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(De-)Accentuation and the Processing of Information Status: Evidence from Event-Related Brain Potentials

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Abstract
The paper reports on a perception experiment in German that investigated the neuro-cognitive processing of information structural concepts and their prosodic marking using event-related brain potentials (ERPs). Experimental conditions controlled the information status (given vs. new) of referring and non-referring target expressions (nouns vs. adjectives) and were elicited via context sentences, which did not – unlike most previous ERP studies in the field – trigger an explicit focus expectation. Target utterances displayed prosodic realizations of the critical words which differed in accent position and accent type. Electrophysiological results showed an effect of information status, maximally distributed over posterior sites, displaying a biphasic N400 - Late Positivity pattern for new information. We claim that this pattern reflects increased processing demands associated with new information, with the N400 indicating enhanced costs from linking information with the previous discourse and the Late Positivity indicating the listener's effort to update his/her discourse model. The prosodic manipulation registered more pronounced effects over anterior regions and revealed an enhanced negativity followed by a Late Positivity for deaccentuation, probably also reflecting costs from discourse linking and updating respectively. The data further lend indirect support for the idea that givenness applies not only to referents but also to non-referential expressions ('lexical givenness').

Keywords
event-related potentials, givenness, information structure, pitch accent, prosody

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1 Introduction

Prosodic cues are used to mark both the information status of an entity (e.g., given vs. new) and the focus-background structure of an utterance. Most studies on the processing of information structure usually do not distinguish between these two levels of semantic-pragmatic description, but we argue that they should be kept apart. In the present paper, we largely concentrate on the level of information status (i.e., givenness) and its relation to accentuation. Furthermore, we claim that an item's information status depends not only on a referent's accessibility within the discourse representation, but also on 'lexical givenness', both of which have an effect on an item's prosodic marking (section 2). After an overview of previous neurolinguistic studies on prosody and information structure (section 3), we present an experiment that investigated the processing of an item's information status (given vs. new) and its prosodic realization (accented vs. deaccented) using event-related brain potentials (ERPs) (section 4). No explicit focus-background partitioning of the test sentences was triggered, unlike it is the common procedure in most previous ERP studies in the field, which determined the focus structure by using question-answer pairs or focus-sensitive particles. The present study uses single sentences to set up the context for the target sentences. It thus represents one of the first ERP studies concentrating on prosody and an item's information status without conflating the latter with the level of focus and background. The paper concludes with a discussion of the results (section 5) and a brief summary (section 6).

2 Prosody and information structure

Information is generally conveyed via propositions, which express predicative relations between referents in specific states or events. These (non-propositional) denotata of individual sentence constituents, which are typically expressed in argument categories such as noun phrases, pronouns or prepositional phrases, have a certain *information status* (cf. e.g., Prince, 1992) or degree of givenness.

Following the somewhat informal cognitive approach to givenness by Chafe (1976, 1994) and Lambrecht (1994), we differentiate between a) the level of *identifiability* of entities, states or events on the basis of the speaker's assumption that the listener has *knowledge* – in the sense of having a mental representation – of these referents or propositions and b) the *degree of activation* of a referent or proposition assumed by the speaker to be in the listener's *consciousness* at the time of utterance. For two reasons we will concentrate on the level of activation in the present study: first, it describes the assumed cognitive state or information status of an item or proposition in the listener's mind during the ongoing discourse, that is, it is subject to immediate contextual changes (which does not apply to the level of identifiability). Second, the level of activation is mainly marked by prosodic means (and lexical form[1]), while (non-)identifiability is marked by morphosyntax. It is commonly assumed for West Germanic languages like German and English that inactive referents are marked by pitch accents, while active referents are unaccented, or – more precisely – *deaccented*[2] (see Ladd, 1996). This basic assumption has recently been confirmed by a cross-linguistic study on the intonational marking of textually given material (Cruttenden, 2006). Example (1) is adapted from this study:[3]

(1) A: You need a pair of black SHOES for the wedding.
B: I've already GOT a pair of black shoes.
(from Cruttenden, 2006, p. 320)

In (1A), the head of the noun phrase *a pair of black shoes* receives a pitch accent, since the referent denoted by this expression is newly introduced into the discourse, in other words, inactive in the listener's consciousness. In the answer (1B), on the other hand, the referent seems to be given (i.e., already active), since it is deaccented. Note, however, that *a pair of black shoes* in (1A) denotes a generic, that is, non-specific, referent, whereas in (1B), the referent encoded by the same noun phrase is specific and can thus be regarded as new (which is supported by its morphosyntactic marking by an indefinite article). What *is* given in (1B) is thus the *referring expression* denoting the referent, not the referent itself.

In light of examples like these, which show that an item's cognitive activation applies not only to *referents* but also to *lexical items* (more specifically to content words), we suggest distributing the analysis of an item's information status to two distinct levels, namely a *referential level* and a *lexical level* (following Baumann & Riester, 2010, forthcoming; Riester & Baumann, 2011; see also Schwarzschild, 1999, whose notion of givenness implies such a distinction, and Halliday & Hasan, 1976). Example (2) also shows clearly that an item's givenness (indicated by deaccentuation) does not necessarily imply coreference but may be due to lexical activation.

(2) A: Why do you study <u>Italian</u>?
B: I'm MArried to an <u>Italian</u>.
(from Büring, 2007, p. 448)

Most previous studies on givenness (e.g., Chafe, 1994) defined the term 'information status' only for nominal expressions denoting discourse referents. The idea of lexical givenness, however, also implies that parts-of-speech other than nominal expressions can be assigned an information status, for example verbs or adjectives (which are commonly regarded as non-referential). Example (3) is a case in point, demonstrating lexical givenness of an adjective, which is marked by deaccentuation.

(3) A: Why do you keep getting <u>ANGRY</u>?
B: Because John MAKES me <u>angry</u>.
(from Cruttenden, 2006, p. 321)

The experiment that is presented in this paper thus also deals (among other aspects) with the notion of lexical givenness by investigating the cognitive processing of lexically given (and new) nouns *and* adjectives.

It has often been shown that intonation (together with word order permutations and syntactic phenomena like clefting or passivization) marks not only different degrees of a discourse referent's givenness but also the focus-background structure of utterances. Thus, the same channel or linguistic level of description is used for two aspects of information structure. However, new information should not be used interchangeably with focus. Similarly, the means used for marking focus should not be confused with the semantic-pragmatic level of focus itself. That is, the function of highlighting as well as newness are "statistical correlatives, but not definitional features, of focus" (Krifka, 2007, p. 30).

In fact, focus seems to be ranked higher than givenness, since focus prosody often 'overrides' activation prosody. An example is given in (4B), in which the noun phrase *John* is given due to immediate previous mention, but is in the focus part of the proposition (indicated by accentuation):

(4) A: Who invited you to <u>John</u>'s party?
B: [<u>JOHN</u>] $_{FOC}$ did.

Thus, focus is generally independent of the item's information status despite many cases of overlap between the focus-background level and the levels dealing with an item's degree of givenness (see Krifka, 2007, for an overview). That is, new referents (or words) often occur in the focus part of an utterance while given referents (or words) are likely to be part of the background (such as *a pair of black shoes* in (1B)).

In a series of production and perception studies on German (Baumann, Grice, & Steindamm, 2006; Baumann, Becker, Grice, & Mücke, 2007; Hermes, Becker, Mücke, Baumann, & Grice, 2008; Becker, Baumann, & Grice, 2009) it has been found that the degree of a target word's (prosodic) prominence depends on the focus condition the word occurs in (i.e., background, broad, narrow, and contrastive focus).[4] As the focus domain narrows, and as we move from non-contrastive to contrastive, the prominence of a target word increases, indicated by various categorical and gradient prosodic (i.e., tonal, durational and articulatory) means. The studies showed that in broad focus, the focus exponent was often marked by downstepping pitch accents, whereas speakers used non-downstepping accents in narrow and contrastive focus. Furthermore, the nuclear accents on focus exponents in narrow and particularly in contrastive focus were characterized by increased duration as well as by higher, steeper and later peaks, adding to the impression of increased prominence.

In the experiment reported below, we do not elicit clear-cut focus-background structures in the target sentences by using question-answer pairs, but employ neutral context sentences – in contrast to the procedure in the studies mentioned above. The experiment is thus primarily concerned with an item's information status (given vs. new) encoded by different prosodic realizations (deaccentuation vs. accentuation – with contrastive accent on nouns and non-contrastive accent on adjectives). The cognitive processing of these items will be investigated by measuring event-related brain potentials.

3 Previous neurolinguistic studies on the influence of prosodic cues on an utterance's information structure

Previous research has revealed that prosody impacts the processing of information structural distinctions. Perception studies have shown not only that different accent types are judged to be appropriate for marking specific classes and degrees of information status, as well as specific focus-background structures (cf. e.g., Baumann et al., 2006, 2007; Becker et al., 2009; Röhr & Baumann, 2011), but also that the interaction of information status and accentuation plays a major role in discourse comprehension. Although it has been proven that new items are comprehended faster if they are accented and given items if they are deaccented (e.g., Terken & Nooteboom, 1987), it could also be shown that structural aspects such as *focus projection* (e.g., Selkirk, 1984) may cause deviations from this one-to-one relation (Birch & Clifton, 1995, 2002; Nooteboom & Kruyt, 1987). Birch and Clifton, for instance, found that neither missing accents on new items nor superfluous accents on given items led to increased processing difficulties or were judged unacceptable if an appropriate accent occurred elsewhere in the phrase.

Prosodic cues are processed incrementally, as is evident from a series of auditory ERP studies, which identified three distinct ERP signatures: a frontal negativity – so-called Expectancy Negativity (EN) – has been observed for the expectancy of a focused constituent supported by a preceding context question (e.g., Hruska & Alter, 2004; Toepel, Pannekamp, & van der Meer, 2009) or focus particle (e.g., Heim & Alter, 2006). In contrast, inadequate accents have elicited an N400 – a negative deflection with a central maximum peaking around 400 ms after the onset of the critical word – by both missing focus accents and superfluous accents on background information (e.g., Heim & Alter, 2006; Toepel, Pannekamp, & Alter, 2007; Toepel et al., 2009 – but see the discussion of Dimitrova, Stowe, Redeker, & Hoeks, 2010 below, who only report an N400 for superfluous accents and not for missing accents). N400 modulations have further been observed in the absence of focus cues, reflecting referential integration difficulties (cf. Heim & Alter, 2006; Schumacher & Baumann, 2010). Unexpected and inappropriate accents have additionally evoked a later centro-parietal positivity, which reflects conflicts between prosodic and information structural cues and possibly signals subsequent discourse reorganization processes (e.g., Magne, Astesano, Lacheret-Dujour, Morel, Alter, & Besson, 2005; Toepel et al., 2007; Schumacher & Baumann, 2010).[5] This Late Positivity has further been observed for the integration of new information, independent of the prosodic marking, again reflecting discourse-internal costs from establishing new information units (e.g., Hruska & Alter, 2004; Toepel & Alter, 2004; Toepel et al., 2007).

The majority of research in this domain has concentrated on the focus-background distinction, elicited by either question-answer pairs or focus particles. For instance, Hruska and Alter (2004) contrasted broad and narrow focus structures (with the information status of the critical entity kept constantly new, thus not distinguishing different types of information status) following a context question, and showed that comprehension is strongly guided by context information and supported by prosody. They found an EN for the anticipated focused constituent and a biphasic N400 - Late Positivity pattern for focused/new information, reflecting difficulties in integrating focused/new information into a given discourse. In turn, Dimitrova et al. (2010) compared different prosodic realizations of contrastively focused constituents, which were given from the preceding context question. They also found a biphasic N400 - Late Positivity for unexpected superfluous accents, while missing focus accents only triggered a Late Positivity in their experiment. They suggest that the absence of an enhanced N400 results from the fact that there is not a complete lack of accentuation, but rather only lack of overt contrastive prominence.

Turning to the processing of information status, research in the visual domain has reported a biphasic N400 - Late Positivity pattern for new relative to given information (e.g., Burkhardt, 2006; Schumacher, 2009). The N400 has been interpreted to reflect costs from lexical-semantic and discourse integration (termed “discourse linking”), a process that has also been associated with searching the discourse for potential antecedents/links (cf. e.g., Streb, Rösler, & Hennighausen, 1999 for pronoun resolution or van Berkum, Hagoort, & Brown, 1999 for N400 effects for ambiguous pronouns). The Late Positivity has been associated with costs of establishing a new discourse entity and reorganizing discourse structure (Burkhardt, 2007) (“discourse updating”). We are aware of only one ERP study that has investigated the prosodic realization of information status, while maintaining the same focus-background structure. In Schumacher and Baumann (2010), context information was kept constant (5A), while the same referential expressions were presented with three different types of accent (5B), which in independent studies (Baumann & Grice, 2006; Röhr & Baumann, 2010) were found to be appropriate markers for given items (deaccentuation), new items (H* accentuation), and the intermediate information status of accessible items (H+L* accentuation). Since the target words represented inferentially accessible referents standing in a part-whole relation to an antecedent mentioned in the context sentence, the H+L* accent was assumed to be their most appropriate prosodic realization.

(5)	A:	Sabine repariert einen alten Schuh.							
		‘Sabine repairs an old shoe.’							
	B:	Dabei zerschneidet	sie die	Sohle	/	SOHle	/	SOHle.
		In-doing-so cuts	she the	sole	/	SOLE	/	SOLE
				0	/	H*	/	H+L*
		‘In doing so, she cuts the sole.’						

Inadequate accentuation (i.e., deaccentuation and H* accentuation) evoked N400 modulations resulting in a statistically significant three-way distinction between the accent types (0 > H* > H+L*). These modulations reflected semantic integration difficulties as a function of the prosodically indicated information status, and were followed by a Late Positivity for deaccentuation which triggered a mismatch between the actual (new) information status of the referent and its prosodically marked given information status.

The findings introduced in this section served as background for the present ERP study, which investigates the processing of information status with respect to its prosodic marking in a contextually unmarked focus structure.

4 The present investigation

In the current experiment, we investigate specific combinations of information status and accentuation, while using context sentences that do not generate expectations for a specific focus-background structure. Our aim is to find out whether and how the prosodic cues influence an utterance's neuro-cognitive processing when no focus-specific expectations are involved. The information structural conditions are elicited via context sentences preceding the target sentences. Information status is investigated by contrasting given (i.e., previously mentioned) and new information. More precisely, we probe the processing of information status at a noun, which is given at the referential and the lexical level in two conditions (*Winzer* 'winegrower' in (7A & 7B) below), and an adjective, which is only lexically given (*heiter* 'cheerful' in (6A & 6B)). The accent types used lead to either a contrastive reading of the noun (as in (6A & 7A) below) or a non-contrastive reading of the adjective (as in (6B & 7B)). The critical context and target sentence combinations are exemplified below, with the star suggesting inappropriate prosody; capital letters indicate the relevant pitch accents, critical target words are marked in bold. The notation of accent types and boundary tones follows the German ToBI (*Tones and Break Indices*) system (see Grice, Baumann, & Benzmüller, 2005), and the zero is meant to indicate deaccentuation.

(6A)	**New-Accented Noun, Given-Deaccented Adjective:**					
Context:	FRAUke	meinte,	dass der HOLZfäller	nicht	sehr HEIter war.	
	Frauke	said	that the lumberjack	not	very cheerful was	
	'Frauke said that the lumberjack was not very cheerful.'					
Target:	Sie erWÄHNte, dass der	**WINzer**	sehr	**heiter**	war.	
	she mentioned that the	***winegrower***	*very*	***cheerful***	*was*	
		L+H* [contrastive]		0	L-%	
	'She mentioned that the **winegrower** was very **cheerful**.'					

(6B)	***New-Deccented Noun, *Given-Accented Adjective:**					
Context:	FRAUke	meinte,	dass der HOLZfäller	nicht	sehr HEIter war.	
	Frauke	said	that the lumberjack	not	very cheerful was	
	'Frauke said that the lumberjack was not very cheerful.'					
Target:	Sie erWÄHNte, dass der	**Winzer**	sehr	**HEIter**	war.	
	she mentioned that the	***winegrower***	*very*	***cheerful***	*was*	
		0		L+H* [non-contrastive]	L-%	
	'She mentioned that the **winegrower** was very **cheerful**.'					

(7A)	***Given-Accented Noun, *New-Deaccented Adjective:**				
Context:	VIvian	berichtete	von	einem	WINzer in BAden.
	Vivian	*talked*	*about*	*a*	*winegrower in Baden*
	'Vivian talked about a winegrower in Baden.'				
Target:	Sie erWÄHNte, dass der	**WINzer**	sehr	**heiter**	war.
	she mentioned that the	***winegrower***	*very*	***cheerful***	*was*
		L+H*		0	L-%
		[contrastive]			
	'She mentioned that the **winegrower** was very **cheerful**.'				

(7B)	**Given-Deaccented Noun, New-Accented Adjective:**				
Context:	VIvian	berichtete	von	einem	WINzer in BAden.
	Vivian	*talked*	*about*	*a*	*winegrower in Baden*
	'Vivian talked about a winegrower in Baden.'				
Target:	Sie erWÄHNte, dass der	**Winzer**	sehr	**HEIter**	war.
	she mentioned that the	***winegrower***	*very*	cheerful	*was*
		0		L+H*	L-%
				[non-contrastive]	
	'She mentioned that the **winegrower** was very **cheerful**.'				

After the context sentences in (6A) and (6B), the noun *Winzer* ('winegrower') is new while the verb phrase including the adjective *heiter* ('cheerful') is given. Moreover, mentioning the *Winzer* in (6A) triggers a contrast with *Holzfäller* ('lumberjack'), so that the nuclear contrastive accent on the noun in (6A) is appropriate. Furthermore, the deaccentuation of the given adjective in the combination (6A) is appropriate as well. Combination (6B), however, displays inadequate prosody on the noun (since the new and contrastive *Winzer* is deaccented) as well as on the adjective (since the lexically given *heiter* receives a pitch accent).

Conversely, after the context sentences in (7A) and (7B), the referential noun *Winzer* ('winegrower') is activated. Thus, deaccentuation of *Winzer* and a nuclear accent on the adjective (in target sentence (7B)) is appropriate, whereas the target sentence in (7A), displaying a nuclear (contrastive) accent on the noun and no accent on the adjective, is inappropriate. Table 1 illustrates the information status and prosodic properties of the test material.

Information status has been described as crucial in establishing dependency relations with prior discourse (cf. e.g., Lambrecht, 1994). On the basis of previous research on referential processing in the visual domain, we predict an N400 for new information relative to given information (cf. Burkhardt, 2006). New information should also evoke a more pronounced Late Positivity as a reflection of costs from establishing an independent discourse representation (cf. Burkhardt, 2006; Schumacher, 2009). For instance, time-locked to the nouns, we predict an N400 - Late Positivity pattern for (6A/B) relative to (7A/B).

In addition, we claim that lexical and referential givenness are important notions for information structure and that a biphasic N400 - Late Positivity pattern should also be observable for the contrast of purely lexically given target words. That is, we predict that time-locked to the adjectives, a more pronounced biphasic pattern should be observable for (7A/B) relative to (6A/B). Notably, from a lexical-semantic perspective, N400 modulations would be predicted for both types of givenness (in particular since they are both *lexically* given), but our discourse-semantic integration account predicts effects on both the N400 and the Late Positive component. In contrast, accounts that only allow for a referential basis of information status would predict that new

Table 1. General design of the experiment.

Sample stimuli	Target word	Information status	Accentuation	Target word	Information status	Accentuation
(6A)	N	**new**	**accented** (appropriate contrastive accent)	ADJ	lexically **given**	**deaccented** (appropriate deacentuation)
(6B)	N	**new**	**deaccented** (missing accent)	ADJ	lexically **given**	**accented** (superfluous non-contrastive accent)
(7A)	N	referentially (and lexically) **given**	**accented** (superfluous contrastive accent)	ADJ	**new**	**deaccented** (missing accent)
(7B)	N	referentially (and lexically) **given**	**deaccented** (appropriate deacentuation)	ADJ	**new**	**accented** (appropriate non-contrastive accent)

adjectives and lexically given adjectives pattern alike, hence no pronounced ERP difference would be expected. Again, from a purely lexical perspective, priming effects of repeated (given) entities are still predicted to emerge (i.e., N400), yet no Late Positivity.

As far as accentuation is concerned, we are interested in the discourse contribution of this cue (i.e., accentuation marking new information and deaccentuation marking given information). On the assumption that (de)accentuation is an important means to mark givenness in German, it might well be possible to observe specific processing demands associated with this prosodic cue. Regarding the processes laid out above, we predict N400 modulations reflecting costs associated with discourse linking, since the prosodic cue requires the establishment of a dependency with previous information in the discourse model in the case of deaccentuation, but not in the case of accentuation (e.g., for nouns: (6B/7B) > (6A/7A)). In line with previous findings from prosody research, it would further be expected that, if the prosodic realization of the information status serves as a strong cue during language processing, inadequate superfluous accents as well as inadequate missing accents should engender a biphasic N400 - Late Positivity (but see Dimitrova et al., 2010 for a Late Positivity only for inadequate missing accents, and our comments above) – e.g., for nouns: (6B/7A) > (6A/7B). Since focus is only elicited indirectly via the accent types used, our results may deviate from previous studies on specific focus structures. For the same reason (i.e., no direct focus expectation) we do not predict an EN.

4.1 Methods

4.1.1 Participants. Twenty-four right-handed, monolingual native speakers of German (13 women) from the University of Mainz participated in the experiment after giving written informed consent. Their ages ranged between 22 and 29 years (mean age: 24.8 years). None of them had any auditory, visual or neurological impairment by their own report. Data from one participant had to be discarded from the analysis owing to excessive ocular artifacts.

Table 2. Acoustic properties of the target words (mean values and standard deviations).

Target word	Acoustic property	Accented	Deaccented
N	duration	425 ms (SD = 102 ms)	379 ms (SD = 101 ms)
	F0 min	103 Hz (SD = 8 Hz)	118 Hz (SD = 10 Hz)
	F0 max	171 Hz (SD = 11 Hz)	132 Hz (SD = 8 Hz)
	average slope	8.8 st	1.9 st
ADJ	duration	510 ms (SD = 126 ms)	478 ms (SD = 123 ms)
	F0 min	100 Hz (SD = 10 Hz)	92 Hz (SD = 16 Hz)
	F0 max	147 Hz (SD = 11 Hz)	106 Hz (SD = 5 Hz)
	average slope	6.7 st	2.5 st

4.1.2 Material and design. We constructed an experimental setting that tests the electrophysiological responses to accented and deaccented constituents with differing information status in a structurally unmarked focus-background structure. Listeners were presented with stimuli that consisted of two types of context sentence and two types of target sentence (one of each per stimulus). The syntactic and rhythmic structures were kept constant for all sets. All critical noun phrases were two or three syllables long and carried a nuclear accent on the first syllable (in the two accented conditions). Critical adjectives[6] also carried an accent on the first syllable. Examples for context sentences and target sentences with varying accentuation were given above in (6) and (7).

Eighty sets of stimuli were constructed with different lexical materials and combined to the four combinations illustrated above. The resulting 320 critical trials were distributed across two lists and presented in three randomizations each, yielding six separate experimental sessions that were distributed evenly across all participants. Each list contained two items from a set, which were distributed in such a way that each participant saw only one instance of a particular context sentence and a particular target sentence. Each session consisted of 250 trials, including 90 filler trials. The context and target sentences were read by a trained phonetician and digitally recorded in a soundproof cabin.

In the context sentences, all subjects (e.g., *Vivian*) and objects (e.g., *Winzer*) carried slightly rising accents, and the complements (e.g., *in Baden*) downstepped accents, which is the typical intonation for broad focus sentences in German. The accents in the target sentences varied, as shown above. That is, we marked each target noun in the (A) sentences by a ‘contrastive’ accent characterized by a steep rise (L+H* with a slope of 8.8 semitones on average; cf. Table 2), and each target adjective in the (B) sentences by a non-contrastive ‘newness’ accent characterized by a less steep rise (L+H* with a slope of 6.7 semitones on average; cf. Table 2). The prosodic properties of the accents used in the experiment were chosen according to the findings reported above (e.g., Baumann et al., 2007). All other target words (noun in (B) sentences and adjective in (A) sentences) were deaccented. In order to guarantee equivalent pitch accent types in all target sentences, we resynthesized the naturally produced contours whenever necessary, using the speech analysis tool Praat (Boersma & Weenink, 1996). The critical phonetic properties of the target words are shown in Table 2.

Examples for each of the two target sentence conditions are given in Figures 1 and 2.[7] The pitch accent on the verb in the main clause (*erwähnte* ‘mentioned’) is not annotated.

To assess participants’ attention, each trial was followed by a verification question, which probed information from either the context or the target sentence. Expected yes/no responses were

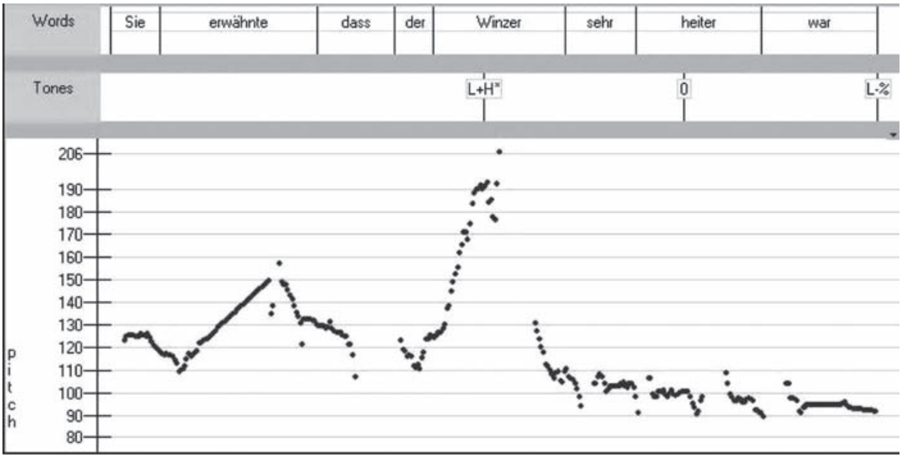

Figure 1. Target sentence of type (A), with a contrastive accent on the noun (*Winzer* 'winegrower') and deaccentuation of the adjective (*heiter* 'cheerful').

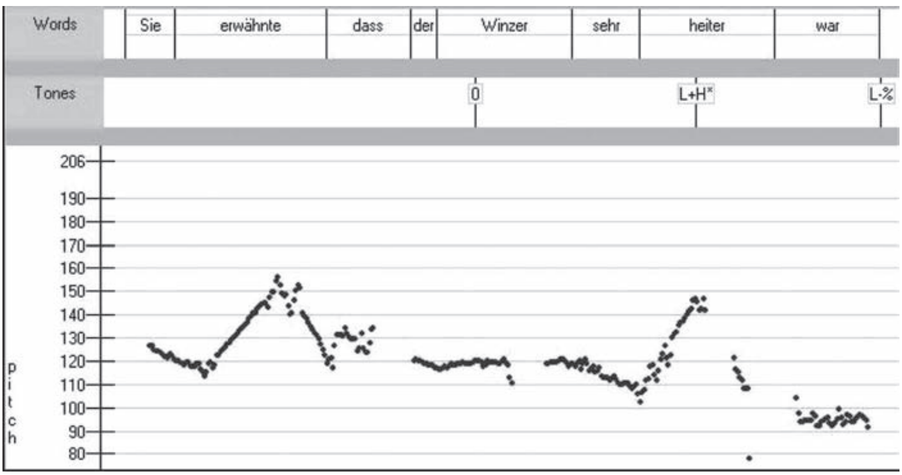

Figure 2. Target sentence of type (B), with deaccentuation of the noun (*Winzer* 'winegrower') and a non-contrastive accent on the adjective (*heiter* 'cheerful').

equally distributed across the materials. Examples of comprehension questions for (6/7) above are 'Was the winegrower in Baden/Munich?' or 'Did Frauke/Lea mention that the winegrower was very cheerful?').

4.1.3 Procedure. Participants sat comfortably in a sound-attenuating cabin. They were instructed to look at the computer screen in front of them and to focus on a fixation star, while the auditory materials were presented over loudspeakers. After each auditory input, they were presented with a comprehension question on the computer screen in front of them and were asked to respond to it by pressing one of two buttons of a response box as quickly and as accurately as possible.

Each trial started with a fixation star presented centrally on the monitor for 500 ms, after which the auditory presentation of the two-sentence discourse started, while the fixation star remained on the monitor. After the auditory input, the screen was blank for 500 ms prior to the presentation of the comprehension question, which occurred in the center of the screen in yellow letters on a blue background. Maximum response times to this question were set to 4000 ms. Fifty trials were presented in a block with an interval of 1000 ms between trials. In total, there were five blocks of fifty trials each; participants determined the duration of the pauses between blocks. The recording session started with a brief practice block during which participants were familiarized with the experimental procedure.

The electroencephalogram (EEG) was recorded and digitized (500 Hz) by means of 24 Ag/AgCl electrodes placed according to the standard 10-20 system via a *BrainVision Brain-Amp* amplifier. The online reference electrode was placed at the left mastoid and AFz served as ground electrode. Recordings were rereferenced offline to linked mastoids. To control for eye-movement artifacts, the electrooculogram (EOG) was recorded by two pairs of electrodes; for horizontal eye movements, these were placed at the outer canthus of each eye, and for vertical eye movements, above and below the left eye. To exclude slow drifts that could lead to stimulus-independent differences, electrode impedances were kept below 5 kΩ. Data were bandpass-filtered offline (0.3–20 Hz).

Average ERPs were computed per condition and participant, prior to grand-averaging over all participants. Trials with eye movements, muscular or amplifier-saturation artifacts were removed offline automatically with a cutoff of ± 40 µV of EOG activity prior to an additional manual artifact rejection procedure (amounting to 11% for the analysis relative to the noun and 15% for the adjective). Trials for which the verification task yielded an incorrect or timed-out response (7.53% in total) were also removed prior to the data analysis.

4.1.4 Data analysis. The verification task served the primary purpose to probe the participants' attentiveness to the materials. Accuracy rates confirm an overall good task performance of the participants (on average 92.47% accuracy). Average ERPs were calculated for correctly answered trials relative to the onset of the critical entity (separately for the noun and the adjective in the target sentence). Repeated-measures analyses of variance (ANOVAs) were computed with the factors INFORMATION STATUS (two levels: new, given) and ACCENTUATION (two levels: with accent, without accent). Analyses were carried out separately for lateral and midline electrodes and included the topographical factor region of interest (ROI) and midline electrode (ELEC), respectively. The lateral topographical factor ROI contained four levels: left anterior (F3/F7/FC1/FC5), right anterior (F4/F8/FC2/FC6), left posterior (P3/P7/CP1/CP5), right posterior (P4/P8/CP2/CP6); the midline analysis included six individual midline electrodes as separate levels (Fz/FCz/Cz/CPz/Pz/POz). All analyses were carried out hierarchically (i.e., only reliable interactions of $p < .05$ were resolved) on the mean amplitude value per condition. Huynh–Feldt corrections were applied whenever the analysis involved factors with more than one degree of freedom in the numerator (Huynh & Feldt, 1970). Analyses were calculated for temporal windows determined by visual inspection: relative to the noun, we computed statistical analyses for the windows between 250–450 ms and 600–900 ms. The time ranges for the analyses time-locked to the adjective were slightly earlier (150–350 ms and 500–800 ms), which is most likely due to the high predictability for the category 'adjective' following the adverbial; additional analyses relative to the onset of the pre-adjective adverb (mean length of 197 ms) yielded the same main effects and interactions. For reasons of comparability with the noun region, we therefore report statistics relative to the onset of the adjective only.

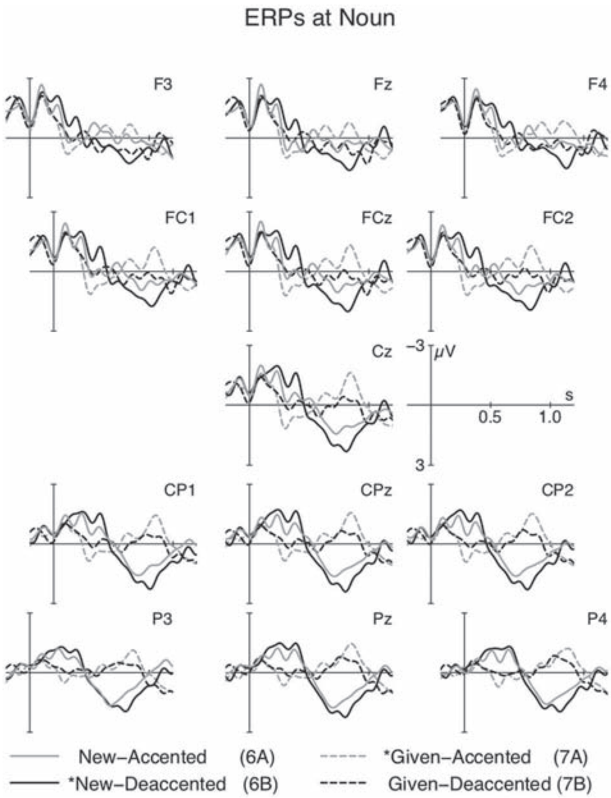

Figure 3. ERPs at selected electrode sites from 200 ms before until 1200 ms after the critical noun in the target sentence (onset at vertical bar). Grand-averages were filtered with a low-pass filter (8 Hz) for the visual presentation of the plots only. Negativity is plotted upwards.

4.2 Results

4.2.1 ERPs at the noun. Figure 3 shows the grand-average ERPs for the four different conditions relative to the onset of the critical noun in the target sentence (onset at vertical bar). The figure demonstrates a robust information status effect over posterior electrode sites – where contextually New entities (6A & 6B) differ from Given information (7A & 7B) – with a biphasic N400 - Late Positivity pattern for nouns representing new information within the current discourse model. The negativity is most pronounced between 250–450 ms followed by a positivity between 600–900 ms. Over anterior electrode sites the electrophysiological responses reflect an effect of deaccentuation: the two Deaccented nouns (6B & 7B) show a more enhanced negative deflection between 250–450 ms, followed by a more pronounced positivity between 600–900 ms, relative to the two Accented nouns (6A & 7A). Visual inspection further suggests that New-Deaccented nouns (6B) (carrying inappropriate prosody) reveal the most enhanced biphasic pattern, while Given-Accented nouns (7A) show a positive-going amplitude between 250–450 ms (P300) relative to Given-Deaccented nouns.[8]

In the time window between 250–450 ms, statistical analyses registered highly significant main effects of INFORMATION STATUS (IS), $F(1,22) = 65.19$, $p < .001$, and ACCENT, $F(1,22) =$

Table 3. Results of statistical analyses of mean voltage changes relative to the onset of the noun for the two critical time windows and separate lateral regions of interest. More highly significant effects for the factors INFORMATION STATUS (IS) and ACCENT are marked in bold to illustrate the divide between the two factors.

ROI	Effect	Negativity (250–450 ms)	Positivity (600–900 ms)
Left anterior	IS	$F(1,22) = 5.34, p < .05$	*ns.*
	Accent	$\mathbf{F(1,22) = 34.90, p < .001}$	$\mathbf{F(1,22) = 17.08, p < .001}$
Right anterior	IS	$F(1,22) = 10.76, p < .01$	$F(1,22) = 7.26, p < .05$
	Accent	$\mathbf{F(1,22) = 55.42, p < .001}$	$\mathbf{F(1,22) = 28.66, p < .001}$
Left posterior	**IS**	$\mathbf{F(1,22) = 91.54, p < .001}$	$\mathbf{F(1,22) = 137.51, p < .001}$
	Accent	$F(1,22) = 12.78, p < .01$	*ns.*
Right posterior	**IS**	$\mathbf{F(1,22) = 76.61, p < .001}$	$\mathbf{F(1,22) = 114.65, p < .001}$
	Accent	$F(1,22) = 13.16, p < .01$	*ns.*

36.05, $p < .001$, and interactions of IS × ROI, $F(3,66) = 21.46$, $p < .001$, and ACCENT × ROI, $F(3,66) = 16.15$, $p < .001$. Resolution of these interactions revealed reliable differences in all ROIs, with stronger effects for IS over posterior sites and ACCENT over fronto-central sites (see Table 3 for detailed results). The analyses of the 600–900 ms window revealed main effects of IS, $F(1,22) = 55.02$, $p < .001$, and ACCENT, $F(1,22) = 17.08$, $p < .001$, as well as interactions of IS × ROI, $F(3,66) = 51.05$, $p < .001$, and ACCENT × ROI, $F(3,66) = 8.99$, $p < .001$. Subsequent analyses by ROI registered an effect of ACCENT over the two anterior ROIs only and an effect of IS over the right anterior and the two posterior ROIs (see Table 3). The analyses of the midline electrodes confirmed the effects and topographical interactions reported for the lateral analyses and, for reasons of brevity, are not reported in detail.

4.2.2 ERPs at the adjective. The grand-average ERPs for the adjective in the four conditions are depicted in Figure 4. As is evident from the figure, there is again a strong effect of information status – where New information (7A & 7B) diverges from Lexically Given information (6A & 6B) – with a posterior maximum reflected in a biphasic N400 - Late Positivity for new information. The effects have an earlier onset latency than those in the noun region (150–350 ms and 500–800 ms), which is most likely related to the constraining power of the preceding adverbial, but are otherwise comparable to the effects observed relative to noun-onset. At anterior electrode sites, Deaccented adjectives (6A & 7A) show a more pronounced negativity followed by a positivity relative to their Accented counterparts (6B & 7B).

Statistical analyses support these observations. In the negativity window (150–350 ms), main effects of IS, $F(1,22) = 29.35$, $p < .001$, and ACCENT, $F(1,22) = 20.60$, $p < .001$, were registered as well as interactions of IS × ROI, $F(3,66) = 35.96$, $p < .001$, and ACCENT × ROI, $F(3,66) = 5.84$, $p < .01$. These interactions were reflected by more pronounced effects of IS over posterior sites and ACCENT over anterior sites as illustrated in Table 4. In the late positivity window (500–800 ms), analyses registered main effects of IS, $F(1,22) = 21.90$, $p < .001$, and ACCENT, $F(1,22) = 12.14$, $p < .01$, and IS × ROI, $F(3,66) = 53.45$, $p < .001$, and ACCENT × ROI interactions, $F(3,66) = 6.91$, $p < .01$. Resolution of the interactions revealed reliable effects of IS over posterior sites only and of ACCENT over anterior regions only (see Table 4 for detailed statistics). The midline analyses registered the same main effects and interactions of the experimental factors with the topographical factor, but are not explicitly reported.

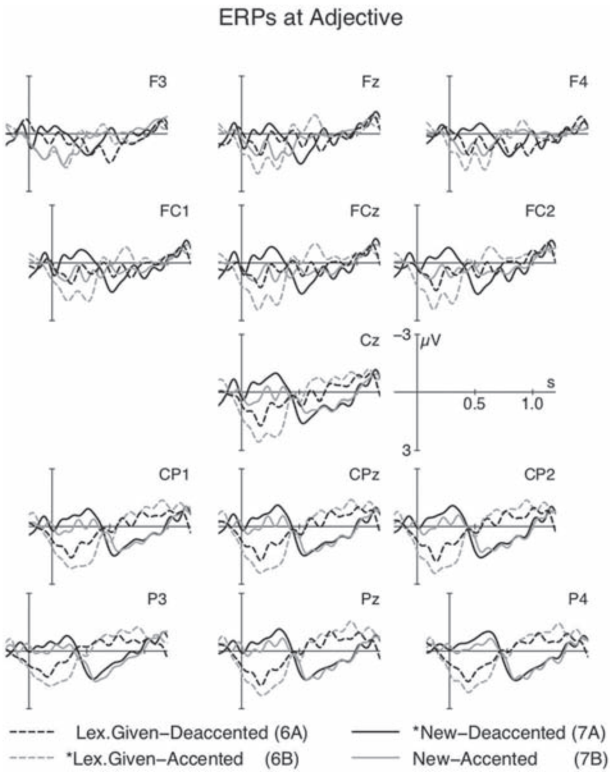

Figure 4. ERPs at selected electrode sites from 200 ms prior to the critical adjective (onset at vertical bar) until 1200 ms after. Grand-averages were low-pass filtered (8 Hz) for the plots only. Negativity is plotted upwards.

Table 4. Results of statistical analyses of mean voltage changes relative to the onset of the adjective for the two temporal windows and separate lateral regions of interest and the two factors INFORMATION STATUS (IS) and ACCENT. More highly significant effects are marked in bold to show the source of the ROI interaction.

ROI	Effect	Negativity (150–350 ms)	Positivity (500–800 ms)
Left anterior	IS	*ns.*	*ns.*
	Accent	**$F(1,22) = 21.43, p < .001$**	**$F(1,22) = 21.78, p < .001$**
Right anterior	IS	$F(1,22) = 10.42, p < .01$	*ns.*
	Accent	**$F(1,22) = 23.64, p < .001$**	**$F(1,22) = 28.48, p < .001$**
Left posterior	**IS**	**$F(1,22) = 37.15, p < .001$**	**$F(1,22) = 59.23, p < .001$**
	Accent	$F(1,22) = 7.11, p < .05$	*ns.*
Right posterior	**IS**	**$F(1,22) = 46.77, p < .001$**	**$F(1,22) = 67.05, p < .001$**
	Accent	$F(1,22) = 8.66, p < .01$	*ns.*

5 Discussion

The present study investigated the interplay of information status and prosody. The ERP data revealed a clear effect of contextually determined information status reflected in a biphasic N400 - Late Positivity for new information relative to given information (maximally distributed over posterior sites). The prosodic manipulation registered more pronounced effects over anterior regions of interest and revealed a biphasic pattern for deaccented entities relative to accented entities. These effects occurred for both nouns and adjectives. The main effects of prosody are very surprising, since previous work has typically shown interactions of accentuation with the contextual factor. The absence of an interaction between contextually determined givenness (or information status) and (de)accentuation thus suggests that these two sources of information are independently engaged in language processing. Yet, even though these two sources do not interact with each other, they both affect the two stages of discourse comprehension laid out above (cf. also Schumacher, 2009) – discourse linking (reflected in N400 modulations) and discourse updating (reflected in the Late Positivity signature). We discuss the findings for these two information sources separately below.

The biphasic ERP pattern for the information status contrast confirms previous findings from referential processing in the visual domain (Burkhardt, 2006; Schumacher, 2009) and reveals that, independent of the mode of presentation, discourse integration proceeds in two core steps, reflected in a (broadly distributed) negativity (N400) and a subsequent Late Positivity centered over posterior sites, respectively. The N400 reflects costs from linking incoming information with the mental model, which is facilitated when the information is already activated. The Late Positivity has been associated with discourse updating costs, resulting from the establishment of an independent discourse representation from previously inactive information. In fact, our data suggest that the enhanced processing costs are due to information status proper (i.e., new information) and not to the level of focus, as implicitly proposed by earlier studies which did not differentiate between these levels (e.g., Hruska & Alter, 2004). Since the design of our experiment generally prevented a focus expectation in the target sentences, the effect of information structure shown in the ERPs can unambiguously be attributed to the level of information status.

Accentuation also affects processing in these two time windows. The data reveal a more pronounced negativity over anterior electrode sites for deaccented information followed by a later positivity. In spite of its frontal distribution, we do not consider the negativity to be an Expectancy Negativity, since previous work has shown that this effect occurs for a context-induced expected accentuation (cf. Heim & Alter, 2006; Toepel et al., 2009). In contrast to these earlier studies, which induced a clear expectancy for the division of focus and background in the target sentences assuming Question-Answer-Congruence, our context sentences did not generate a strong prediction for focus-background structure. We interpret the negativity as an N400, reflecting increased processing demands during discourse linking. Surprisingly, statistical analyses indicate that the effect occurs when information is deaccented, irrespective of whether an item is contextually given or new.

In previous research, N400 effects have been observed for referents with missing accents that are focused (and at the same time new), as well as for superfluous accents on background information (e.g., Hruska & Alter, 2004; Heim & Alter, 2006; Toepel et al., 2007), that is for *inappropriate* prosody. Although the negativity we found is indeed more pronounced for (inappropriate) New-Deaccented items, our data generally suggest that the N400 observed for the deaccented conditions arises from the inherent function of deaccentuation, that is from signaling the givenness of the respective entity, which in turn results in a search for a proper (given) discourse entity. Accentuation for new information, by contrast, does not enforce any particular search in discourse and therefore should not trigger enhanced processing demands during this stage. Such an account of the N400 can be related to findings from the processing of pronouns, which by definition are referentially deficient and also require a discourse search for a proper antecedent. Crucially, processing of pronouns has also been reported to engender a more pronounced N400 relative to full noun phrases (which do not require a search by default) (cf. e.g., Streb et al., 1999). Converging evidence comes from the referential processing of new but inferentially licensed entities, where deaccentuation also showed the most enhanced N400 (Schumacher & Baumann, 2010). The prosody-dependent Late Positivity reached significance only over anterior regions – again driven by the deaccented conditions – suggesting that this effect might be dissociable from the information structurally induced positivity. The Positivity is most pronounced for the New-Deaccented condition, indicating a mismatch between the contextual and prosodic assessment of the information status.

However, the biphasic pattern for deaccentuation we found cannot substantiate the findings from Dimitrova et al. (2010), who report a monophasic Late Positivity for inadequate missing accents. As an explanation for the lack of an N400 effect, the authors suggest that the accent is not completely missing but only its contrastive prominence, which is supported by the example pitch contour presented (see Figure 1b in Dimitrova et al., 2010, p. 2). Thus, an accent (however weak) seems to suffice as an appropriate marker of focused information, even if a contrastive focus has been triggered (which nevertheless contradicts Toepel & Alter, 2004, who found that prosodically underspecified accents lead to processing difficulties expressed by negative peaks). In accordance with Dimitrova et al.'s explanation, accents in our data (whether contrastive or not) generally did not show an N400 whereas deaccentuation consistently led to an N400 (over anterior regions). An alternative explanation for the lack of an N400 in Dimitrova et al.'s data could be that their focused target items represented *given* information, and that the effect attributed to missing accents was actually an effect of information status (which we found predominantly over posterior regions). (Note that Dimitrova et al. measured neither *information status* nor *focus structure* as a factor, but contextual *congruity* of the prosodic marking. This may be the reason why they did not find an effect of topography.)

Interestingly, superfluous accentuation of given information did not evoke a biphasic N400 - Late Positivity signature in the present study. This stands in stark contrast to previous work that has reported a biphasic N400 - Late Positivity pattern for superfluous accents (Toepel et al., 2007, 2009; Dimitrova et al., 2010). Visual inspection of the early time window even revealed a more positive-going waveform for superfluously accented given information – but statistical analysis did not support such an account. However, we briefly want to address the possibility of a positive-going effect for accented entities that might co-occur with the negativity for deaccented entities. A few studies have already reported P300 effects for accentuation of given information. For instance, Magne et al. (2005) investigated the processing of contrastive focus and reported a (long-lasting) P300 for inadequate prosody in sentence-medial position, which they interpreted with respect to surprise. Note that the participants' explicit task in the Magne et al. study was to judge the prosodic acceptability of a target sentence. In fact, from a more general cognitive perspective, P300 effects that exhibit fronto-central scalp distribution occur when a target stimulus is unexpected (i.e., in a classical oddball paradigm). Thus in contrast to the question-induced expectations associated with the Expectancy Negativity, P300 effects correspond to task-related expectations as well as sentential predictability (cf. e.g., Picton, 1993; Polich, 2003). The present data support these findings in that they suggest that encountering *accented* given information results in a more enhanced surprise positivity than encountering an

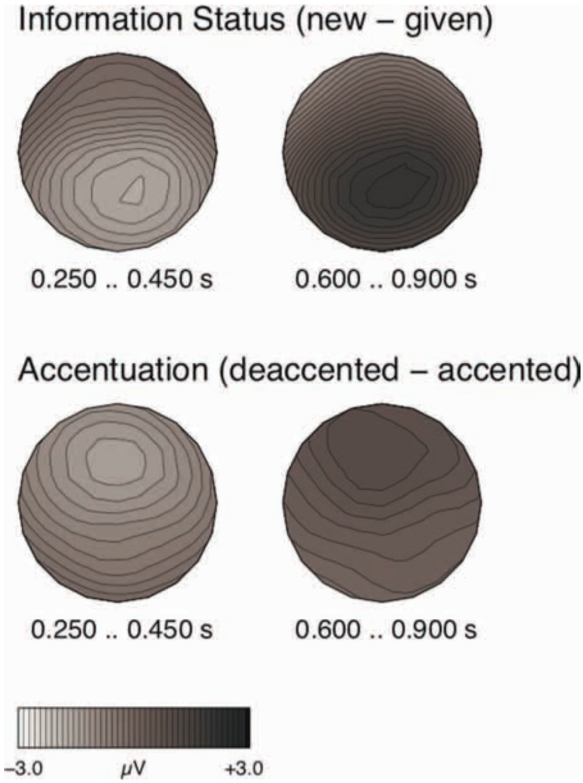

Figure 5. Topographical maps for the two main effects in the two successive time windows relative to noun-onset. The information status effect was computed by subtracting Given-Accented from New-Accented noun conditions. Accentuation effect was computed by subtracting New-Accented from New-Deaccented noun conditions. Frontal electrodes are at the top of each map. Time intervals are indicated below each map. Light shading indicates the center for the negative amplitudes, dark shading illustrates the center for the positive-going amplitudes (with a posterior center for the New conditions and a more anterior center for the Deaccented conditions in both time intervals).

adequately *deaccented* given entity – in an experiment in which the participants' task was a comprehension task and not a prosodic judgment task (as in Magne et al., 2005).

As elaborated above, only two main effects were observed in the present study, yet no interaction of information status and prosody. This suggests that accentuation and context-dependent information status independently affect discourse comprehension. The topographical differences revealed by the ROI interactions point in this direction as well. Figure 5 presents topographical maps for the two different types of information status (top panel) – revealing a posterior maximum for both effects – and for the two types of accentuation (bottom panel) – revealing an anterior center for both ERP signatures. This notwithstanding, we maintain the view that these two factors separately contribute to the discourse linking and updating stages.

In addition, the experimental factors INFORMATION STATUS and ACCENTUATION affected the ERP responses to nouns and adjectives in a very similar way: there was no decisive difference between the two types of target word. This result sheds light on two minor aspects laid out in the design of our study. First, the current data confirm our prediction that lexically given entities should engender the same biphasic pattern as referentially given entities and suggest that information status differences not only are relevant for nominal expressions denoting discourse referents, which are thus ‘referentially’ given, but must be extended to non-nominal parts-of-speech such as adjectives, which can only be ‘lexically given’. Crucially, the fact that adjectives also elicited a biphasic pattern – and not just an N400 for pure lexical repetition – lends support to the claim that the notion of givenness must capture both referential givenness and lexical givenness as outlined in Baumann and Riester (2010, forthcoming).

Second, the experiment included two different accent types (apart from deaccentuation), which induced a contrastive focus reading on the target nouns and a non-contrastive narrow focus reading on the target adjectives. Even though the design does not allow us to compare these two types of accentuation directly, the data do not seem to reveal different processing correlates as a function of accent type and, in turn, focus type, neither if the accent was contextually appropriate nor if it was inappropriate. We would like to speculate that this observation suggests that the difference between the two rising accent types (steeply rising L+H* vs. less steeply rising L+H*) might have been too subtle, for instance in comparison with the accent types investigated in Schumacher and Baumann (2010), who found a difference in the N400 amplitude between H* and H+L* (and deaccentuation) during the processing of accessible items. We may thus hypothesize that accent type is used rather to indicate differences in information status than in focus structure. Since we induced different types of focus only indirectly in the present study, however, this claim has to remain vague. Future research should thus investigate the combination of information status and focus-background structure and its prosodic (de-)coding more directly.

6 Summary and conclusion

The ERP experiment reported here showed two general effects: first, an effect of information status, which was most pronounced over posterior sites, and second, an effect of prosody, maximally distributed over anterior sites, both displaying a biphasic N400 - Late Positivity pattern. With respect to information status, the pattern reflects enhanced processing demands associated with new information in comparison to given information, with the N400 indicating enhanced costs from linking information with the previous discourse and the Late Positivity indicating the listener’s effort to update his/her discourse model. Since focus structure was kept contextually unmarked, our findings suggest that information status is a relevant level for language processing which functions independently from the level of focus and background. Prosody shows the same biphasic pattern over anterior electrodes for deaccentuation, suggesting that its inherent function of marking given information has a strong individual influence on discourse processing, and not just the detection of an inappropriate prosodic realization as proposed by previous research. We interpret the prosody-induced N400 as a reflection of linking costs associated with the intrinsic requirement of deaccentuation to identify a given entity in the discourse space. Taking a closer look at information status, our data support the idea that givenness applies to both referents (‘referential givenness’) and non-referential expressions such as adjectives (‘lexical givenness’), since they showed the same pattern in the ERPs. Results deviating from previous studies on the prosodic marking of information structure and its neuro-cognitive processing may be due to different task requirements, since the present study neither implied direct prosodic appropriateness judgments nor permitted its experimental setup to trigger specific focus expectations.

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Notes

1 Discourse-active referring expressions often surface as pronouns, while less active referents are encoded in their full lexical form (see e.g. Ariel, 1988; Gundel, Hedberg, & Zacharski, 1993).
2 The term 'deaccentuation' indicates more clearly a lack of accent in a place where it would have been expected under default conditions.
3 The referents in question are underlined. Nuclear pitch accents are indicated by capital letters.
4 Narrow focus only includes one element, whereas broad focus expands over the whole information unit.
5 Different labels can be found in the literature to refer to prosody-induced positivities, such as 'Closure Positive Shift' associated with prosodic boundaries (cf. e.g. Steinhauer, Alter, & Friederici, 1999) or new information (cf. Hruska, Alter, Steinhauer, & Steube, 2001), or 'Focus-related positive shift' more narrowly attributed to focus prosody (cf. Toepel et al., 2009). We use the more general label 'Late Positivity', because we believe that the observed effects are not specific to prosody, but reflect a modality-independent process associated with information structural updating.
6 A small number of items ($N = 6$) included participles at the critical position. For reasons of readability, we are using the label "adjective" for this position.
7 The examples are presented as screen shots from the speech analysis tool EMU (see Cassidy & Harrington, 2001). Labeling tiers include the words spoken and tone labels for pitch accents and boundary tones (following GToBI; see Grice et al., 2005). Furthermore, the pitch contours of the utterances are given, measured in Hertz (Hz).
8 The superfluous accent on given information further seems to evoke a more negative-going deflection in the later time window between 800–900 ms over fronto-central electrodes relative to the adequate deaccented given condition. We did not analyze this additional short window, but suggest that it might be a task-specific effect related to a late negativity observed to the deviant sounds, which reflects processes of reorientation from a task-irrelevant to a task-relevant mechanism (Schröger & Wolff, 1998).

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