–500 ms after the finite verb and a frontally distributed positivity 500–700 ms after the DP2. Similar word order effects on ERPs at subsequent sentence positions have been reported in other studies (e.g., a negativity around 350–550 ms relative to verb onset (Wolff et al., 2008); a positivity (400–700 ms) at DP2 (Fiebach, Schlesewsky, & Friederici, 2002)). In line with these studies, we interpret the word order effects in our study as reflecting general processing costs for OS compared to SO sentences.

4.5. Aboutness topic and sentence comprehension

In line with recent studies using either offline (e.g., Meng et al., 1999; Weskott et al., 2011) or online methods (e.g., Bornkessel et al., 2003; Schumacher & Hung, 2012), our study shows that the type of context information crucially affected offline comprehensibility judgments and online sentence processing of non-canonical sentences in German. Unlike previous studies, we manipulated the topic status of our referents in terms of explicitly announcing the aboutness topic of the upcoming sentence rather than also manipulating givenness and/or focus. Taking into consideration the results of both experiments, we argue that the information structural concept aboutness topic serves as a felicitous context for the comprehension of OS declarative sentences. The indication of the topic in our study did not coincide with animacy-based prominence of the characters (Tomlin, 1986) that could have led to any additional ordering preferences (e.g., Bornkessel-Schlesewsky & Schlesewsky, 2009b; Hung & Schumacher, 2014; Lenerz, 1977). In our study, grammatical and thematic role coincided (the grammatical subject was always the agent, the grammatical object was always the patient at both sentence positions); therefore, it is important to note that we interpret our context effects within each word order. Information-structurally, the topic –what the sentence is about– is preferably announced at the sentence-initial position (e.g., Büring, 1999; Reinhart, 1981). A recent study (Bornkessel-Schlesewsky et al., 2012) confirmed that in German aboutness-based information correlates with word order in the prefield, while prominence-based information affects word order in the middlefield. In line with these properties, we found that topic status seemed to affect information packaging in the prefield: If the sentence-initial object in OS has been established as topic by the preceding context the non-canonical word order was felicitous. This impact of topic was detectable in the offline judgments, as stories containing the OS target sentence were judged as harder to comprehend without a supportive context (i.e., neutral context). In line with this, we interpret the reduced late positivity during online processing of OS sentences following the topic context as reflecting reduced discourse updating costs compared to the neutral context.

The reduction of the late positivity is in line with reduced costs for updating the discourse representation in the listener as assumed by the SDM (Schumacher & Hung, 2012; Wang & Schumacher, 2013) as well as by the eADM (Bornkessel & Schlesewsky, 2006a). Hence, our findings are further evidence that currently processed information is directly interpreted and incrementally integrated in relation to a previously established discourse representation and support assumptions of recent sentence processing models (eADM, SDM, ISPH by Cowles, 2003). Although we can only speculate about the underlying brain structures, the "New dorsal–ventral stream model of sentence comprehension" of Bornkessel-Schlesewsky and Schlesewsky (2013) would assume the following left hemispheric brain regions to engage in our task: The dorsal processing stream is responsible for the time-dependent syntactic computations and actor identification. The frontal cortex is engaged in top-down-control and conflict resolution (hence, the establishment and updating of word-order-expectations). Anterior lIFG has been shown to correlate with aboutness information (Bornkessel-Schlesewsky et al., 2012). Parietal brain regions are involved in linking single sentences to the previous discourse. However, these assumptions would need to be tested systematically in the future with experimental techniques other than ERPs and comprehensibility judgments.

In summary, the results of the offline comprehensibility judgments are directly reflected during online processing of the sentence-initial topic in these sentences. Offline measures, such as behavioral judgments, most likely coincide with metalinguistic awareness (Sprouse & Schütze, 2013). The additional online measure using ERPs emphasizes the impact of the topic information on the processing of non-canonical sentences in German. Thus, our ERP findings add explanatory information regarding the subsequent steps of sentence comprehension modulated by preceding discourse information. As processing of non-canonical sentences was crucially modulated by the preceding topic context, we argue that the processing of specific syntactic structures (e.g., with varying word order) is sensitive to discourse level information. Our data nicely fit to the SDM (see Schumacher & Hung, 2012 or Wang & Schumacher, 2013) which assumes two core processes of referential processing: (1) During *discourse linking* the expectation of the listener immediately modulates the processing of incoming information to connect current information to previously given information (not modulated in our study). (2) During *discourse updating*, the listener updates the previously established internal discourse representation and adapts the syntax-discourse mapping accordingly. The aboutness topic in the present study effectively reduced the discourse updating costs as reflected in the reduced late positivity in the non-canonical sentences and the higher comprehensibility judgments, even though all referents were given in the previous context.

5. Conclusion

The present study characterized the nature and time course of an aboutness topic context on the comprehension of German declarative sentences within fictitious discourses. For non-canonical, but not for canonical sentences, we found an impact of the topic context which indicated one of two previously given characters of the scene as the aboutness topic compared to a context in which a wide scope of the scene was induced (neutral context). The results of both experiments, the offline comprehensibility judgment task and the ERPs during online sentence processing, indicate that the topic context selectively facilitated comprehension

of the non-canonical word order. In the ERPs, easier comprehension of OS sentences preceded by the topic context was detectable in terms of a reduced late positivity at the sentence-initial object position. This reduced late positivity is interpreted as reflecting less effortful processing demands for updating the current discourse model in case the aboutness topic entity has previously been integrated therein. The present study supports recent evidence that during online sentence processing listeners immediately take incoming discourse information into account and dynamically adapt their internal discourse representation.

Acknowledgments

This research was supported by the Collaborative Research Centre (SFB 632) 'Information structure' funded by the German Research Foundation (DFG). IW was supported by the Stifterverband für die Deutsche Wissenschaft (Claussen-Simon-Stiftung). We thank Franziska Machens and Tobias Busch for assistance in data acquisition and analysis as well as Dr. Christina Harzman for proof reading.

References

American Electroencephalographic Society. (2006). Guideline 5: Guidelines for standard electrode position nomenclature. *Journal of Clinical Neurophysiology*, 11, 111–113.

Baayen, R. H. (2008). *Analysing linguistic data*. Cambridge: Cambridge University Press.

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language, 59*, 390–412.

Bader, M., & Häussler, J. (2010). Word order in German: A corpus study. *Lingua, 120*(3), 717–762.

Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language, 68*(3), 255–278.

Bates, D. M., Maechler, M., & Dai, B. (2009). *Lme4: Linear-mixed-effect models using S4 classes*. Vienna, Austria: R Foundation for Statistical Computing.

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

Bornkessel, I., & Schlesewsky, M. (2006b). The role of contrast in the local licensing of scrambling in German: Evidence from online comprehension. *Journal of Germanic Linguistics, 18*(1), 1–43.

Bornkessel, I., Schlesewsky, M., & Friederici, A. D. (2002). Grammar overrides frequency: Evidence from the online processing of flexible word order. *Cognition, 85*, B21–B30.

Bornkessel, I., Schlesewsky, M., & Friederici, A. D. (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), 871–882.

Bornkessel, I., Zysset, S., Friederici, A. D., von Cramon, D. Y., & Schlesewsky, M. (2005). Who did what to whom? The neural basis of argument hierarchies during language comprehension. *NeuroImage, 26*(1), 221–233.

Bornkessel-Schlesewsky, I., Grewe, T., & Schlesewsky, M. (2012). Prominence vs. aboutness in sequencing: A functional distinction within the left inferior frontal gyrus. *Brain and Language, 120*(2), 96–107.

Bornkessel-Schlesewsky, I., & Schlesewsky, M. (2009a). The role of prominence information in the real-time comprehension of transitive constructions: A cross-linguistic approach. *Language and Linguistics Compass, 3*(1), 19–58.

Bornkessel-Schlesewsky, I., & Schlesewsky, M. (2009b). Minimality as vacuous distinctness: Evidence from cross-linguistic sentence comprehension. *Lingua, 119*(10), 1541–1559.

Bornkessel-Schlesewsky, I., & Schlesewsky, M. (2012). Linguistic sequence processing and the prefrontal cortex. *The Open Medical Imaging Journal, 6*, 47–61.

Bornkessel-Schlesewsky, I., & Schlesewsky, M. (2013). Reconciling time, space and function: A new dorsal–ventral stream model of sentence comprehension. *Brain and Language, 125*(1), 60–76.

Brouwer, H., Fitz, H., & Hoeks, J. (2012). Getting real about semantic illusions: Rethinking the functional role of the P600 in language comprehension. *Brain Research, 1446*, 127–143.

Büring, D. (1999). Topic. In P. Bosch & R. van der Sandt (Eds.), *Focus: Linguistic, cognitive, and computational perspectives* (pp. 142–165). Cambridge: University Press.

Büring, D. (2007). Semantics, intonation and information structure. In G. Ramchand & C. Reiss (Eds.), *The Oxford handbook of linguistic interfaces* (1st ed., pp. 445–474). Oxford: Oxford University Press.

Burkhardt, P. (2005). *The syntax-discourse interface: Representing and interpreting dependency*. John Benjamins Publishing Company.

Burkhardt, P. (2006). Inferential bridging relations reveal distinct neural mechanisms: Evidence from event-related brain potentials. *Brain and Language, 98*(2), 159–168.

Burkhardt, P. (2007). The P600 reflects cost of new information in discourse memory. *NeuroReport, 18*(17), 1851–1854.

Burkhardt, P., & Roehm, D. (2007). Differential effects of saliency: An event-related brain potential study. *Neuroscience Letters, 413*(2), 115–120.

Chafe, W. L. (1976). Givenness, contrastiveness, definiteness, subjects, topics, and point of view. In C. N. Li (Ed.), *Subject and topic* (pp. 25–55). New York: Academic Press.

Choi, H.-W. (1996). *Optimizing structure in context: Scrambling and information structure (Dissertation)*. Stanford University.

Clark, H., & Haviland, S. E. (1977). Comprehension and the given-new contract. In R. O. Freedle (Ed.), *Discourse production and comprehension* (pp. 1–40). Hillsday, New Jersey: Erlbaum.

Coulson, S., Federmeier, K. D., van Petten, C., & Kutas, M. (2005). Right hemisphere sensitivity to word- and sentence-level context: Evidence from event-related brain potentials. *Journal of Experimental Psychology. Learning, Memory, and Cognition, 31*(1), 129–147.

Coulson, S., King, J. W., & 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 (Dissertation)*. San Diego: University of California.

Cowles, H. W., 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.

Diedrichsen, E. (2008). Where is the precore slot? Mapping the layered structure of the clause and German sentence topology. In R. D. Van Valin, Jr. (Ed.), *Investigations of the Syntax–Semantics–Pragmatics Interface* (pp. 203–224). Amsterdam: John Benjamins Publishing Co.

Donchin, E., & Coles, M. G. H. (1988). Is the P300 component a manifestation of context updating? *Behavioral and Brain Sciences, 11*(3), 355–372.

Dunn, B. R., Dunn, D. A., Languis, M., & Andrews, D. (1998). The relation of ERP components to complex memory processing. *Brain and Cognition, 36*(3), 355–376.

Evans, K. M., & Federmeier, K. D. (2007). The memory that's right and the memory that's left: Event-related potentials reveal hemispheric asymmetries in the encoding and retention of verbal information. *Neuropsychologia, 45*(8), 1777–1790.

Fanselow, G., & Lenertová, D. (2011). Left peripheral focus: Mismatches between syntax and information structure. *Natural Language & Linguistic Theory, 29*(1), 169–209.

Federmeier, K. D., & Kutas, M. (2001). Meaning and modality: Influences of context, semantic memory organization, and perceptual predictability on picture processing. *Journal of Experimental Psychology: General, 27*(1), 202–224.

Féry, C., & Krifka, M. (2008). Information Structure: Notional Distinctions, Ways of Expression. In P. van Sterkenburg (Ed.), *Unity and diversity of languages* (pp. 123–136). Amsterdam: John Benjamins Publishing Co..

Fiebach, C. J., Schlesewsky, M., & Friederici, A. D. (2002). Separating syntactic memory costs and syntactic integration costs during parsing: The processing of German WH-questions. *Journal of Memory and Language, 47*, 250–272.

Frey, W. (2004a). A medial topic position for German. *Linguistische Berichte, 198*, 153–196.

Frey, W. (2004b). The grammar-pragmatics interface and the German prefield. *Sprache und Pragmatik, 52*, 1–39.

Frey, W. (2007). Some contextual effects of aboutness topics in German. In A. Späth (Ed.), *Interfaces and Interface conditions. Language, Context and Cognition*. Berlin: Walther de Gruyter (pp. 329–348).

Friederici, A. D. (2002). Towards a neural basis of auditory sentence processing. *Trends in Cognitive Sciences, 6*(2), 78–84.

Friederici, A. D., Steinhauer, K., Mecklinger, A., & Meyer, M. (1998). Working memory constraints on syntactic ambiguity resolution as revealed by electrical brain responses. *Biological Psychology, 47*(3), 193–221.

Friederici, A. D., Wang, Y., Herrmann, C., Maess, B., & Oertel, U. (2000). Localization of early syntactic processes in frontal and temporal cortical areas: A magnetoencephalographic study. *Human Brain Mapping, 11*, 1–11.

Friedrich, C. K., & Kotz, S. A. (2007). Event-related potential evidence of form and meaning coding during online speech recognition. *Journal of Cognitive Neuroscience, 19*(4), 594–604.

Frisch, S., Schlesewsky, M., Saddy, D., & Alpermann, A. (2002). The P600 as an indicator of syntactic ambiguity. *Cognition, 85*, B83–B92.

Givón, T. (1983). *Topic continuity in discourse: A quantitative cross-language study. Typoloical studies in language* (Vol. 3). Amsterdam, Philadelphia: John Benjamins Publishing Co..

Gorrell, P. (2000). The subject-before-object-preference in German clauses. In B. Hemforth (Ed.), *German sentence processing* (pp. 25–63). Dordrecht: Kluwer Academic Publishers.

Gratton, G., Coles, M. G. H., & Donchin, E. (1983). A new method for off-line removal of ocular artifact. *Electroencephalography and Clinical Neurophysiology, 55*(4), 468–484.

Greenhouse, S. W., & Geisser, S. (1959). On methods in the analysis of profile data. *Psychometrika, 24*(2), 95–112.

Gundel, J. K. (1985). Shared knowledge' and topicality. *Journal of Pragmatics, 9*, 83–107.
Gundel, J. K. (1988). Universals of topic-comment structure. In M. Hammond, E. Moravczik, & J. R. Wirth (Eds.), *Studies in syntactic typology* (pp. 209–239). Amsterdam: Benjamins.
Hagoort, P. (1993). The Syntactic Positive Shift (SPS) as an ERP Measure of Syntactic Processing. *Language and Cognitive Processes, 8*(4), 439–483.
Haider, H., & Rosengren, I. (1998). Scrambling. *Sprache und Pragmatik, 49*, 1–104.
Halliday, M. A. K. (1967). Notes on transitivity and theme in English. *Journal of Linguistics, 3*(2), 199–244.
Haviland, S. E., & Clark, H. H. (1974). What's new? Acquiring new information as a process in comprehension. *Journal of Verbal Learning and Verbal Behavior, 13*(5), 512–521.
Heister, J., Würzner, K.-M., Bubenzer, J., Pohl, E., Hanneforth, T., Geyken, A., et al. (2011). DlexDB – eine lexikalische Datenbank für die psychologische und linguistische Forschung. *Psychologische Rundschau, 62*(1), 10–20.
Hemforth, B. (1993). *Kognitives Parsing: Repräsentation und Verarbeitung sprachlichen Wissens (Dissertation)*. Bochum: Ruhr-Universität Bochum.
Hirotani, M., & Schumacher, P. B. (2011). Context and topic marking affect distinct processes during discourse comprehension in Japanese. *Journal of Neurolinguistics, 24*(3), 276–292.
Hockett, C. F. (1958). *A course in modern linguistics*. New York: McMillan.
Hung, Y.-C., & Schumacher, P. B. (2012). Topicality matters: Position-specific demands on Chinese discourse processing. *Neuroscience Letters, 511*(2), 59–64.
Hung, Y.-C., & Schumacher, P. B. (2014). Animacy matters: ERP evidence for the multi-dimensionality of topic-worthiness in Chinese. *Brain Research, 1555*, 36–47.
Jacobs, J. (2001). The dimensions of topic–comment. *Linguistics, 39*(4), 641–681.
Jacobs, J. (1988). Fokus-Hintergrund-Gliederung und Grammatik. In H. Altmann (Ed.), *Intonationsforschung* (pp. 89–134). Tübingen: Niemeyer.
Jaeger, T. F. (2008). Categorical data analysis: Away from ANOVAs (transformation or not) and towards logit mixed models. *Journal of Memory and Language, 59*(4), 434–446.
Johnson-Laird, P. N. (1980). Mental models in cognitive science. *Cognitive Science Proceedings, 4*, 71–115.
Kaan, E., Dallas, A. C., & Barkley, C. M. (2007). Processing bare quantifiers in discourse. *Brain Research, 1146*, 199–209.
Kempen, G., & Harbusch, K. (2005). The relationship between grammaticality ratings and corpus frequencies: A case study into word order variability in the midfield of German clauses. In S. Kepser & M. Reis (Eds.), *Linguistic evidence – empirical, theoretical, and computational perspectives*. Berlin: Mouton De Gruyter.
Knoeferle, P., Habets, B., Crocker, M. W., & Münte, T. F. (2007). Visual scenes trigger immediate syntactic reanalysis: Evidence from ERPs during situated spoken comprehension. *Cerebral Cortex, 18*(4), 789–795.
Krifka, M. (2008). Basic notions of information structure. *Acta Linguistica Hungarica, 55*(3), 243–276.
Kutas, M., & Federmeier, K. D. (2011). Thirty years and counting: Finding meaning in the N400 component of the event-related brain potential (ERP). *Annual Review of Psychology, 62*(1), 621–647.
Lambrecht, K. (1994). *Information structure and sentence form: Topic, focus and the mental representations of discourse referents*. Cambridge: University Press.
Lau, E. F., Phillips, C., & Poeppel, D. (2008). A cortical network for semantics: (De)constructing the N400. *Nature Reviews Neuroscience, 9*(12), 920–933.
Lenerz, J. (1977). *Zur Abfolge nominaler Satzglieder im Deutschen. Studien zur deutschen Grammatik*. Tübingen: TBL Verlag Gunter Narr. Vol. 5.
Lenerz, J. (2000). Word order variation: Competition or Co-operation? In G. Müller & W. Sternefeld (Eds.), *Studies in Generative Grammar 49. Competition in Syntax*. Berlin & New York: Walther de Gruyter (pp. 249–282).
Luck, S. J., & Hillyard, S. A. (1994). Electrophysiological correlates of feature analysis during visual search. *Psychophysiology, 31*(3), 291–308.
Matzke, M., Mai, H., Nager, W., Rüsseler, J., & Münte, T. F. (2002). The costs of freedom: An ERP-study of non-canonical sentences. *Clinical Neurophysiology, 113*(6), 844–852.
Meng, M., Bader, M., & Bayer, J. (1999). Sprachverstehen im Kontext: Zur Rolle struktureller und semantisch-pragmatischer Information bei der Auflösung von Subjekt-Objekt-Ambiguitäten im Deutschen. In I. Wachsmuth, B. Jung (Eds.), *Proceedings der 4. Fachtagung der Gesellschaft für Kognitionswissenschaft* (pp. 244–249). St. Augustin, Germany: Infix.
Müller, G. (1999). Optimality, Markedness, and Word Order in German. *Linguistics, 37*, 777–818.
Nagy, M. E., & Rugg, M. D. (1989). Modulation of event-related potentials by word repetition: The effects of inter-item lag. *Psychophysiology, 26*(4), 431–436.
Nieuwenhuis, S., Aston-Jones, G., & Cohen, J. D. (2005). Decision making, the P3, and the locus coeruleus – norepinephrine system. *Psychological Bulletin, 131*(4), 510–532.
Oldfield, R. C. (1971). The assessment and analysis of handedness: The Edinburgh handedness inventory. *Neuropsychologia, 9*(1), 97–113.
Osterhout, L., & Holcomb, P. J. (1992). Event-related brain potentials elicited by syntactic anomaly. *Journal of Memory and Language, 31*(6), 785–806.
Pittner, K., & Berman, J. (2008). *Deutsche Syntax* (3rd ed.). Tübingen: Gunter Narr Verlag.
Prince, E. F. (1981). Topicalization, focus-movement, and Yiddish-movement: A pragmatic differentiation. In Berkley Linguistics Society (Ed.), *Proceedings of the seventh annual meeting of the Berkeley Linguistics Society* (pp. 249–264).
Prince, E. F. (1992). The ZPG letter: Subjects, definiteness, and information-status. In S. Thompson & W. Mann (Eds.), *Discourse description: Diverse analyses of a fund raising text* (pp. 295–325). Amsterdam: John Benjamins Company.
Prince, E. F. (1998). On the limits of syntax, with reference to left-dislocation and topicalization. In P. Culicover & L. McNally (Eds.), *The limits of syntax. Syntax and semantics*. NY: Academic Press (29th ed., pp. 281–302).
R Core Team. (2013). *R: A language and environment for statistical computing, Vienna*, Austria.
Reinhart, T. (1981). Pragmatics and linguistics: An analysis of sentence topics. *Philosophica, 27*(1), 53–94.
Roehm, D., Bornkessel-Schlesewsky, I., Rösler, F., & Schlesewsky, M. (2007). To predict or not to predict: Influences of task and strategy on the processing of semantic relations. *Journal of Cognitive Neuroscience, 19*(8), 1259–1274.
Rosengren, I. (1993). Wahlfreiheit mit Konsequenzen – Scrambling, Topikalisierung und FHG im Dienste der Informationsstrukturierung. In M. Reis (Ed.), *Wortstellung und Informationsstruktur* (pp. 251–312). Tübingen: Niemeyer.
Rösler, F., Pechmann, T., Streb, J., Röder, B., & Henninghausen, E. (1998). Parsing of sentences in a language with varying word order: Word-by-word variations of processing demands are revealed by event-related brain potentials. *Journal of Memory and Language, 38*(2), 150–176.
Rossi, S., Jürgenson, I. B., Hanulíková, A., Telkemeyer, S., Wartenburger, I., & Obrig, H. (2011). Implicit processing of phonotactic cues: Evidence from electrophysiological and vascular responses. *Journal of Cognitive Neuroscience, 23*(7), 1752–1764.
Rugg, M. D. (1985). The effects of semantic priming and word repetition on event-related potentials. *Psychophysiology, 22*(6), 642–647.
Scheepers, C., & Crocker, M. W. (2004). Constituent order priming from reading to listening: A visual-world study. In M. Carreiras & C. Clifton (Eds.), *The on-line study of sentence comprehension. Eyetracking, ERPs and beyond*. New York: Psychology Press (pp. 167–185).
Schlesewsky, M., Fanselow, G., Kliegl, R., & Krems, J. (2000). The subject preference in the processing of locally ambiguous wh-questions in German. In B. Hemforth (Ed.), *German sentence processing* (pp. 65–93). Dordrecht: Kluwer Academic Publishers.
Schumacher, P. B. (2014). Content and context in incremental processing: "the ham sandwich" revisited. *Philosophical Studies, 168*(1), 151–165.
Schumacher, P. B., & Hung, Y.-C. (2012). Positional influences on information packaging: Insights from topological fields in German. *Journal of Memory and Language, 67*(2), 295–310.
Schwarzschild, R. (1999). GIVENness, AvoidF and other constraints on the placement of accent. *Natural Language Semantics, 7*, 141–177.
Siewierska, A. (1993). On the interplay of factors in the determination of word order. In J. Jacobs, A. von Stechow, W. Sternefeld, & T. Vennemann (Eds.), *Syntax: An international handbook of contemporary research* (pp. 826–846). Berlin: Walther de Gruyter.
Skopeteas, S., & Fanselow, G. (2010). Effects of givenness and constraints on free word order. In M. Zimmermann & C. Féry (Eds.), *Oxford linguistics. Information structure. Theoretical, typological, and experimental perspectives*. Oxford, New York: Oxford University Press (pp. 307–331).
Skopeteas, S., Fiedler, I., Hellmuth, S., Schwarz, A., Stoel, R., Fanselow, G., Krifka, M. (2006). *Questionnaire on information structure (QUIS): Reference manual: ISIS|Working papers of the SFB 632|4 (2006)*. Universität Potsdam: Universitätsverlag Potsdam.
Speyer, A. (2004). Competing constraints on Vorfeldbesetzung in German. In *Proceedings of the Dislocated Elements Workshop*. ZASPiL 35 vol. 2 (pp. 519–541).
Speyer, A. (2008). German Vorfeld-filling as constraint interaction. In A. Benz & P. Kühnlein (Eds.), *Constraints in discourse* (pp. 267–290). Amsterdam: John Benjamins Company.
Sprouse, J., & Schütze, C. (2013). Judgment data. In R. J. Podesva & D. Sharma (Eds.), *Research methods in linguistics*. Cambridge: University Press.
Steedman, M. (2000). Information structure and the syntax-phonology interface. *Linguistic Inquiry, 31*(4), 649–689.
Sutton, S., Braren, M., Zubin, J., & John, E. R. (1965). Evoked-potential correlates of stimulus uncertainty. *Science, 150*(3700), 1187–1188.
Tomlin, R. S. (1986). *Basic word order. Functional principles*. London: Croom Helm.
Vallduvi, E., & Engdahl, E. (1996). The linguistic realisation of information packaging. *Linguistics, 34*, 459–519.
van Berkum, J. J. A. (2012). The electrophysiology of discourse and conversation. In M. Spivey, M. Joanisse, & K. McRae (Eds.), *The Cambridge handbook of psycholinguistics* (pp. 589–613). Cambridge: Cambridge University Press.
van Petten, C., Kutas, M., Kluender, R., Mitchiner, M., & McIsaac, H. (1991). Fractionating the word repetition effect with event-related potentials. *Journal of Cognitive Science, 3*(2), 131–150.
Verleger, R. (1988). Event-related potentials and cognition: A critique of the context updating hypothesis and an alternative interpretation of P3. *Behavioral and Brain Sciences, 11*(3), 343–356.
Wang, L., Schlesewsky, M., Philipp, M., & Bornkessel-Schlesewsky, I. (2012). The role of animacy in online argument interpretation in Mandarin Chinese. In M. Lamers & P. de Swart (Eds.), *Case, Word Order and Prominence. Interacting Cues in Language Production and Comprehension*. Dordrecht: Springer Netherlands (pp. 91–120).
Wang, L., & Schumacher, P. B. (2013). New is not always costly: Evidence from online processing of topic and contrast in Japanese. *Frontiers in Psychology, 4*, 363.

Weber, A., & Müller, K. (2004). Word order variation in German main clauses: A corpus analysis. In *Proceedings of the 20th international conference on computational linguistics*. Geneva, Switzerland.

Weskott, T., Hoernig, R., Fanselow, G., & Kliegl, R. (2011). Contextual licensing of marked OVS word order in German. *Linguistische Berichte, 225*(16), 3–18.

Wickham, H. (2009). *Ggplot2: Elegant graphics for data analysis (Version 2)*. New York: Springer Publishing Company.

Wolff, S., Schlesewsky, M., Hirotani, M., & Bornkessel-Schlesewsky, I. (2008). The neural mechanisms of word order processing revisited: Electrophysiological evidence from Japanese. *Brain and Language, 107*, 133–157.