Intonation influences processing and recall of left-dislocation sentences by indicating topic vs. focus status of dislocated referent.

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We tested the effects of two intonation contours on the processing and cued recall of German sentences with a left-dislocated subject vs. object: (i) a rising accent on the dislocated phrase, followed by a rising-falling hat contour on the main clause, (ii) a falling accent on the dislocated phrase, followed by a falling accent plus subsequent deaccentuation. The contours had differential effects depending on the grammatical function of the dislocated phrase (subject/object) and, for the recall, on the cue type for the recall (subject/object), in certain conditions overriding the subject-before-object preference normally found in processing. To account for the findings we propose: (a) Contour (i) signals the topic status of the referent of the dislocated phrase. Contour (ii) signals that referent's focus status. (b) Topics are referents that serve as an address in a structured discourse representation in working memory under which information about that referent is stored. (c) Subjects are default topics whereas objects are not, so that topic-marking an object is motivated, which results in an object-before-subject preference for sentences with topical objects during processing. (d) Retrieval of information from an address incurs a lower processing load if the appropriate address is cued than if some other referent is cued.

Key words: left dislocation, intonation, topic, focus, sentence processing, cued recall, discourse representation

The choice of pitch accent or intonation contour has been shown to influence discourse processing. Pitch accents that mark contrast or narrow focus versus given information can affect discourse processing by guiding listeners in the anticipation of upcoming referents (Chen, den Os & de Ruiter, 2007; Dahan, Tanenhaus & Chambers, 2002; Ito & Speer, 2008, Watson, Tanenhaus & Gunlogson, 2008 for English; Weber, Braun & Crocker, 2006 for German). Additionally, the choice of pitch accent can influence the representation of the discourse in memory. Discourse referents marked as contrastive by a pitch accent are represented in the discourse model with greater semantic detail than non-contrastive referents. This includes information about the contrast set (e.g. Fraundorf, Watson & Benjamin, 2010; Sanford, Sanford, Molle & Emmott, 2006). Similar findings have been presented for different intonation contours, such as the double peak contour in comparison to the hat contour in Dutch, which also affect the memory structure of the discourse (Braun & Tagliapetra, 2010).

Whereas these effects of contrast- and focus-marking intonation can be considered as fairly well established, little is known about the effects that pitch accents or intonation contours have with respect to the semantic-pragmatic function of topic marking. The present study addresses this issue for the processing of left dislocation sentences in German, where the intonation contour of the sentence marks the dislocated phrase either as topic or as focus. The results show that topics due to their specific role in discourse organization produce distinct processing and retrieval costs during comprehension compared to focus-marked referents.

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Theoretical assumptions and previous empirical findings

Topics and foci

We take a topic to be the entity a sentence is *about* (e.g. Reinhart, 1981). Example (1) illustrates. (1a) is about Prince Charles, (1b) is about Camilla Parker Bowles. Truth-conditionally, there is no difference between these two sentences, i.e. they are true in the same situations.

(1) a. [Prince Charles]$_{TOPIC}$ [married Camilla Parker Bowles]$_{COMMENT}$
b. [Camilla Parker Bowles]$_{TOPIC}$ [married Prince Charles] $_{COMMENT}$

The topics in (1) correspond to the subjects of these sentences. Subjects very often are topics (cf. e.g. Givón, 1983; Reinhart, 1981). In the psycholinguistic literature, the notion of subject and topic are sometimes conflated (e.g. Arnold, 1998). However, constituents with a different grammatical function may also be the topic of a sentence. This can best be seen in languages that use explicit means for topic marking, such as Japanese, which uses the *wa*-morpheme to mark topics (Kuno, 1972; Kuroda, 1965):

(2) Context: *Tell me something about that hat.* *Japanese* (Vermeulen, 2013)
ano boosi-wa John-ga kinoo kaimasita.
that hat-TOP John-NOM yesterday bought
'John bought that hat yesterday.'

Since many languages use topic-marking devices, for instance morphological markers, as just seen (e.g. Korean, Japanese), or designated syntactic positions (e.g. German, Frey, 2004a), specific phrases (e.g. English: *As for x...*), or prosody (e.g. Mandarin Chinese, Wang & Xu 2011; German, see below), we may ask what the *raison d'être* is for topic marking.

In the theoretical linguistic literature, topicality has been proposed to influence the way that the common ground – the set of propositions that the interlocutors mutually agree to be true (Karttunen 1974; Stalknaker 1974) – is structured: topical referents correspond to *file cards* or *addresses* in the common ground, under which the information about the referent is stored (e.g. Reinhart, 1981; Vallduví, 1992; Vallduví & Engdahl, 1996 and subsequent literature). The notions of *file card* and *address* have been used in different ways in these proposals. For instance, Vallduví (1992) uses an extra representation layer of information structure in the form of a file card system, whereas Portner & Yabushita (1998) assume that the common ground update is done in the semantics. Siding with the latter kind of proposal here, we will assume that the common ground is a sequence of pairs of entities (= individual referents) and propositions, such that the proposition denoted by a clause is associated with the referent that is denoted by the topic phrase of the clause. For example, the proposition denoted by the two sentences in (1) would be associated with the Prince Charles referent, if it is conveyed in the form of (1a), and it would be associated with the Camilla Parker Bowles referent if it is conveyed in the form of (1b). Note that the notion of *comment* (see example 1 above) is not relevant here. It is the entire proposition that is associated with the topic rather than 'just' the comment.

Now, theoretical models of referents in the common ground do not assume that it is only topical referents that are represented in the common ground (for a general file card metaphor see Heim, 1982; also cf. Kamp & Reyle, 1993). So how are non-topical referents represented in a model that associates referents with propositions? Portner & Yabushita (1998) propose that non-topical referents are also paired with propositions but with propositions that are formed on the basis of the corresponding referential expression only, such as "referent is Prince Charles" in (1a).

Turning to the psycholinguistic side of this issue, let us assume that the common ground can be conceived of as the mental discourse representation of a speaker. In general, we might assume then that organizing the mental discourse representation in the way described above, makes discourse processing easier – which is why topic marking exists. Staying with the address metaphor, it seems plausible to assume that associating incoming information directly with an existing address makes integration of the new information easier than if there were no such association. Furthermore, information stored under an address might be easier to access in later discourse (see Portner & Yabushita, 1998 for linguistic evidence from Japanese supporting this assumption).

In experimental studies, topical referents have generally been found to be more salient than other referents (e.g. Cowles, 2003, 2007; Cowles & Ferreira, 2012; see further below for a discussion of these findings). In terms of the above model of the mental discourse representation, we might hypothesize that this is so because the address function makes the topical referent salient, i.e. increases its activation: the information conveyed by the entire sentence – the proposition that has been asserted – is associated with the topical referent. Other referents are associated with comparatively little information, and they are not associated with the information that has been asserted. The latter is crucial information because it is this information that the speaker suggests to become part of the common ground, and to whose truth s/he is committed.

Now, if topical referents are indeed more salient than others, and if they are indeed crucial in the organization of the mental representation of the discourse, we might hypothesize that at some point after the comprehender has stored a proposition at a topic address, mention of that address – by appropriate referential means, such as an anaphor, or, as in the present study, by a cross-modal priming cue, – should facilitate retrieving the stored information. Let us formulate this idea in a hypothesis:

(3) *Hypothesis (i) – Topics as addresses*
Topics are referents that serve as addresses. Retrieving information from an address is facilitated if the address is pointed at directly.

We mentioned above that subjects very often are topics. They can be considered default topics. We might therefore expect that during sentence (and discourse) processing, topic marking interacts with grammatical function: in contrast to subjects, objects are not default topics. Topic marking turns the object referent into the subject of predication. Therefore, marking an object as topic will lead to a mental representation that is different from the default case because the information conveyed by the sentence is entered under the address of the object referent. As a consequence, the object referent might come to enjoy some of the advantages which subject referents normally have, such as that it is more salient. Explicitly marking a subject as topic, on the other hand, will not lead to a different representation in comparison to the default case. We suggest that this interaction of topic marking with grammatical function has consequences both for processing a sentence and for retrieving information. This suggestion is formulated in the following hypothesis:

(4) *Hypothesis (ii) Topic marking interacts with grammatical function.*
Topic-marking an object effects a mental representation that otherwise could not be created. Topic marking a subject will not effect a non-default mental representation because subjects are default topics.
Processing: Topic-marked objects should have processing advantages in comparison to objects that are not topic-marked. For topic-marked subjects there should be no processing advantages in comparison to subjects that are not topic-marked.
Retrieval: Topic-marking an object helps the retrieval of the corresponding referent and the information associated with it in comparison to an object without topic marking. For topic-marked subjects there should be no advantage at retrieval in comparison to subjects without topic marking.

Hypothesis (ii) leaves open whether or not there might be disadvantages of explicitly marking subjects as topics. We may assume that redundant topic marking is cost-free, or that it is costly. We will come back to this issue in the discussion section.

We argued above that topics might be hypothesized to be particularly salient referents. The same can be said for foci: like topical referents, focussed referents have been argued to be salient in the discourse and therefore are expected to play a privileged role during processing and retrieval. In contrast to topics, however, foci do not mark addresses. To explore our hypotheses for topics, we compare topics directly to foci in our study. With respect to *hypothesis (i)*, we do not expect that pointing at, i.e. cueing, the focussed referent of a sentence some time after processing should help retrieval of the information conveyed in the sentence in the same way that cuing the topic-marked referent, i.e. the address, does. With respect to *hypothesis (ii)*, we assume that focus marking does not interact with grammatical function in the same way that topic marking does. We argued above that subjects are default topics whereas objects are not. Since neither subjects nor objects are default or even typical (narrow) foci, focus marking should not interact with grammatical function:

(5) *Hypothesis (iii) Focussed referents do not serve as addresses, therefore focus marking does not interact with grammatical function – neither during processing, nor during retrieval.*
Processing: Focus-marking a subject has the same effects for processing the subject referent, as does focus-marking an object for the object referent.
Retrieval: Cueing the referent of a focus-marked phrase is less effective for retrieval of information conveyed in the sentences where the focus-marked phrase occurred, in comparison to cuing a referent corresponding to a topic-marked phrase because the information conveyed by the sentence is stored under the topic address and not with the focussed referent.

As foci very often are assumed to convey new information – which is a confound that we wish to avoid, let us make the notion of focus that we employ here more precise. We take focus to mark the presence of alternatives (e.g. Krifka, 2008; Rooth, 1985)[1], i.e. to be not

[1] If we assume that focus marks alternatives one might wonder what the role of contrast marking – which also indicates the presence of alternatives – is. The precise delimitation of contrast from narrow focus is highly problematic. Contrast is often associated with a limited set of explicit alternatives, with an exhaustive (i.e. exclusive) interpretation, or with discourse contexts like corrections (see Repp, 2010 for a review). All these contexts can also be said to involve narrow focus – they all involve alternatives. Narrow focus, however, can be found in a wider range of contexts, for instance in answers to *wh*-questions. In experimental studies, contrast is often implemented as either a limited set of explicit alternatives (e.g. Fraundorf et al., 2010; Ito & Speer, 2008; Sedivy, Tanenhaus, Chambers

directly associated with new information, contrary to what is often assumed. A focussed referent can be new, as in the following question-answer discourse, where the focussed object referent in the answer, *Peter,* is discourse-new: *Q: Who did Julie's mother praise? A: She praised Peter*$_{FOCUS}$. A focussed referent can also be given, as in the following question-answer discourse: *Q: Who did Peter's mother praise? A: She praised Peter*$_{FOCUS}$. Here the focussed object referent in the answer, *Peter*, is given because it was mentioned in the question. In both cases, the focussed part in the answer picks out from a set of alternatives the one that is true as an answer to the question. The observation that focus often represents new information can be explained if we assume that discourses answer implicit *wh*-questions such as *Who came?* for narrow focus, or *What happened?* for broad focus (cf. Schmerling, 1976 and subsequent literature). The focussed part of a sentence then represents the new information, which is used to answer the implicit *wh*-question. In our experiment, we test isolated sentences, so all referents are new referents. These referents are denoted by definite noun phrases, so their existence and uniqueness has to be accommodated.

We should point out here that topics often are given. Indeed, in many psycholinguistic studies, topicality is implemented as givenness (Kaiser, 2006 for English; Kaan, 2001, Stolterfoth, 2005 for German; Mak, Vonk & Schriefers, 2008 for Dutch, Hirotani & Schumacher, 2011 for Japanese). There are also studies, however, that dissociate givenness from topicality. This dissociation is important in our view. We assume that both given and new referents can be topics in the address sense (see e.g. Endriss, 2009; Reinhart, 1981; but see Gundel, 1988; Hedberg, 1990; Hockett, 1958; Portner and Yabushita, 1998 for accounts which assume that topics necessarily are given). Studies that dissociate givenness (and subjecthood) from topicality are Cowles (2003, 2007) and Cowles & Ferreira (2012). In these studies, participants heard a setup sentence which contained either an *about*-phrase, e.g. *about the lightning* or *about the baby* as in (6a), or an adjunct clause as in (6b). The *about*-phrase was used to implement topicality in a non-subject position. After participants heard the setup sentence they were presented with three words: a verb, e.g. *frightened*, and two arguments, one of which was given information because it had been mentioned in the setup sentence, e.g. *lightning* and *baby*. Participants had to formulate a sentence using these words.

(6) a. A nurse noticed something about the {lightning / baby}.
b. The nurse noticed something as she watched the {lightning / baby}.

The results showed that both givenness and topicality influenced which of the arguments was placed first in the sentence that participants had to produce. Given arguments had an early-mention advantage. Importantly, this advantage increased if the argument had been presented in an *about*-phrase rather than in an adjunct clause in the setup sentence (Cowles & Ferreira 2012)[2]. These findings suggest that topics indeed are salient referents in the discourse representation.

Related evidence has been found in Chinese, where topics are marked syntactically: they occur in clause-initial position, cf. (7). Hung & Schumacher (2012) found that processing the target sentence in (7) in a context like (7A), where a different phrase than in the target

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& Carlson, 1999), or as correction (e.g. Breen, Fedorenko, Wagner & Gibson, 2010). In other work, contrast and narrow focus are considered the same (e.g. Sanford et al., 2006). Contrast does not play a role in the current study because we tested isolated sentences so there is no context that would provide explicit alternatives, or license a correction reading. We will say more about contrast in the discussion section.

[2] Cowles & Ferreira (2012) also tested whether participants actually classified the referent introduced by the *about*-phrase as a topic. They found that overall the subject of the matrix clause was classified as the topic of the sentence but that the presence or absence of an *about*-phrase modulated this result. This is evidence that topichood is not entirely dependent on subjecthood in English.

sentence is topic-marked, elicits an ERP component that has been suggested to reflect reorganization of discourse-functional information (late positivity).

(7) *Schematic representation of Chinese sentences*

Context A :	$Lisi_{TOPIC}$ what?	('What about Lisi?')
Context B:	What?	('What happened?')
Context C:	$Zhangsan_{TOPIC}$ what?	('What about Zhangsan?')
Target:	$Zhangsan_{TOPIC}$ Lisi beat	('Lisi beat Zhansan.')

Hung & Schumacher suggest that the component marks a topic shift in this case. Importantly, the component was not found if the target sentence occurred in context B, which did not contain a topic-marked phrase, and it was not found after context C, where the same phrase as in the answer was topic-marked. So the establishment of a completely new topic, or the continuation of a given topic behaved alike in this study.

Taken together, this evidence suggests that topicality and givenness influence discourse processing independently of each other. We suggest that the high correlation of topicality with givenness that is generally assumed in the literature can be explained if we consider that coherent discourses tend to be about the same entity, at least for a while (in so-called *topic chains*). A topic is kept constant over a series of sentences, and more and more information is entered under the topic's address. As already mentioned, we kept givenness constant in our study – both for topics and for foci: all noun phrases are definite noun phrases in isolated sentences.

Left dislocation

The sentence structure that we chose for our investigation is left dislocation in German. In a left-dislocation structure, a noun phrase[3] occurs at the left periphery of the clause and is taken up later in the clause by a resumptive d-pronoun, i.e. by a personal pronoun that has the same form as the definite article in German. The resumptive d-pronoun has the same case, number, and person features as the left-dislocated phrase. This is illustrated for a left-dislocated subject with nominative case in (8), and for a left-dislocated object with accusative case in (9).

(8)

Der	Fuchs,	der	jagt	den	Wolf.
the.NOM.SING.MASC	fox	RP.NOM.SING.MASC	chases	the.ACC.SING.MASC	wolf

'The fox, it chases the wolf.'

(9)

Den	Fuchs,	den	jagt	der	Wolf.
the.ACC.SING.MASC	fox	RP.ACC.SING.MASC	chases	the.NOM.SING.MASC	wolf

'The fox, the wolf chases it.'

Left dislocation is a structure that is mainly used in spoken German. It implements informational separation – as we find it in the topic-comment separation – with syntactic means. And indeed, left dislocation is generally assumed to mark the topicality of the dislocated phrase (e.g. Frey, 2004b; Jacobs, 2001). So in (8) and (9), the fox referent would be the topic of the sentence, and according to our hypothesis, there would be an address for it in the mental discourse representation. The information given in the clause would be entered under that address.

Upon closer scrutiny, it turns out that the information-structural status of the left-dislocated phrase is not restricted to topics. (10) and (11) might be taken as illustrations for

3 Left dislocation is also possible with prepositional phrases, complementizer phrases or adjective phrases, where the resumptive pronoun is an adverbial proform. We do not investigate such cases here.

left-dislocated elements denoting a focussed referent. In (10) a phrase with the focus particle *nur* ('only') is left-dislocated, in (11) a phrase with the focus particle *sogar* ('even') is left-dislocated (also see Reis, 2005 for an example with *nur* ('only') presented in an independent discussion).

(10) *Niemand versteht dieses Theorem sofort. ('Nobody understands this theorem right away'.)*
Nur der Streber dort,
only the.NOM eager.beaver over.there
der hat's natürlich gleich kapiert.
RP.NOM has.it of.course straightaway got
'Only the eager beaver over there got it straightaway, of course.'

(11) *Alle haben es verstanden. ('Everybody has understood it'.)*
Sogar der Max, der hat's verstanden.
Even the.NOM Max, RP.NOM has.it understood
'Even Max understood it.'

It might be argued that (10) and (11) are instances of dislocated topics which also are foci, i.e. contrastive topics (as suggested by an anonymous reviewer). Note, however, that intuitively, (10) is about the theorem and not about the eager beaver. Similarly, the left dislocation structure in (11) is not about Max. Furthermore, and maybe more importantly, the left-dislocated phrases in both examples must be spoken with a falling accent, which is an accent that is never used for contrastive topics (see the section on the prosodic marking of topic and focus).[4] So we assume that the dislocated elements indeed are foci. That foci can be left-dislocated is further supported by the fact that left dislocation structures can be used in question-answer discourses such as (12). The dislocated referent element corresponds to the *wh*-term in the question, i.e. by general consent in the literature, is a focus.

(12) *Whom did Paula introduce to the president?* (Frey 2004b)
Den Karl, den hat Paula dem Präsidenten vorgestellt.
the.ACC Karl, RP.ACC has Paula the.DAT president introduced
'Karl, Paul introduced HIM to the president.'

Another non-topical function which shows that left dislocation does not necessarily mark topics, is illustrated in (13). The context is a conversation about snakes, and the speaker wishes to say something about a snake that a friend of a friend has, i.e. the speaker wishes to carry on the conversation about snakes. The two friends, which are denoted by phrases in two different dislocations, are only mentioned to link the particular snake to the speaker. The dislocated elements are not topics – the sentence is not about them – and nothing is said about them in the subsequent discourse.

[4] Note, however, that these examples have an intonation contour in the main clause which is different from the intonation contour that we use in our experimental materials. (10) has two falling accents – one on the resumptive pronoun, and one on *gleich* ('straight away'). (11) has a rather flat contour throughout the main clause. These differences are due to the fact that intonation is influenced by context, and the context in the two examples differs – different things are given. For our experimental materials, we used the intonation contour that is appropriate for (12). See the stimuli section for specification.

(13) *An ongoing conversation about snakes*
N' Freund von mir, der hat 'ne Freundin,
a friend.MASC of mine RP.NOM.MASC has a friend.FEM
die hat 'ne Boa als Haustier.
RP.NOM.FEM has a boa as pet
'A friend of mine has a friend that has a boa for a pet.'
This boa lives in the conservatory and feeds on mice that the family cat catches.

In sum, the examples in (10) through (13) clearly speak against the common assumption that left dislocation reliably marks topics.

In the current study, we compare left dislocation structures with dislocated topics to left dislocation structures with dislocated foci. We entertain the hypothesis that the two can be differentiated by intonation:

(14) *Hypothesis (iv) – Information structure in left dislocation structures*
A left-dislocated phrase can refer to a topical or to a focussed referent, depending on the intonation pattern of the left-dislocation structure it occurs in.

The relevant intonation patterns will be discussed in a separate subsection further below.

To our knowledge, left dislocation structures in German have not been tested previously in experimental work. For English, Netz, Eviatar & Kuzar (2011) report an auditory recall experiment where they found that an element that appears in a left-dislocated position as *Thomas* in *Thomas, he found Susan* is recalled better than an element that is 'topicalized' (= fronted) as in *Thomas, Susan found,* and also better than a clause-initial element that is not separated syntactically but only prosodically from the remainder of the clause, as in *Thomas, found Susan*. However, this study has several limitations. One is that the materials seem to have contained only one particular sentence as critical item. Furthermore, it is unclear what particular prosody was used for the tested structures. Finally, two of the structures in the experiment involved a subject whereas one involved an object. So overall it is quite unclear what exactly contributed to the observed effects.

Subject-object asymmetries

Left-dislocating an object places the object before the subject, i.e. results in a word order that should produce increased processing costs: there is a robust subject-before-object preference in the processing of isolated sentences, which is reflected in shorter reading times and in other processing measures (for German e.g. Bader & Meng, 1999; Friederici, Schlesewsky & Fiebach, 2003; Hemforth, 1993; Keller, 2003; Konieczny, 2000; Pechmann, Uszkoreit, Engelkamp & Zerbst, 1994; Rösler, Pechmann, Streb, Röder, & Hennighausen, 1998; Stolterfoht, 2005; Weskott, 2003). The advantage of the subject-before-object preference can be alleviated to some extent by contextual factors such as givenness, narrow focus induced by a *wh*-question, or corrective focus (e.g. Bornkessel & Schlesewsky, 2006; Meng, Bader & Bayer, 1999). Weskott, Hörnig, Fanselow & Kliegl (2011) report that in German the marked object-before-subject order can even be preferable (higher acceptability, faster reading times) over the subject-before-object order, if in sentences with clause-initial objects the object denotes a referent that stands in a part-whole relation with some referent already evoked in the discourse model, and where the subject is a pronoun. An English example is *Peter washed [the car]$_{WHOLE}$. [The side mirror]$_{PART}$ he polished with particular diligence.* Now, the part referent in a partially-ordered set relations can be viewed as an instance of a partial topic (Büring, 1997). 'Partial' because it is implied that there are other referents belonging in the car

part category, about which something different could or will be said. The results obtained by Weskott et al. might therefore be taken to show that placing a partial topic in a left-peripheral position helps the reader to recognize that the new address s/he establishes is closely connected to an entity introduced previously in comparison to a structure where the partial topic is not in this position. This assumption seems plausible but there also is an alternative, or additional, explanation available for the observed effects. Partial topics typically are implied to stand in a contrastive relation to other partial topics. Therefore, the effect might be due to the contrast between these various topical referents, where contrast can also be viewed as a close relation between referents. We cannot decide between these options here but will come back to it in the discussion section.

In the present study we do not manipulate semantic relations like part-whole relations for the contextual licensing of topicality. Our study differs in two crucial aspects from previous studies. The first is that we investigate left-dislocation structures, which, due to the syntactic separation of the information in the sentence are potentially well-suited to mark a topic-comment informational separation. This clearly-marked informational separation might prove advantageous for the processing of object-initial sentences. The second is the manipulation of prosody.

Prosodic marking of topics and foci

In the present study, we investigate whether prosody can distinguish between focus vs. topic and whether that – in accordance with the theoretical assumptions made above – leads to a discourse representation where the topic-marked element is stored as an address, whereas the focus-marked element is not. We expect that this difference will be reflected in a processing advantage for topic-marked elements during retrieval. The prosodic reflexes of information structure in German are fairly well investigated but there are still many open questions. Non-pronominal topics in German are realized by a rising accent (Braun, 2005, 2006; Féry, 1993; Frascarelli & Hinterhölzl, 2007; Mehlhorn, 2001). There is some controversy about the specific accent type involved because it is unclear whether or not non-contrastive and contrastive topics are distinguished prosodically. In a corpus investigation of radio talk shows, Frascarelli & Hinterhölzl (2007) found that new non-pronominal topics are realized by L+H* whereas contrastive topics are realized by L*+H. However, in an experimental study, Braun (2005, 2006) could not find a reliable difference between non-pronominal given topics and contrastive topics in terms of what rising accent type speakers produced. For both types of topics, the peak was reached in the post-stressed syllable – which suggests the use of L*+H throughout. Although the place of the L trough varied, which Braun interpreted as the use of L+H* versus L*+H, these different rises did not correlate with context. Rather, speakers marked contrastive topics vs. non-contrastive topics either with a higher pitch, or with a later pitch peak, or with both. Furthermore, the duration of the F0 rise was longer in contrastive sentences, and there was a larger rise excursion (also see Mehlhorn, 2001 for similar results).

The rising accent that marks topics is often – especially in the case of contrastive topics – assumed to be part of the so-called *hat pattern*. The hat pattern is an intonation contour where the clause-initial rise on the topic is followed by a plateau which later in the clause, viz. in the comment part, ends in a fall (Féry, 1993; Mehlhorn, 2001; Steube, 2001; Wunderlich, 1991). However, Braun (2006) showed that the hat pattern is produced by speakers less reliably than is usually assumed. Interestingly, non-contrastive and contrastive contexts do not differ in the use of the hat pattern. Braun found that, independent of the presence of the hat pattern, contrastive topics tend to be accompanied by a falling pitch accent in the comment part (H*+L or !H*+L) rather than by a high pitch accent that is followed by a low phrase tone (e.g. H*L-; !H*L-).

Narrow new information focus in German is usually marked by a falling accent, viz. by a H*(+L)[5] accent (Batliner, 1989; Baumann & Hadelich, 2003; Féry, 1993; Uhmann, 1991), which has a higher pitch in comparison to broad focus (Baumann, Grice & Steindamm, 2006; Féry & Kügler, 2008), and a longer duration (Baumann et al., 2006; Kügler, 2008). Furthermore, a pitch accent indicating narrow focus has been observed to be downstepped less often, i.e. realized as !H*(+L), than a pitch accent in a broad focus sentence (Baumann et al., 2006, Féry & Kügler, 2008). The prosodic realization of given information in a sentence with narrow focus depends on its pre- vs. postfocal position. Pre-focally, it is realized with lower pitch accents. Post-focally, it is deaccented (Féry & Kügler, 2008; Uhmann, 1991).

Let us summarize these findings from the phonetic-phonological literature on German intonation:

(15) a. Topics are reliably marked by a rising accent, sometimes as part of a hat pattern.
b. Narrow new information focus is realized by a falling accent. Post-focal given material is deaccented.

Given these findings, we chose the following intonation contours for the stimuli in our study. In sentences with a dislocated topic, the dislocated phrase was realized with a rising accent, followed by a break. The remainder of the sentence started with a rise on the resumptive pronoun, which was part of a hat pattern in the main clause. In sentences with a dislocated focus, the dislocated phrase was realized with a falling accent, followed by a break. The remainder of the sentence began with a fall on the resumptive pronoun, after which there was post-focal deaccentuation. The details of these contours will be described in the materials subsection in the experimental section below.

Experiment

In the experiment, we tested the predictions that can be formulated on the basis of the four hypotheses which we developed in the previous sections. We investigated in how far the prosody of a left dislocation structure – and thus, by hypothesis, the information-structural status of the left-dislocated phrase as topic or focus – influences the processing of the structure, and, in addition, how prosody, and thus information structure, influences the retrieval of the information conveyed by the left dislocation structure from memory. We presented participants with left dislocation structures like (8) and (9), i.e. transitive sentences, where either the subject or the object was dislocated. Sentences were presented auditorily. They either had the intonation contour that we hypothesize to mark the dislocated phrase as topic, or as focus. A sample set, which will be described in more detail further below, is given in Table 1. After the presentation of the sentences, participants were given a mathematical task: they were to judge whether or not a mathematical equation indeed had the result that was suggested to them. After the maths task, participants had to recall the sentence from memory. Just before they were shown the prompt for recall, participants saw a written cue which either corresponded to the subject noun or to the object noun.

The maths task served as an indicator of the processing load associated with the processing of the target sentence: we expected that the accuracy of the participants' judgements in the maths task and the time they needed to solve the task, would reflect this processing load. Fedorenko, Gibson & Rohde (2007) showed that language integration processes and integration processes in the calculation of arithmetic sums share common working memory resources. In a series of dual-task experiments, they found that the

[5] Most descriptions of the German tone inventory assume an H*+L accent but German ToBI (Grice, Baumann, & Benzmüller 2005) assumes that the corresponding pitch movements are better analyzed as H* followed by a L– phrase accent, which is aligned with the post-stressed syllable.

processing of syntactic dependencies interacts with the difficulty of the arithmetic task that participants also had to solve. Therefore, we may hypothesize that processing costs associated with the establishment of a topic address and integration of the information conveyed by the target sentence at that address, will be reflected in the accuracy and reaction times for the maths task. Further evidence against domain-specific working memory resources can be found e.g. in Fedorenko, Gibson & Rohde (2006). Also cf. Scheepers, Sturt, Martin, Myachykov, Teevan & Viskupova (2011) for the interaction of mathematical problem solving and language processing. The maths task in the present experiment also served a purpose in relation to the recall task: it engaged the working memory of the participants and therefore should prevent active rehearsal of the recall, at least to some extent.

In accordance with the hypotheses put forward above, we formulated the following predictions with respect to the processing of the dislocation structures. We predicted that the intonation that we assume to mark the dislocated phrase as a topic, would have an impact on the subject-before-object preference, whereas the intonation that we assume to mark the dislocated phrase as focus, would not. Since topic marking an object in contrast to topic marking a subject leads to a discourse model in memory that otherwise cannot be obtained, the subject-before-object preference might decrease, or even be overwritten, if we compare sentences containing a dislocated topical subject to sentences containing a dislocated topical object. For focus marking, we predict no influence on the subject-before-object preference. In our experiment, we expected that the interaction of topicality with grammatical function would be reflected in greater accuracy and reduced decision times in the maths task for sentences with a dislocated topical object in comparison to sentences with a dislocated topical subject. Furthermore, for sentences with a dislocated object we expected greater accuracy and reduced decision times in the maths task if the dislocated object was a topic rather than a focus.

To approach the issue in how far topic marking influences retrieval from a structured discourse representation where topics serve as addresses, we investigated how the cross-modal priming cue that was presented to the participants just before the recall, influences the recall of the target sentences. The cue was either the subject noun or the object noun (without determiner). Since subjects/objects could be dislocated topics, dislocated foci, or sentence-internal noun phrases, the cue could correspond (i) to the topic address of the target sentence, (ii) to the referent of the focus-marked dislocated phrase (iii) to the referent of the sentence-internal noun phrase. We expected that a cue corresponding to a topic-marked referent would ease retrieval of the information conveyed by the target sentence because the information was stored under this address during processing. This easier retrieval could be reflected in greater accuracy of the recall and reduced voice onset times. For a cue corresponding to a focus-marked referent, we expected no facilitating effect. For cues corresponding to a sentence-internal noun phrase, we had no specific predictions. We shall elaborate on this issue in the discussion section.

Participants

Forty German native speakers (mean age 23.6 years, range 20-28, 14 male) living in the Berlin/Brandenburg region in Germany participated in this experiment after giving informed consent. They were paid 7 Euros. All participants were students of subjects other than linguistics. All had normal or corrected-to-normal vision, good auditory acuity, and had no prior exposure to the experimental trials. Three participants were excluded from the data analysis because they did not reach 80 % accuracy in the maths task or due to technical problems during the recording. This left 37 participants for analysis.

Stimuli and design

The material consisted of manipulations of two sets of 16 transitive sentences with a left-dislocated noun phrase, where the two sets differed in swapped roles for agent and patient to control for plausibility. The following factors were manipulated: ORDER (left-dislocated subject vs. left-dislocated object), INTONATION (*TOPIC* intonation vs. *FOCUS* intonation), and CUE TYPE (*SUBJECT* noun vs. *OBJECT* noun), yielding eight conditions (2x2x2 design). The factors ORDER and INTONATION were implemented in the acoustic stimulus material. 128 sentences were digitally recorded with a sampling rate of 44.1 kHz and 16-bit resolution. They were spoken by a trained, male speaker with a standard High German accent. In combination with the factor CUE TYPE, the entire set of materials consisted of 256 experimental items, which were distributed over four lists with 64 critical sentences each, such that a participant saw a trial once with subject-before-object order, and once with object-before-subject order (order of presentation balanced across participants). The factors INTONATION and CUE TYPE were balanced over participants and trials. There also were 32 unrelated filler sentences from another experiment.

Table 1 illustrates the conditions that we tested for a sample sentence (see appendix 2 for more items). S_{TOP}-O in Table 1 refers to a sentence with a dislocated subject and a clause-internal object where the intonation contour is the contour that by hypothesis marks the dislocated element as topic. S_{FOC}-O refers to a sentence with a dislocated subject and a clause-internal object where the intonation contour is the contour that by hypothesis marks the dislocated element as focus. O_{TOP}-S and O_{FOC}-S are the respective object-initial sentences, i.e. the dislocated noun phrase is the object, and the clause-internal noun is the subject. All noun phrases were definite. They had masculine gender so that their case could be identified via the definite determiner *der* (nominative) vs. *den* (accusative), and identification as subject vs. object was unambiguous. As laid out above, the resumptive d-pronoun, which is homophonous with the definite determiner, had the same case, number and gender as the dislocated noun phrase.

Table 1 Sample material set: The sentence *The fox chases the wolf* with left dislocation.

SENTENCE TYPE	EXAMPLE						CUE
S_{TOP}-O	Der the.NOM	/FUCHS, fox L*+H H-H%	/DER RP.NOM L*+H	jagt chases	den the.ACC	\WOLF. wolf !H* L-L%	*Fuchs/ Wolf*
S_{FOC}-O	Der the.NOM	\FUCHS, fox H* L-L%	\DER RP.NOM H*	jagt chases	den the.ACC	Wolf. wolf L-L%	*Fuchs/ Wolf*
O_{TOP}-S	Den the.ACC	/WOLF, wolf L*+H H-H%	/DEN RP.NOM L*+H	jagt chases	der the.NOM	\FUCHS. fox !H* L-L%	*Fuchs/ Wolf*
O_{FOC}-S	Den the.ACC	\WOLF, wolf H* L-L%	\DEN RP.NOM H*	jagt chases	der the.NOM	Fuchs. fox L-L%	*Fuchs/ Wolf*

Phonological description of the materials

Table 1 also gives the intonation contours of the *TOPIC* vs. *FOCUS* conditions in the annotation scheme of auto-segmental approaches for German (Féry, 1993; Grice, Baumann & Benzmüller, 2005). In both contours, the dislocated phrase and the remainder of the clause formed separate intonational phrases with a break in between. In the *TOPIC* contour, the dislocated noun phrase came with rising intonation: the stressed syllable of the noun had a rising accent L*+H, which was followed by a high phrase accent H- and a high boundary tone H%. Since the number of syllables after the stressed syllable of the nouns used in the materials varied (between zero and two) the H tone was within the stressed syllable or later. The remainder of the clause, i.e. the second intonational phrase, came with what can be described as a hat contour. The resumptive pronoun carried a rising accent L*+H. The peak of this accent was reached in the syllable after the resumptive pronoun. The pitch then remained high, forming a plateau, and fell again on the clause-internal noun, whose stressed syllable came with a downstepped !H*, followed by a low phrase accent L- and a low boundary tone L%. In the *FOCUS* contour, the dislocated noun phrase came with falling intonation. The stressed syllable had a high pitch accent H* and the intonational phrase ended with a low phrase accent and low boundary tone. The second intonation phrase in this contour did not display the hat pattern. Instead, there was a falling accent H*+L on the resumptive pronoun[6], followed by low pitch until the end of the utterance, which ended with a low phrase accent

[6] The low tone of the H*+L was actually only reached on the next stressed syllable, which corroborates the assumptions in the GToBI model (Grice et al., 2005), according to which there is no H*+L bitonal accent in German but that such accents are better described as H* tones followed by a low phrase accent. We gloss over this here as this is immaterial for the present investigation.

and boundary tone. Sample contours are given in Figure 1 for the *TOPIC* contour, and in figure 2 for the *FOCUS* contour.

Figure 1. Sample *TOPIC* intonation contour

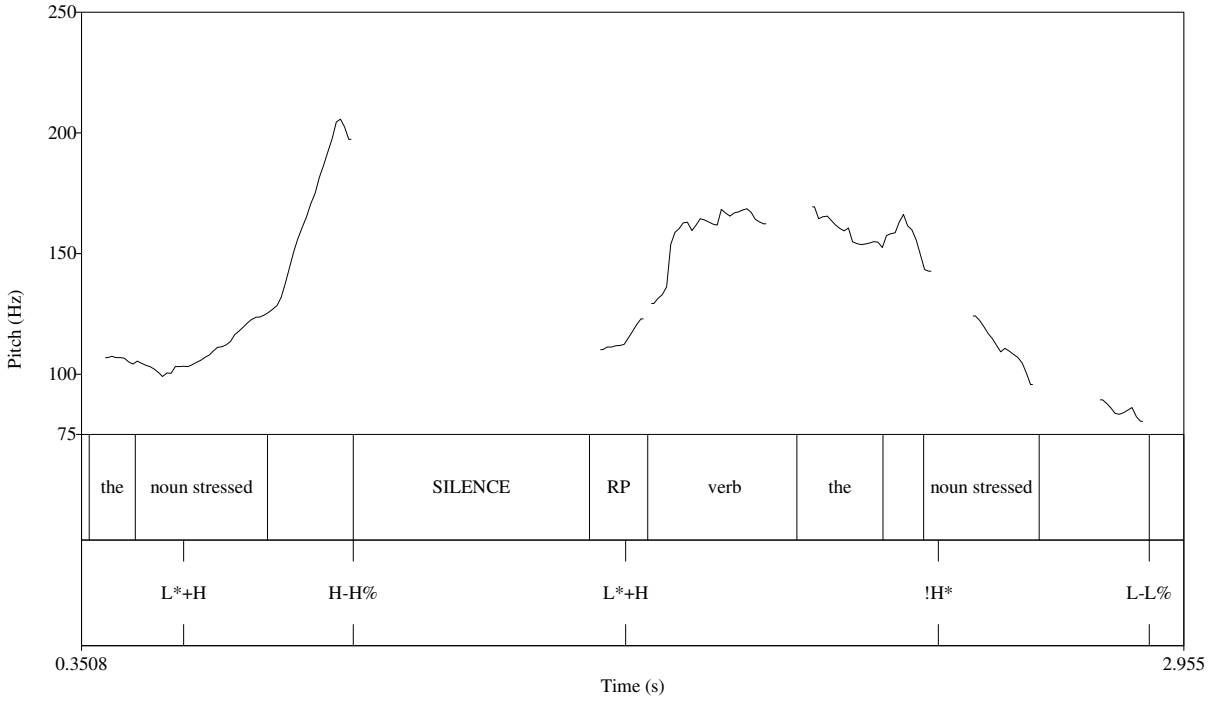
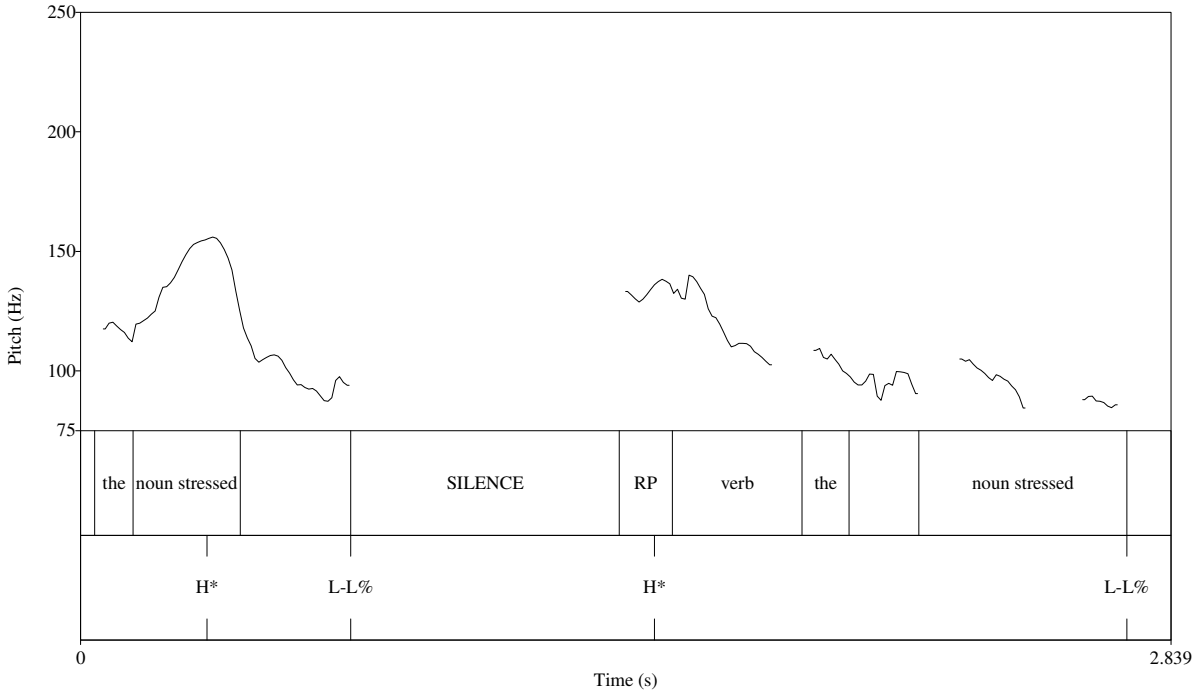


Figure 2: Sample *FOCUS* intonation contour



Acoustic analyses of the materials

Acoustic analyses were carried out to verify that the *TOPIC* vs. *FOCUS* contours indeed were distinct in the crucial measurements but that ORDER manipulations were not. For the dislocated noun, the resumptive pronoun and the clause-internal noun we compared the *direction of slope*, implemented as the position of minimum pitch vs. maximum pitch within the interval of the stressed syllable and the subsequent unstressed syllable(s) (if there were any), the *maximum pitch* within that interval, the *pitch excursion* within that interval, implemented as the frequency of maximum pitch minus minimum pitch, as well as the *duration* and the *mean intensity* of the stressed syllable. For the break between the dislocated noun and the main clause we analyzed the duration. For the verb we analyzed the maximum pitch. The descriptive data are given in Table 2. The statistical analysis is given in Appendix 1a. To briefly summarize the most important results, analysis revealed that the dislocated noun was realized with a rise in the *TOPIC* contour, and with a fall in the *FOCUS* contour. The peak of the rise in the *TOPIC* contour was higher and its excursion was greater than the peak and excursion of the fall in the *FOCUS* contour. The stressed syllable of the dislocated noun was louder in the *FOCUS* contour than in the *TOPIC* contour. The break was the same in both contours. The resumptive pronoun was realized with a rise in the *TOPIC* contour, and a fall in the *FOCUS* contour. The pitch peak was higher and the intensity was greater in the *FOCUS* contour than in the *TOPIC* contour. There was a length difference between subject pronouns and object pronouns, which can be put down to segmental differences. The verb, which occurred after the resumptive pronoun, came with a higher maximum pitch in the *TOPIC* contour than in the *FOCUS* contour. The pitch in the *TOPIC* contour stayed high, the plateau ending just before the stressed syllable of the clause-internal noun. These results indicates that the *TOPIC* contour indeed came with a hat pattern, whereas in the *FOCUS* contour there was deaccentuation after the resumptive pronoun. Apart from the length difference for the resumptive pronoun which was already mentioned, there were no prosodic differences between subject-before-object orders vs. object-before-subject orders.

Table 2. Acoustic features of the stimuli by factors INTONATION and ORDER. Pitch is given in *Hz*, duration is given in *ms*. Standard deviations are in brackets. 'σ' is the syllable symbol.

		dislocated noun	*break*	*RP*	*verb: second syllable*	*clause-internal noun*
direction of slope	***TOPIC***	rise	/	rise	/	fall
	FOCUS	fall	/	fall	/	fall
maximum pitch for interval $\sigma_{stress}(\sigma(\sigma))$	***TOPIC***	182.8 (7.70)	/	150.2 (10.2)	192.25 (49.28)	143.5 (13.2)
	FOCUS	158.0 (21.4)	/	160.0 (10.8)	137.9 (49.2)	122.2 (68.2)
pitch excursion for interval $\sigma_{stress}(\sigma(\sigma))$	***TOPIC***	92.8 (24.75)	/	50.02	/	62.8 (14.5)
	FOCUS	61.5 (14.31)	/	43.55	/	36.6 (68.5)
duration of stressed syllable (ms)	***TOPIC***	370 (118)	630 (161)	156 (27)	/	321 (115)
	FOCUS	363 (130)	570 (119)	153 (20)	/	326 (109)
mean intensity of stressed syllable (db)	***TOPIC***	51.0 (2.5)	/	55.2 (1.8)	/	53.6 (2.8)
	FOCUS	58.5 (2.5)	/	62.1 (1.6)	/	49.6 (2.8)
direction of slope	***SUBJECT***	mixed	/	mixed	/	fall
	OBJECT	mixed	/	mixed	/	fall
maximum pitch for interval $\sigma_{stress}(\sigma(\sigma))$	***SUBJECT***	171.6 (20.3)	/	153.3 (10.2)	170.1 (93.2)	135.1 (51.3)
	OBJECT	169.0 (20.0)	/	156.3 (12.54)	160.0 (64.6)	130.3 (49.6)
pitch excursion for interval $\sigma_{stress}(\sigma(\sigma))$	***SUBJECT***	75.2 (27.7)	/	46.45 (17.83)	/	52.4 (52.3)
	OBJECT	78.9 (23.1)	/	47.08 (12.98)	/	4.8 (50.4)
duration of stressed syllable	***SUBJECT***	366 (125)	583 (148)	144 (23)	/	309 (111)
	OBJECT	366 (123)	613 (140)	166 (19)	/	339 (111)
mean intensity of stressed syllable (db)	***SUBJECT***	54.6 (4.2)	/	58.2 (3.9)	/	52.0 (3.5)
	OBJECT	55.0 (4.8)	/	59.2 (3.8)	/	51.1 (3.8)

Procedure

Participants were seated in front of a 17 inch colour monitor in a quiet laboratory. At the beginning of the experiment, participants were given written instructions on a sheet of paper, which were additionally repeated on the computer screen when the experiment started. The experiment was controlled using DMDX (http://www.u.arizona.edu/~kforster/dmdx/dmdx.htm).

First, four practice trials were presented. After this practice set, the 64 critical sentences and the 32 filler sentences were presented in pseudo-randomized order. Each trial began with the presentation of an asterisk in the middle of the screen. At the same time participants heard an experimental sentence via headphones (Sennheiser PC 131, half-open, with noise-cancelling microphone), which was followed by a visually presented mathematical equation of varying difficulty that appeared in the middle of the screen, e.g. *(4 + 4) * 4 = 30* or *(5 + 5) * 1 = 15*. There were 64 different equations, which were pseudo-randomly assigned to the 64 critical items of each list. In addition, there were 32 equations for the fillers. Equations could be correct or incorrect. Correctness was pseudo-randomized within lists (half correct and half incorrect), and balanced across lists. The task of the participants was to judge within a maximum interval of 2000 ms by pressing one of two buttons whether or not the mathematical equation was correct. If participants did not press a button within the given time interval the trial continued. There was no feedback. Next, a priming cue (subject or object noun) was presented in the middle of the screen for 600ms. Finally a row of four exclamation marks (*!!!!*) appeared in the middle of the screen which served as the prompt for the participants to recall and repeat the heard sentence. Their answer was recorded onto the hard drive disc of the computer.

Results

The dependent variables were the accuracies of the judgement in the maths task, the reaction times for the judgement of the maths tasks for accurate judgements, the accuracies of the recall, and the voice onset times for accurate recalls. All reaction times were log-transformed. For all the statistical analyses reported below, we applied general linear mixed effect models (Bates & Sakar, 2007) with orthogonal contrast coding. In the maths task, the fixed factors were INTONATION (contrast coding: + .5 for TOPIC conditions, -.5 for FOCUS conditions) and ORDER (contrast coding: +.5 for subject-before-object conditions, -.5 for object-before-subject conditions). In the recall task, CUE TYPE was an additional fixed factor (contrast coding: +.5 for subject noun cues, -.5 for object noun cues). In all analyses, participant and item were random factors. As a part of our model evaluations, we tested models with random slopes for participants and items (Baayen, Davidson & Bates, 2008; Barr, Levy, Scheepers & Tily, 2012). We fitted models with all predictor variables and allowed maximal interaction. In a second step we reduced the model stepwise by excluding those fixed effects which were not significant ($t < 2$). Following Baayen et al. (2008), *t* values exceeding 2 indicate significance at the level of 5%. Additionally, likelihood ratio tests were performed by comparing models. For regression models we present MCMC-estimated (Markov chain Monte Carlo simulations with 10,000 samples)[7] *p*-values that are considered significant at the $\alpha = .05$ level (Baayen 2009). Accuracies were submitted to logistic regression. Therefore only *z*-values will be presented. In the paper, we present the results of the most adequate fitted models. A reviewer requested the colinearity numbers for interactions, which are given in Appendix 1b.

[7] At the moment, it is not possible to calculate *p*-values for models with random correlation patterns. Therefore, we present the *p*-values for the simpler models with random slopes but without correlation pattern (e.g. Hofmeister, Jaeger, Arnon, Sag & Snider, 2011).

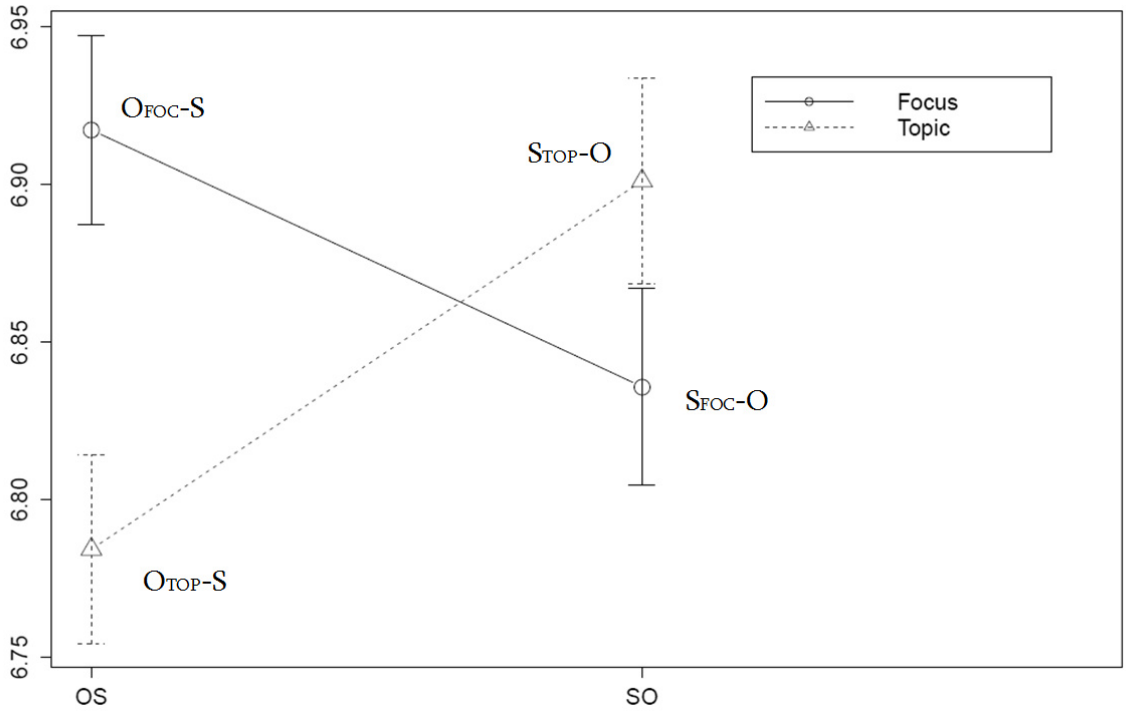
Mathematical equation

The mean proportions of accurate answers and the reaction times are given in Table 3. For the accuracies of the judgement, there were no effects. For the log-transformed reaction times, there was a main effect of INTONATION (*estimate* = -.13611, *se* = .04653, *t* = -2.93, *p* < .01), a weak main effect of ORDER (*estimate* = -.08216, *se* = .04319, *t* = -1.90, *p* < .08), and an interaction INTONATION *x* ORDER (*estimate* = .21555, *se* = .08410, *t* = 2.56, *p* < .001). As can be seen in Figure 3, equations were judged (i) faster after participants had heard an O_{TOP}-S sentence compared to a S_{TOP}-O sentence, (ii) faster after participants had heard a S_{FOC}-O sentence compared to an O_{FOC}-S sentence, (iii) faster after participants had heard an O_{TOP}-S sentence compared to a O_{FOC}-S sentence, (iv) faster after participants had heard a S_{FOC}-O sentence compared to a S_{TOP}-O sentence.

Table 3. Mean proportions accurate answers and mean reaction times (log-transformed) for the judgement of the correctness of the mathematical equation.

clause type	*mean accuracy*	*se*	*mean RT (log-transformed)*	*se*
S_{TOP}-O	0.8583	0.0199	6.9518	0.0313
S_{FOC}-O	0.8714	0.0202	6.8860	0.0309
O_{TOP}-S	0.8367	0.0194	6.8675	0.0200
O_{FOC}-S	0.8538	0.0198	6.9374	0.0283

Figure 3. Mean reaction times (log-transformed) with 95% confidence interval for the judgement of the correctness of the mathematical equation.



Sentence recall

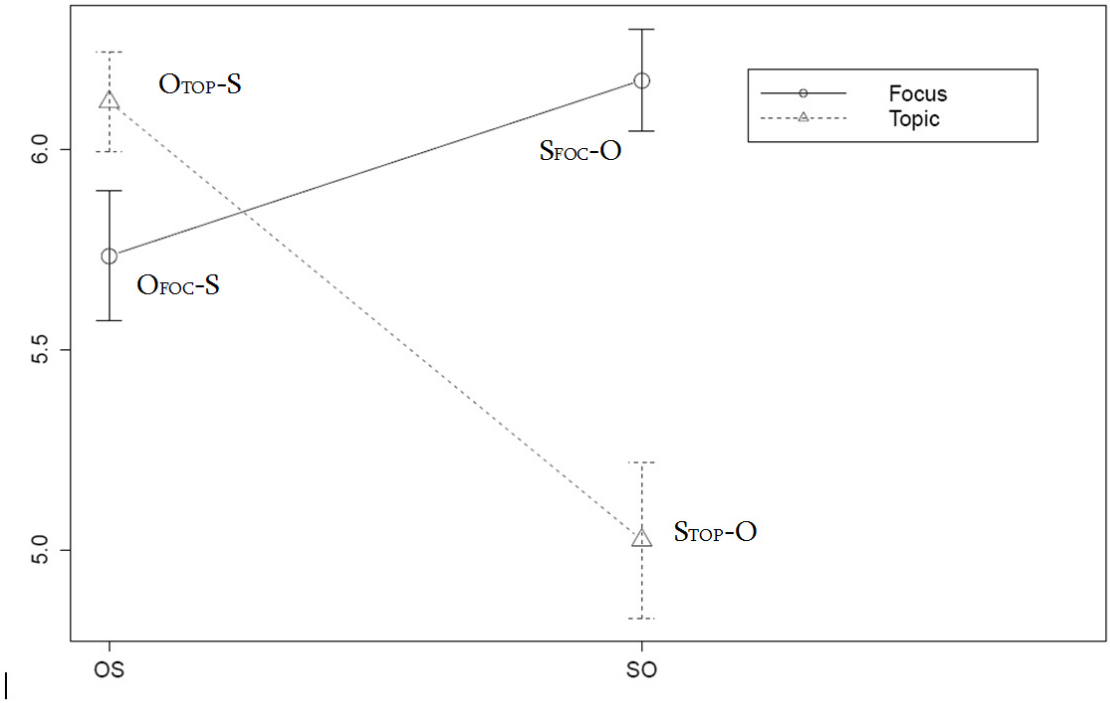
8.7% of the sentence recall data had to be excluded due to recording errors. For a recall to be accurate, the following criteria had to be met. In a correct recall, the syntax and semantics of the stimulus sentence were not altered. So if participants used a wrong verb, a wrong determiner, forgot the resumptive pronoun etc., the recall was incorrect. Furthermore, false starts, and recalls with mid-sentence hesitations counted as incorrect. The use of a different intonation than in the stimulus did not count as incorrect recall as this was not relevant with respect to the predictions tested. Incorrect recalls were excluded from the analysis of voice onset times. Voice onset times below 100 ms and above 2500 ms were excluded from the statistical analysis.

The mean proportions of accurate recalls and the mean voice onset times are given in Table 4. For the accuracy of the recall no effects were observed. For the voice onset times there were no main effects but there was a three-way interaction of INTONATION, ORDER and CUE TYPE (*estimate* = -1.6331, *se* = .5522, *t* = -2,957, $p < .05$). Resolving this three-way interaction by CUE TYPE revealed for subject cues a two-way interaction of INTONATION and ORDER (*estimate* = -1.0231, *se* = .4462, *t* = -2.293, $p < .05$). For object cues there also was a two-way interaction of INTONATION and ORDER (*estimate* = .5663, *se* = .2572, *t* = 2.20, $p < .05$). As can be seen in Figure 4, after a subject cue, recall was (i) faster for S_{TOP}-O than for S_{FOC}-O, (ii) faster for O_{FOC}-S than for O_{TOP}-S, (iii) faster for S_{TOP}-O than for O_{TOP}-S, (iv) faster for O_{FOC}-S than for S_{FOC}-O. After an object cue, recall was faster for S_{FOC}-O than for S_{TOP}-O.

Table 4. Mean proportions accurate recalls and voice onset times (log-transformed) of recall.

cue type	*clause type*	*mean accuracy*	*se*	*mean VOT (log-transformed)*	*se*
subject noun	**S_{TOP}-O**	0.7824	0.0259	5.0240	0.1944
	S_{FOC}-O	0.7731	0.0255	6.1720	0.1282
	O_{TOP}-S	0.7977	0.0264	6.1183	0.1252
	O_{FOC}-S	0.8301	0.0275	5.7335	0.1624
object noun	**S_{TOP}-O**	0.8122	0.0268	6.3467	0.0971
	S_{FOC}-O	0.8162	0.0269	5.9337	0.1291
	O_{TOP}-S	0.8235	0.0272	5.9732	0.1388
	O_{FOC}-S	0.8520	0.0281	6.0566	0.1303

Figure 4. Mean voice onset times (log-transformed) with 95% confidence interval for conditions with subject cue.



Discussion

In this study, we addressed four hypotheses about the effects that two different intonation contours, which we assumed to be related to the information-structural categories *topic* (rise-plus-hat-contour) and *focus* (fall-plus-deaccentuation contour), have on the processing as well as on the recall of left-dislocation structures in German. These four hypotheses were based on a model of the mental representation of discourse which pairs topical referents and propositions, such that the proposition that is denoted by the clause in which the topic phrase occurs, is associated with the topic referent. So, in this model, topics – by metaphor – are addresses, where information is stored.

According to our hypotheses, topic marking should lead to easier retrieval of a proposition, if the topic address is referred to / cued in later discourse *(= hypothesis i)*. Furthermore, we assumed that topic marking interacts with grammatical function during processing because subjects are default topics whereas objects are not. Therefore, marking an object as a topic leads to a discourse representation that otherwise cannot be created. As a consequence, topic-marked objects should have processing advantages over objects that are not topic-marked. Furthermore, referring to / cuing for a topic-marked object should be more effective than cuing for an object that is not topic-marked. For subjects we did not expect such effects *(= hypothesis ii)*. We also hypothesized that focus marking would not interact with grammatical function during processing or retrieval *(= hypothesis iii)*. Finally we suggested that a left-dislocated phrase can refer to a topical or a focussed referent, depending on the intonation pattern of the left-dislocation structure it occurs in *(= hypothesis iv)*.

The analysis of our experimental data shows that both the processing of left-dislocation structures and their retrieval from memory are influenced by the intonation contour of the dislocation structure, and that depending on the intonation contour, there is interaction with grammatical function during processing, which has corresponding

consequences for retrieval later on. We propose that the effects can best be explained if the two different intonation contours are indeed assumed to mark the left-dislocated phrase as a topic and a focus, respectively.

Sentence processing

We investigated the processing of left dislocation sentences by testing listeners' performance in a mathematical judgement task presented immediately after the auditory presentation of the target sentence. We found that the intonation contour did not influence the accuracy rates of the judgements. Since the accuracy rates were fairly high (83-87%), we assume that the task was not demanding enough to reflect different processing costs associated with the different types of left dislocation sentences in the accuracy of the judgements. The task was demanding enough, however, to reflect different processing costs in the reaction times of the judgement task. Judgements for the maths task were faster after the processing of a sentence with a left-dislocated object if that sentence came with the presumed topic intonation contour, in comparison to sentences with the presumed focus intonation contour. For sentences with left-dislocated subjects, the effect was reversed: judgements in the maths task were slower for sentences with the topic intonation contour in comparison to sentences with the focus intonation contour. These findings support *hypothesis (ii)*: Topic marking interacts with grammatical function during processing. Topical dislocated objects have processing advantages over non-topical (= focussed) dislocated objects. Topical dislocated subjects do not have processing advantages over non-topical (= focussed) dislocated subjects. As a matter of fact, topical dislocated subjects have a processing disadvantage in comparison to non-topical dislocated subjects.

Considering that subjects are default topics, the finding that topical dislocated subjects are more costly during processing than non-topical dislocated subjects might be considered surprising. One way of making sense of this finding is the following. If the topic intonation indicates that the left-dislocated phrase is a topic, say, rather than a focus, this information is redundant for subjects because subjects are default topics, and they are not expected to be focus. This redundancy might be costly, as in other cases of over-informative utterances (e.g. Davies & Katsons, 2009, 2010). An alternative explanation[8] builds on the assumption that the topic contour should be the default contour for sentences with topical subjects. The topic intonation in left dislocation structures, however, might indicate that the dislocated element is a non-default topic, i.e. an object. This assumption would also explain the higher reaction times for sentences with topical subjects in comparison to focussed subjects: the intonation signals a non-default topic so the parser has to double-check.

Another result for the processing of our left dislocation sentences was that the presumed topic intonation contour resulted in faster reaction times in the performance of the maths task if the left-dislocated phrase was an object rather than a subject. The focus intonation contour, on the other hand, resulted in faster reaction times for the judgement task if the dislocated phrase was a subject rather than an object. These results indicate that processing a sentence with a dislocated object topic is less costly than processing a sentence with a dislocated subject topic. The typical subject-before-object preference is overwritten in this case, which further supports hypothesis *(ii)*. Marking an object as topic demotes the subject in its topic status since the referent of the object rather than that of the subject is used as the address for the storage of the information conveyed by the sentence.

Furthermore, we found that sentences with a dislocated object focus induce a higher processing load than sentences with a dislocated subject focus. We take this finding to reflect the normal subject-before-object preference during processing, which supports *hypothesis*

[8] This was suggested to us by an anonymous reviewer.

(iii). Neither subjects nor objects are typical foci and therefore do not show diverging effects of focus marking depending on grammatical function.

Our findings indicate that the left dislocation structure seems to be an appropriate syntactic means for topic marking if it comes with the appropriate intonation contour. So far, clause-initial objects could only be shown to be preferred over clause-initial subjects if there was a part-whole relation between the clause-initial object and the object of the previous sentence (Weskott et al., 2011). We suggested that such part-whole relations can be considered a subcase of topicality (*partial topics*, Büring, 1997). Our results indicate that left dislocation with the rise-plus-hat contour is a means of marking topicality without being semantically restricted to part-whole relations. Since objects are not default topics, dislocating them in a left dislocation structure seems to be a good choice to clearly mark them as topics.

Furthermore, our data bear on the question of whether left dislocation only marks topics – as has traditionally been assumed in the literature – or whether it can also mark focus – as we proposed in *hypothesis (iv).* We did not find an effect in the maths task that would support the topic-only assumption. It was not the case that left-dislocation with the fall-plus-deaccentuation contour, i.e. the presumed focus contour, overall resulted in longer reaction times or reduced accuracies in the maths task. On the contrary, the focus contour actually resulted in faster reaction times in the performance of the maths task. This finding highlights that the focus prosody did not incur additional processing costs or was dispreferred.

Our experiment was not designed to discriminate whether or not the facilitating influence of the topic-marking intonation contour on the processing of object-initial sentences is tied to the left dislocation structure. It might be the case that simple object-verb-subject sentences are easier to process than simple subject-verb-object sentences if they come with a hat contour (rise on the first noun phrase, fall on the second noun phrase) rather than with a fall-plus-deaccentuation contour (fall on the first noun phrase). It might also be the case, however, that the informational separation that underlies the topic-comment structure, which finds a straightforward structural realization in the left dislocation structure, is required to conspire with the intonation to override the strong subject-before-object preference. We leave this issue for future research.

There are recent findings about the processing of non-local dependencies, which are directly relevant to our present discussion. It is well known that non-local dependencies incur higher processing costs than local dependencies. The subject-object asymmetry in German discussed above is a reflex of this fact: in object-initial structures, the object is locally separated from the verb. As for the source of the higher processing costs for non-local dependencies, there is no consensus in the literature yet. One type of account – which is most relevant to us here – identifies the source in working memory restrictions (e.g. Gibson, 1998, 2000; Just & Carpenter, 1992; King & Just, 1991). According to this type of account, non-local dependencies are more costly because the first dependent element needs to be retrieved from memory when the second dependent element is encountered. Local dependencies do not require this retrieval, hence the difference in processing cost. Supporting evidence for this view comes from the observation that processing costs increase if the retrieval of the first dependent is made more difficult, e.g. by increasing the distance between the dependents (e.g., Van Dyke & Lewis, 2003; Fedorenko, Gibson, & Rohde, 2006; Gordon, Hendrick, & Levine, 2002; Gordon et al., 2001; Grodner & Gibson, 2005). Recently, it has also been shown that the retrieval of the first dependent can be made easier. For instance, Hofmeister (2011) showed that increasing the semantic complexity of the first dependent (e.g. a noun phrase with, rather than without, modifiers) reduces the processing load. Fedorenko, Woodbury & Gibson (2013) showed in a dual-task paradigm where participants had to recall a word that was presented to them before they read a cleft sentences with a clefted subject or object, that the processing of an object cleft sentence was easier if the recall word corresponded to the object of the sentence than when it was an unrelated word. Fedorenko et

al. suggested that the recall word made the object noun highly active in memory, which resulted in a higher robustness of the memory representation of the clefted object so that retrieval at the verb position was easier.

With respect to our study, we can say that topic marking made the object referent more salient, and gave it a more robust memory representation: the object referent was used as an address for incoming material. Our data also suggest that focus marking is less effective than topic marking in creating a robust memory representation: sentences with a dislocated object focus are harder to process than sentences with a dislocated object topic. We have to remain silent here with respect to the question of how this finding is to be implemented in a model of mental discourse representation: it might be appropriate to say that topics have a higher activation than foci, at least in certain contexts. We leave this question for future research.

Recall

We found that different intonation contours of left dislocation structures in German have differential effects on the recall of these structures. As with the maths task, the different contours only had an impact on the reaction times (voice onset times) and not on the accuracies of the recall. We assume that the recall task was relatively easy because the time that elapsed between the presentation of the sentence and its recall was rather short: there were between five and six seconds between the utterance of the clause-initial dislocated phrase and the recall prompt. We suggest that this is the reason for why there were no effects of intonation in the accuracies of the recall.

To evaluate the results for the voice onset times of the recall, we make the same assumptions about the relation between the intonation contour and information structure as before. The rise-plus-hat pattern contour marks the dislocated noun phrase as a topic, and the fall-plus-deaccentuation contour marks the dislocated noun phrase as focus. Against this background, our results suggest that retrieving information from the topic address yields advantages during the recall of the information conveyed by the target sentence, thus confirming *hypothesis (i)*.

First, if the cue that was presented just before the recall prompt, corresponded to the subject noun the retrieval of a sentence with a dislocated subject was found to be facilitated, i.e. faster, provided that the dislocated subject was a topic rather than a focus. We suggest that the reason for this finding is that in sentences with a dislocated topical subject, the information conveyed by the sentence is stored under the address that corresponds to the referent of the subject. Cuing retrieval with the subject noun then directly cues the address. If the dislocated subject is a focus the default status of the subject as topic is overwritten by focus-marking with the fall-plus-deaccentuation contour. Consequently, there is no address for the subject referent. Cuing retrieval with the subject is less effective in this case.

Second, a subject cue was found to speed up the recall of a sentence with a left-dislocated object if that object was a focus rather than a topic. We propose that the reason for this finding is the following. If the dislocated object is a focus the sentence-internal subject has its default topic role and the information conveyed in the sentence is stored under the address corresponding to the subject. Cuing retrieval with the subject noun then directly cues this address. If the dislocated object is a topic, on the other hand, the information conveyed in the sentence will be stored under the address corresponding to the object referent. Cuing retrieval with the subject noun does not target the appropriate address, and therefore retrieval takes longer.

So far, our results might be taken to suggest that subject noun cues work best if subjects are also topics. We might assume that this is simply a consequence of the normal correlation of subjecthood with topicality: all sentences where the subject is not the topic take

longer to retrieve. However, our results for the recall with an object noun cue suggest that this assumption cannot be correct. We found that an object noun cue facilitates the recall of a sentence if the dislocated subject is a focus, i.e. not topical, in comparison to a sentence with a dislocated topical subject. Thus, it is not the case that sentences generally are faster to retrieve if the subject is a topic – rather, cue type matters. Cue type plays a crucial role with respect to the intonation contour used, and thus, by extension, with respect to the information-structural status of the left-dislocated phrase. If an object noun cue is used retrieval is easier provided the dislocated subject is a focus rather than a topic. As before, we assume that the default status of the subject as topic is overwritten by focus-marking with the fall-plus-deaccentuation contour. We assume that in sentences with a dislocated focal subject, the clause-internal object is interpreted as a topic, its referent is used as an address, so that cuing retrieval with the object noun facilitates retrieval.

Our results show clearly that syntactic and intonational separation of a noun phrase from the main clause has quite different effects for the speed of recall, depending on the precise intonation contour, and on the cue type used. It is not the case that the separation, which leads to the highlighting of the separated phrase, and makes it more salient, invariably leads to easier retrieval of the sentence information if the separated noun is used as a cue for retrieval. A cue corresponding to a sentence-internal expression can also be effective: it makes a difference if the separated phrase is marked as a topic – which not only makes its referent salient but also links it to an address –, or as a focus – which makes its referent salient but does not link it to an address.

Taking a broader perspective, we can relate our findings to general approaches to retrieval processes such as the encoding specificity principle (Tulving & Osler, 1968; Tulving & Thomson, 1973), and transfer-appropriate processing (Morris, Bransford, & Franks, 1977), cf. Roedinger & Guynn, (1996) and Rajaram & Barber (2008) for an overview. In these approaches, it is assumed that recall improves if encoding and retrieval involve the same type of processing, i.e. if there is an encoding-retrieval match. If we assume that the noun cue is used as an address cue during retrieval by the participant, the encoding and retrieval processes match for sentences where the noun referent was encoded as the address with which the proposition denoted by the sentence was associated, i.e. where the respective noun phrase was a topic.

Possible alternative explanations and conclusion

In sum, the results support the four hypotheses that we proposed in the introductory sections. According to *hypothesis (iv),* a left-dislocated phrase can refer to a topical or to a focussed referent, depending on the intonation pattern of the left-dislocation structure it occurs in. We showed that our data support this hypothesis. According to *hypotheses (ii) and (iii)*, topic marking interacts with grammatical function whereas focus marking does not. We showed that the two intonation contours we tested, have different effects during processing and during retrieval, depending on whether they mark the subject or the object as topic vs. focus. According to *hypothesis (i),* topics are referents that serve as addresses. Information concerning a referent that is stored under the address of this referent can be more easily retrieved than information concerning a referent that is not stored under that referent's address.

In the following we discuss some alternative explanations which might be considered to be compatible with our results. When we introduced the phonology and phonetics of various information-structural categories in German we emphasized that the correlations between accent types / intonation contours and information-structural categories are not completely clear-cut. One confounding factor was that the hat contour can mark both non-contrastive and contrastive topics. Since in previous research it was shown that contrast

marking has an influence on discourse processing (e.g. Braun & Tagliapetra, 2010; Fraundorf et al., 2010; Ito & Speer, 2008; Sanford et al, 2006), we need to ask the question of whether the intonation contour that we suggest marks a topic, in our experiment might have been perceived as marking a contrastive topic and, crucially, whether contrast might have triggered the observed effects. The answer to this question is that contrast alone cannot explain the observed effects. Contrast is not expected to be sensitive to grammatical function. Prima facie there is no reason to assume that subjects are more likely than objects to be contrasted with an alternative or vice versa.[9] Contrast is exactly like focus in this respect. Thus, even if the rise-plus-hat-pattern contour was not perceived as marking the left-dislocated phrase as a non-contrastive topic but as a contrastive topic it is the topicality of the phrase that must account for the observed effects. Contrast alone cannot be responsible for the different costs induced by the processing of dislocated objects vs. dislocated subjects in sentences with that intonation contour.

Another alternative explanation for the observed results for the recall is to assume that the effects are purely intonation-based, unmediated by information structure.[10] This explanation comes with two plausible premises. (i) The last accented constituent in a sentence is more salient than accented material before it or deaccented material following it. (ii) Cueing with the less salient information of a sentence provides a greater recall advantage than cueing with the already salient information. Note that accent type plays no role in this account. Now, if we assume (i) and (ii) we can say the following. In the 'topic' conditions, the clause-internal noun phrase is the more salient constituent because it carries the last accent in the clause. Therefore, cueing with the less salient dislocated 'topic' noun will bring a greater advantage. In the 'focus' condition, the clause-internal noun phrase is the less salient constituent because it is deaccented. Therefore, cuing with that clause-internal noun will bring a greater advantage. Although this suggestion seems plausible at first sight, we do not think that it actually works for our data. Let us make the plausible assumption that a referent that is denoted by a 'less salient constituent' is not salient in the mental representation. As a consequence, the processing and retrieval of this referent should be more effortful, i.e. incur a higher processing load and take more time. If we assume that the information conveyed by the sentence is at least weakly associated with the cue referent (there must be some associative link, otherwise cueing would not work), retrieval of that information should also take longer – and not shorter, as suggested by the reviewer. One might assume that cuing with a less salient referent increases the success of recall (accuracy) because this way, the non-salient information does not 'get lost'. Crucially, our findings are findings about reaction times and not accuracy. So this alternative explanation, which makes a direct link between the presence/absence and position of (unspecified) accents, and the mental representation of referents, cannot account for our data.

Yet another alternative explanation suggested by an anonymous reviewer is that our data might be explained in terms of desirable difficulties (Bjork, 1994). A desirable difficulty is a difficulty that is introduced during encoding and therefore makes encoding harder but improves retrieval later on. We think that this explanation is interesting but not applicable to the present case for two reasons. First, it would only hold for a subset of the recall data, namely for those where the cue noun was the subject noun. For these data it looks as if sentences that were hard to process are easier to retrieve and vice versa. However, for the object cues, sentences that were hard to process are also hard to retrieve. Second, since desirable difficulties mainly have been studied for longer term memory effects, since they – as far as we know – have not been studied with respect to the processing of sentences with different grammatical or prosodic structures (but note that Hofmeister's (2011) findings,

[9] This assumption needs quantitative back-up. We are not aware of any studies that have investigated this issue.

[10] The explanation was suggested to us by an anonymous reviewer.

mentioned above, might be taken to support the idea), and since difficulties in general differ enormously with respect to whether or not they are desirable (e.g. McDaniel & Butler, 2010) the precise relevance of this concept for our investigation is not so clear (at present).

We would also like to point out that the set of hypotheses that we advocate here make different predictions than the *discourse instantiation hypothesis* put forward by Frazier & Clifton (2002). According to this hypothesis, processing a noun phrase with an overt determiner leads to the postulation of an entity in the discourse representation unless one already exists. Noun phrases without an overt determiner, on the other hand, do not introduce a discourse referent. Bader & Frazier (2005) confirm the validity of the discourse instantiation hypothesis for a specific type of topicalization structure in German. Importantly, for this hypothesis, the information-structural status of the postulated referent is immaterial. There are no differences between discourse referents in terms of the role they play in the discourse model. Our *hypothesis (i)*, which, building on earlier literature, states that topical referents serve as addresses, i.e. as prominent locations where information is stored, is compatible with the discourse instantiation hypothesis but it goes beyond it. A discourse representation with topics is structured. There are referents that serve as addresses, and there are referents that might be part of the comment information that is stored under the topic address. Our data show that the specific structure of the discourse representation has an influence on the processing and retrieval of information.

We conclude that in left dislocation structures in German intonation can serve to mark the dislocated phrase as a topic, or as a focus. A contour with a rising accent on the dislocated phrase, a rising accent on the resumptive pronoun, followed by a plateau and a fall on the noun within the main clause signals topicality of the dislocated phrase. A contour with a falling accent on the dislocated phrase, a falling accent on the resumptive pronoun followed by deaccentuation signals the focus status of the dislocated phrase. The information-structural status of the dislocated phrase influences both the processing and the retrieval of the structure. Marking a phrase as topic that is not already a default topic yields processing advantages. Marking a phrase as topic that already is a default topic is costly. Topics serve as addresses in the discourse representation. If that address is cued during retrieval retrieval is facilitated. If a different referent than the address is cued retrieval is hindered.

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Appendix 1: Details of the statistics

Appendix 1a: Statistical analysis of the acoustic stimuli

For the statistical analysis of the acoustics of the stimuli we applied linear mixed effect models (Bates & Sakar, 2007). Item was used as a random factor. As a part of our model evaluations, we tested models with random slopes for items (Baayen, Davidson & Bates, 2008; Barr et al., 2012). We fitted models with all predictor variables and allowed maximal interaction. In a second step we reduced the model stepwise by excluding those fixed effects which were not significant ($t < 2$). Following Baayen et al. (2008), *t* values exceeding 2 indicate a significance at the level of 5%. Additionally, likelihood ratio tests were performed by comparing models. For the regression models we present MCMC-estimated (Markov chain Monte Carlo simulations with 10,000 samples) *p*-values that are considered significant at the $\alpha = .05$ level (Baayen 2009). In the following, we present the results of the most adequate fitted models. Fixed effects were ORDER (contrast coding: +.5 for subject-before-object conditions, -.5 for object-before-subject conditions) and INTONATION (+ .5 for TOPIC conditions, -.5 for FOCUS conditions).

Dislocated noun phrase. For the *direction of slope*, there was a main effect of INTONATION (*estimate* = .52606, *se* = .06544, *t* = 8.038, *p* = .0001). The dislocated noun in the *TOPIC* contour was realized with a rise, in the *FOCUS* contour it was realized as a fall. There was no effect of ORDER (*estimate* = .02585, *se* = .03420, *t* = .756, *p* > .1). For the *maximum pitch* on the dislocated noun there was a main effect of INTONATION (*estimate* = 24.762, *se* = 5.509, *t* = 4.5, *p* < .0001), and no effect of ORDER (*estimate* = 1.957, *se* = 2.877, *t* = .68, *p* > .1). The maximum pitch in the *TOPIC* contour was higher than in the *FOCUS* contour. For the *pitch excursion* on the dislocated noun there was a main effect of INTONATION (*estimate* = 31.422, *se* = 6.53, *t* = 4.812, *p* = .0001), and no effect of ORDER (*estimate* = -4.527, *se* = 3.421, *t* = -1.323, *p* > .1). The pitch excursion in the *TOPIC* contour was larger than in the *FOCUS* contour. The *duration* of the stressed syllable did not differ for INTONATION (*estimate* = .011, *se* = .03, *t* = .370, p > .1) or ORDER (*estimate* = -.004, *se* = .062, *t* = -.273, *p* > .1). For the *mean intensity* of the stressed syllable there was a main effect of INTONATION (*estimate* = -7.4719, *se* = .7874, *t* = -9.49, *p* < .0001) but not for ORDER (*estimate* = -.2133, *se* = .4123, *t* = -.52, *p* > .1). The stressed syllable of the dislocated noun phrase was louder in the *FOCUS* contour than in the *TOPIC* contour.

These analyses reveal that, as intended, the dislocated noun phrase was realized with a different intonation in the *TOPIC* contour than in the *FOCUS* contour, and that there were no differences between the contours depending on whether the dislocated noun phrase was a subject or an object. In the topic contour, the dislocated noun was realized with a rise whose peak was higher and whose excursion was greater than the peak and excursion of the fall in the *FOCUS* contour. There were no differences in the duration of the stressed syllable but the stressed syllable was louder in the *FOCUS* contour than in the *TOPIC* contour.

Break between dislocated noun and main clause. The duration of the break between the two intonational phrases was the same in all conditions. There were no effects of INTONATION (*estimate* = .06365, *se* = .02166, *t* = 1.537, *p* > .1) or ORDER (*estimate* = .028, *se* = .04140, *t* = 1.306, *p* > .1).

Resumptive pronoun. For the *direction of slope* there was a main effect of INTONATION (*estimate* = .26802, *se* = .04091, *t* = 6.552, *p* = .0001) but no effect of ORDER (*estimate* = .01439, *se* = .02140, *t* = .672, *p* > .1). In the *TOPIC* contour the pronoun was realized with a rise, in the *FOCUS* contour it was realized with a fall. For the *maximum pitch* there was a main effect of INTONATION (*estimate* = -9.702, *se* = 3.550, *t* = -2.73, *p* < .01), no effect for ORDER (*estimate* = -3.368, *se* = 1.861, *t* = -1.81, p > .05). The resumptive pronoun was realized with a higher pitch in the *FOCUS* contour than in the *TOPIC* contour. For the *pitch excursion* there were no effects: INTONATION (*estimate* = 6.740, *se* = 4.423, *t* = 1.522, *p* > .1), ORDER (*estimate* = -1.034, *se* = 2.321, *t* = -.445, *p* > .1). For the *duration* of the pronoun there was no effect of INTONATION but a main effect of ORDER (*estimate* = -.022, *se* = .004, *t* = -6.20, *p* < .0001). Subject pronouns were shorter than object pronouns. For the *mean intensity* of the resumptive pronoun there was a main effect of INTONATION (*estimate* = -6.9327, *se* = .5156, *t* = -13.44, *p* < .0001), no effect of ORDER (*estimate* = .01439, *se* = *.02140* , *t* = .672, *p* > .1). The pronoun was louder in the stimuli used for the *FOCUS* conditions than in the stimuli used for the *TOPIC* conditions.

The data show that the intonation of the resumptive pronoun differed in the *TOPIC* contour versus *FOCUS* contour in the relevant measures. There was a rise in the *TOPIC* contour, and a fall in the *FOCUS* contour. The data also show, however, that the length of the pronoun differed depending on its subject/object status. We suggest that this latter aspect can be explained if we consider that the pronoun only ever took on two forms: if it was a subject pronoun it was *der* [deɐ], and if it was an object pronoun it was *den* [den]. So the length difference is due to the segmental difference between the nasal in the coda of object pronoun, in comparison to the schwa sound in the subject pronoun.

Verb. We report the maximum pitch for the second syllable only, independent of stress (the second syllable could be stressed or not). The first syllable was part of the measurements for the pronoun and therefore is not reported separately. Duration is not analyzed because it interacts with stress. For the *maximum pitch*, there was a main effect of intonation (*estimate* = 54.73, *se* = 25.26, *t* = 2.167, *p* < .05), no effect of ORDER (*estimate* = -11.40, *se* = 3.20, *t* = -.863, *p* > .1). In the *TOPIC* contour the maximum pitch was higher than in the *FOCUS* contour.

This result indicates that the *TOPIC* contour indeed came with a hat contour, i.e. the pitch remained high, whereas in the *FOCUS* contour the pitch fell sooner, i.e. there was deaccentuation after the resumptive pronoun.

Clause-internal noun. The *direction of slope* was always a fall. For the *maximum pitch* there were no effects: INTONATION (*estimate* = 21.445, *se* = 15.833, *t* = 1.355, *p* > .1), ORDER (*estimate* = 4.148, *se* = 8.297, *t* = .500, p > .1). For the *pitch excursion* there were no effects: INTONATION (*estimate* = 26.304, *se* = 15.873, *t* = 1.657, *p* > .1), ORDER (*estimate* = 4.746, *se* = 8.297, *t* = .572, *p* > .1). Numerically, the pitch excursion was larger for the topic conditions, indicating a larger fall but there was much variation in the data so that the difference did not reach significance. For the *duration* of the stressed syllable of the noun there was no effect of INTONATION but a main effect of ORDER (*estimate* = -.0344, *se* = .0130, *t* = -2.646, *p* < .01). The stressed syllable of object nouns was longer than that of subject nouns. We have no explanation of this length difference at present but since duration is not a major cue in signalling information structure and since the other measurements show no differences between subject and object nouns we neglect this issue here. For the *mean intensity* of the stressed syllable there was a main effect of INTONATION (*estimate* = 3.9534, *se* = .8537, *t* = 4.63, *p* < .001) but not for ORDER (*estimate* = .7910, *se* = .4481, *t* = -1.77, *p* > .1). The stressed syllable of the clause-internal noun was louder in the stimuli used for the *TOPIC* conditions than in the stimuli used for the *FOCUS* conditions.

The data for the clause-internal noun do not reveal significant pitch differences between the *TOPIC* and *FOCUS* contours. We suggest that the reason for this finding is the following. In the phonological description of the two intonation contours we characterized the falling accent on the clause-internal noun phrase in the *TOPIC* contour as a downstepped !H*+L. Thus the stressed syllable is noticeably lower than the previous H tone. Closer visual inspection of the *TOPIC* contour revealed that the downstepped !H* is lower than the previous unstressed syllable. In that sense the description

as H tone might be misleading. However, in view of the fact that the contour after the stressed syllable still is falling we consider the H label as more appropriate than a L label. An additional comparison of the maximum pitch of the pre-stressed syllable of the two intonation contours revealed a main effect of INTONATION (*estimate* = 48.171, *se* = 3.349, *t* = 14.38, *p* <.0001), no effect of ORDER (*estimate* = 1.674, *se* = 1.749, *t* = .96, *p* > .1). The pitch was higher in the *TOPIC* contour than in the focus contour. We take this finding as evidence that in the topic contour there was indeed a kind of hat contour even if the plateau ended before the stressed syllable of the clause-internal noun.

Appendix 1b: Correlation matrices of the interactions in the results section

Table 5. Correlation of fixed effects for the reactions times in the maths task

	intercept	INTONATION	ORDER
INTONATION	-.269		
ORDER	-.277	.431	
INTONATION *x* ORDER	.149	-.541	-.720

Table 6. Correlation of fixed effects for the three-way interaction for the voice onset times for the sentence recall

	intercept	CUE	INTONATION	ORDER	CUE *x* INTONATION	CUE *x* ORDER	INTONATION *x* ORDER
CUE	.-273						
INTONATION	-0.511	.191					
ORDER	-.480	.446	.323				
CUE *x* INTONATION	.329	-.555	-.753	-.265			
CUE *x* ORDER	-.034	-.652	.120	-.476	.247		
INTONATION *x* ORDER	.216	-.265	-.767	-.520	.652	.181	
CUE *x* INTONATION *x* ORDER	.012	.056	.282	.303	-.542	-.558	-.512

Table 7. Correlation of fixed effects for the two-way interaction for the voice onset times for the sentence recall of conditions with subject cue

	intercept	INTONATION	ORDER
INTONATION	-.520		
ORDER	-.533	.481	
INTONATION *x* ORDER	.196	-.447	-.499

Table 8. Correlation of fixed effects for the two-way interaction for the voice onset times for the sentence recall of conditions with object cue

	intercept	INTONATION	ORDER
INTONATION	-.477		
ORDER	-.480	.223	
INTONATION X ORDER	.205	-.777	-.443

Appendix 2: Sample items

1. Der Fuchs, der jagt den Wolf.
   the.NOM fox RP.NOM chases the.ACC wolf
   Den Wolf, den jagt der Fuchs.
   the.ACC fox RP.ACC chases the.NOM wolf
2. Der Hase, der bekämpft den Biber.
   the.NOM hare RP.NOM fights the.ACC beaver
   Den Biber, den bekämpft der Hase.
3. Der Storch, der ärgert den Luchs.
   the.NOM stork RP.NOM teases the.ACC lynx
   Den Luchs, den ärgert der Storch.
4. Der Affe, der beneidet den Tiger.
   the.NOM monkey RP.NOM envies the.ACC tiger
   Den Tiger, den beneidet der Affe.
5. Der Elefant, der belehrt den Löwen.
   the.NOM elephant RP.NOM teaches the.ACC lion
   Den Löwen, den belehrt der Elefant.
6. Der Präsident, der sieht den Minister.
   the.NOM president RP.NOM sees the.ACC minister
   Den Minister, den sieht der Präsident.
7. Der Matrose, der verachtet den Steuermann.
   the.NOM sailor RP.NOM despises the.ACC helsman
   Den Steuermann, den verachtet der Matrose.
8. Der Förster, der schlägt den Bauern.
   the.NOM ranger RP.NOM beats the.ACC farmer
   Den Bauern, den schlägt der Förster.
9. Der Chef, der haut den Arbeiter.
   the.NOM boss RP.NOM hits the.ACC worker
   Den Arbeiter, den haut der Chef.
10. Der Adler, der erblickt den Wurm.
    the.NOM eagle RP.NOM beholds the.ACC worm
    Den Wurm, den erblickt der Adler.
11. Der Major, der besucht den Offizier.
    the.NOM major RP.NOM visits the.ACC officer
    Den Offizier, den besucht der Major.
12. Der Clown, der überredet den Artisten.
    the.NOM clown RP.NOM persuades the.ACC acrobat
    Den Artisten, den überredet der Clown.
13. Der Hexer, der verflucht den Zauberer.
    the.NOM witch RP.NOM curses the.ACC magician
    Den Hexer, den verflucht der Zauberer.
14. Der Dirigent, der fürchtet den Cellisten.

the.NOM conductor RP.NOM fears the.ACC cellist
Den Cellisten, den fürchtet der Dirigent.

15. Der Polizist, der beschwört den Raser.
the.NOM policeman RP.NOM conjures the.ACC speeding driver
Den Raser, den beschwört der Polizist.
16. Der Professor, der umarmt den Studenten.
the.NOM professor RP.NOM embraces the.ACC student
Den Studenten, den umarmt der Professor.