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Vann, Roderick G L orcid.org/0000-0002-3105-2546, Brunner, Jakob, Ellis, R et al. (2 more authors) (2016) Preliminary measurements of the edge magnetic field pitch from 2-D Doppler backscattering in MAST and NSTX-U. Review of Scientific Instruments. 11D902. pp. 1-6. ISSN: 0034-6748

<https://doi.org/10.1063/1.4962253>

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Agentivity drives real-time pronoun resolution: Evidence from German *er* and *der*

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Received 7 July 2015; received in revised form 20 May 2016; accepted 6 July 2016

Abstract

We report two experiments on the referential resolution of the German subject pronoun *er* and the demonstrative *der* ('he'). Using the visual world eye-tracking paradigm, we examined the effects of grammatical role, thematic role and the information status of potential referents in the antecedent clause operationalized by word-order (canonical/non-canonical), in the context of active–accusative verbs (Exp. 1) and dative-experiencer verbs (Exp. 2). In information-structurally neutral contexts, *er* prefers the proto-agent and *der* the proto-patient. This suggests that agentivity is a better predictor for pronoun resolution than subjecthood or sentence topic as previously proposed. It further supports the claim that agentivity is a core property of language processing and it more generally substantiates the proposal from cognitive sciences that agentivity represents core knowledge of the human attentional system. With non-canonical antecedent clauses, because they lack alignment of prominence features, interpretive preferences become less stable, indicating that multiple cues are involved in pronoun resolution. The data further suggest that the demonstrative pronoun elicits more reliable interpretive biases than the personal pronoun.

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Keywords: Pronoun resolution; Demonstrative; Prominence; Information structure; Agentivity; German; Visual world paradigm

1. Introduction

Language users are constantly occupied with reference resolution; a speaker must keep track of whether or not the hearer is likely to have constructed a representation of a particular referent (i.e., it is identifiable cf., Lambrecht, 1994) and then on the basis of this decision, must choose the appropriate referring expression, for instance a pronoun for an identifiable entity or a definite noun phrase for one that is not yet active (e.g., *she* vs. *the doctor*) (cf., Gundel et al., 1993; Ariel, 2001). The hearer's task is to determine which entities—ever-changing throughout a dynamic discourse and/or conversation—the speaker is making reference to on the basis of the referring expressions used. Therefore, given the ubiquitous yet rather complex nature of reference resolution, it is unsurprising that much research has centered on the production and interpretation of pronouns in both the linguistics and psycholinguistics literature. One major assumption from this large body of work is that the more reduced in phonological form a referring expression (e.g., a null or an

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unstressed pronoun), the more activated or prominent the antecedent must be in the mind of the hearer because the form itself is comparatively lexically underspecified (e.g., Ariel, 2001; Gundel, 2003). Much research has centered on what factors affect the prominence of a potential referent for reference resolution. Research on this question has found that more prominent antecedents are likely to be subjects rather than objects (Grosz et al., 1995), first rather than second-mentioned referents (e.g., Gernsbacher, 1990; Gernsbacher and Hargreaves, 1988), often the agent of a clause, the topic vs. non-topic, given information rather than new, and not carrying focal pitch accent (see Arnold, 2008; Ellert, 2011, for a detailed overview). However, one of the difficulties in attempting to single out the effects of such individual factors on reference prominence is that many of these factors often converge on the same entity, particularly in English (e.g., (1)), where the rigid word order gives rise to the fact that the subject (*The doctor*) is often also the topic, the first-mentioned NP, given information, de-accented, etc.

- (1) The doctor_i wanted to hug the magician_j, but he_{i>j} was too small.

One way to better unpack the potentially different contributions of these various factors to the comparative prominence of an antecedent is to investigate pronominal resolution in more flexible word order languages, and researchers have started to do so, focusing on languages such as German, Finnish, Russian, Dutch and Estonian (Bosch et al., 2003, 2007; Bosch and Umbach, 2007; Bouma and Hopp, 2007; Ellert, 2011; Järviö et al., 2005, 2014; Kaiser, 2010a,b; Kaiser and Trueswell, 2004a,b; 2008; Pyykkönen and Järviö, 2010; Wilson, 2009). In this paper, we too make use of a flexible word order language (German) to investigate the effects of grammatical role (subject vs. object), thematic role (agent vs. patient) and the information status of potential referents via word order variations (canonical vs. non-canonical). Here we study the resolution preferences in German discourse for the unstressed subject pronoun *er* and the demonstrative *der* ('he').¹

At first blush, it might seem that the two pronominal forms *er* and *der* are in fact synonymous, given that they can both be used to refer to the same entity in unambiguous contexts (2a) and that they are equally able to resolve toward animate (*Peter*) or inanimate (*Benz*) referents—shown by the fact that (2b) (from Zifonun et al., 1997) must be disambiguated by semantic information in the second sentence (unlike in the English translation, where *it* can only refer to the inanimate *Benz*).

- (2) a. Peter_i will einkaufen gehen. Er_i (Der_i) hat wohl zuviel Geld.
'Peter wants to go shopping. He might have too much money.'
b. Peter_i will einen Benz_j kaufen. Er_{i/j} (Der_{i/j}) soll aber nicht so teuer sein.²
'Peter wants to buy a Benz. It should however not be too expensive.'

However, in the linguistics literature, the two forms have been distinguished in function. For instance, in syntactic accounts (e.g., Diessel, 1999) it is claimed that *er* should resolve toward the grammatical subject and *der* toward the non-subject. Other linguistic accounts differentiate the two forms on the basis of information status, particularly in terms of topic–non-topic, such that the role of *er*, being the least marked form, is to refer to the current topic, and *der* to entities which are similarly active in the mind of the hearer/speaker but not (yet) topics (i.e., signaling topic shift) (e.g., Ahrenholz, 2007; Bosch et al., 2003; Bosch and Umbach, 2007; Comrie, 1997; Lambrecht, 1994; Zifonun et al., 1997). If one assumes that under neutral information structure conditions, an element appearing in the first position of a German main clause is topical (cf. e.g., Klein, 2008), then one can topicalise an accusative-marked referent by moving it to this position. This is illustrated in the comparison of (3b) vs. (3a) below, where in both cases the magician hugs the doctor, but the topicalisation of the accusative referent *den Arzt* (3b) reflects an information structurally licensed reading, a contextually induced given–new ordering, or a contrastive interpretation. The meaning of this non-canonical structure is in certain respects similar to an *it*-cleft in English. If indeed *er* is resolved toward topics and *der* non-topics, then this predicts that *er* should prefer to refer to this fronted, accusative referent, and *der* to the nominative entity in (3b), whereas a syntactic account would predict the opposite, with *er* resolving toward the nominative-marked entity and *der* the accusative, irrespective of word order.

- (3) a. Der Zauberer_i wollte den Arzt_i umarmen. Aber er_{i/j} (der_{j/i}) war viel zu klein.
The-NOM magician wanted the-ACC doctor to-hug. But he-NOM (DEM-NOM) was much too small.
'The magician wanted to hug the doctor. But he was much too small.'

¹ German has two demonstrative forms, the demonstrative pronoun *dieser* and the d-pronoun *der*. In the current study, we used the latter variety only and refer to it as "demonstrative". Furthermore, we only consider the unstressed personal pronoun in the current research. Stressed *er* is typically used to refer to an entity that is not the most prominent entity in discourse.

² Note that the stars provided for the indices in (2b) are guided by the contextual consideration that Peter cannot be too expensive. In a semantically ambiguous situation, both pronouns could potentially refer to Peter.

- b. Den Arzt_i wollte der Zauberer_j umarmen. Aber er_{i/j} (der_{i/j}) war viel zu klein.
The-ACC doctor wanted the-NOM magician to-hug. But he-NOM (DEM-NOM) was much too small.
'The doctor, the magician wanted to hug (him). But he was much too small.'

Thus many theorists assume a complementary distribution of preferences (cf., The Complementary Hypothesis, Bosch et al., 2007; Pragmatic Neo-Gricean Theory of Anaphora, Levinson, 1991), with *er* referring to subjects and/or topics or old information, and *der* to non-subjects, non-topics and/or new information (signaling topic shift). A difference in behavior would also be predicted by many psycholinguistic theories of anaphora that assume that the less informative the referring expression, the more accessible or cognitively active the referent needs to be in the mind of the hearer. For example, Ariel's (2001) Accessibility Hierarchy predicts that the personal pronoun *er* would be classified as a higher accessibility marker than the demonstrative *der*, on the basis of their phonological form.³ Gundel et al.'s (1993; Gundel, 2003) Givenness Hierarchy would also predict that *er* should unambiguously resolve toward the topical entity and *der* toward the non-topic, with the added prediction that where two potential referents are introduced into the discourse, the interpretation of *der* should be more ambiguous, because it can—but need not—refer to either entity. That is, although both forms require an antecedent that is currently active in working memory, *er* must refer to the entity that is also currently the center of attention (i.e., the entity that is 'in focus' in Gundel's classification). In contrast, Comrie (1997) suggests that the demonstrative excludes the most prominent antecedent.

The empirical evidence to date on the resolution preferences of these two referring expressions is mixed. Bosch et al. (2007) report a corpus study and two experiments, one using an acceptability judgment task and the other, a self-paced reading task, to investigate the resolution preferences of the two pronominal forms with canonical subject-verb-object (SVO) and non-canonical OVS antecedent order. For the canonical SVO word order condition, the authors found a strong preference for *der* to resolve toward the accusative entity (approximately 82%), but only a tendency for the personal pronoun (55%) to resolve toward the subject. In the non-canonical word order conditions (OVS), again, there were weak preferences, with the personal pronoun referring to the subject and the demonstrative to the object (both approximately 55%). In a visual world eye-tracking study, Wilson (2009) found that *er* had an initial preference for the second mentioned entity in canonical SVO contexts, which later in the time course switched to a first-mentioned advantage, and no preference was observed for *er* for resolution to either the subject or the object in OVS word order antecedent contexts, which runs counter to the prediction that *er* should be less ambiguous than *der* (Gundel, 2003). The findings reported in these two studies for the personal pronoun differ from others that have shown that German personal pronouns are strongly attracted to grammatical subjects, irrespective of word order, or type of clause (e.g., Bouma and Hopp, 2007), which has also been observed for subject pronouns in Finnish (Kaiser and Trueswell, 2008; Järviö et al., 2005), Dutch (Kaiser and Trueswell, 2004a) and Russian (Krasavina and Chiarcos, 2007). As regards *der*, it appears to elicit more robust preferences than the personal pronoun, since both Bosch et al. (2007) and Wilson (2009) found that it was sensitive to word order, and displayed a strong preference for second-mentioned, non-topical entity, and this mirrors findings from other studies of the demonstrative form with languages other than German (e.g., Kaiser and Trueswell, 2008; Kibrik, 1996; Krasavina and Chiarcos, 2007). Wilson argues that while the demonstrative is more sensitive to discourse constraints (given that there was a preference for non-topical entities, irrespective of their grammatical role), the personal pronoun is sensitive to both syntactic and information structure information. Bosch and colleagues argue that the demonstrative should refer to the non-topic, whereas the personal pronoun is neutral in this regard (see also Ahrenholz, 2007; Comrie, 1997; Zifonun et al., 1997). Whichever account is correct, when the results are taken together, it would appear that *er* induces less robust preferences than *der*—it is more ambiguous, contra the accounts of e.g., Gundel (2003) and Levinson (1991)—and these findings also run counter to the predictions of accounts that assume a complementary distribution of resolution preferences (e.g., Bosch and colleagues' Complementary Hypothesis).

The referents in the antecedent contexts used in the above-reported studies were arguments in active accusative constructions and thus marked for nominative and accusative case, and therefore it is not possible to tease apart the relative influences of factors such as grammatical role, linear order and information status, since these converge on the same entity (e.g., first-mentioned referent is also the topic and is also the grammatical subject in SVO contexts). In an attempt to separate grammatical role from information status, Ellert (2011) used double nominative comparative antecedent structures to investigate the resolution preferences of *er* and *der* in both canonical (4a) and non-canonical (clefted) (4b) contexts. Since both antecedent noun phrases (NPs) were marked for nominative case, it was possible to disentangle the potential effects of order of mention (first vs. second) from grammatical role.

³ Most of the classic theories of anaphor have been based on evidence from languages which do not have such demonstrative forms, and therefore it is not always possible to assess what predictions they may make for them.

- (4) a. Canonical, topic-comment antecedent
Der Schrank_i ist schwerer als der Tisch_j. Er_{i/j} (Der_{i/j}) stammt aus einem Möbelgeschäft in Belgien.
The-NOM cupboard is heavier than the-NOM table. He-NOM (DEM-NOM) originates from a furniture store in Belgium.
'The cupboard is heavier than the table. It originates from a furniture store in Belgium.'
- b. Non-canonical, topic-focus antecedent
Schwerer als der Tisch_i ist der Schrank_j. Er_{i/j} (Der_{i/j}) stammt aus einem Möbelgeschäft in Belgien.
Heavier than the-NOM table is the-NOM cupboard. He-NOM (DEM-NOM) originates from a furniture store in Belgium.
'Heavier than the table is the cupboard. It originates from a furniture store in Belgium.'

The findings show that the type of antecedent affected the resolution preferences of *er* and *der*, such that German speakers preferred to resolve *er* toward the first-mentioned entity and *der* toward the second-mentioned, non-topical referent following the canonical, topic-comment antecedent context (4a). However, with non-canonical antecedents (4b), both pronouns were robustly resolved toward the second mentioned, pragmatically focused referent (*der Schrank*). Furthermore, there was a difference in the timing of the effects: following non-canonical contexts, the effect was visible 200 ms after the onset of the critical pronoun (*er/der*), whereas it was in evidence from approximately 800 ms in the canonical conditions. Overall, the data suggest that the information status of the referents is highly important and that in particular the focus/non-focus cue was extremely strong, creating an expectation very early in the comprehension process that the discourse would continue with the focused entity.⁴ In the current experiment, we examine the role of information structure further, comparing canonical to non-canonical constructions of different types.

In sum, although somewhat mixed, the range of results discussed above at least suggest that the two pronominal forms perform different functions. This finding is in line with more recent studies which have demonstrated that the discourse prominence of a potential antecedent for a referring expression like a subject pronoun is most likely influenced by multiple, weighted constraints (e.g., Arnold et al., 2000; Badecker and Straub, 2002; Järvikivi et al., 2005, 2014), rather than by one factor alone, such as word order (e.g., Strube and Hahn, 1999), structural parallelism (Chambers and Smyth, 1998), coherence relations (Kehler et al., 2008), and verb semantics (Stevenson et al., 2000). In other words, rather than being uniformly mapped upon a prominence hierarchy, different types of referring expressions (e.g., short vs. emphatic pronouns, demonstratives, etc.) may in fact be differentially sensitive to these various factors of potential referents. For example, Kaiser and Trueswell (2004a) have found that Dutch speakers' choice between using a full vs. a reduced pronominal (*zij* vs. *ze*, 'she') was driven by contrast (see also Kaiser, 2010a for similar findings for Estonian), whereas choosing a pronoun vs. a demonstrative (*die*) to refer to an animate referent depended on how prominent the referent was in the earlier discourse, with the former being used for more highly activated entities. Like Dutch and German, Finnish also has a demonstrative form that can be used to refer to singular, animate entities, and research into the different uses of the demonstrative (*tämä*, 'he') in comparison to the personal pronoun (*hän*, 'he') supports the claim that resolution preferences may be *form-specific*, since the pronoun *hän* prefers to resolve toward grammatical subjects (see also Järvikivi et al., 2005) whereas demonstratives, although also sensitive to an antecedent's grammatical role, are also influenced by word order, preferring referents in the post-verbal position (Kaiser and Trueswell, 2004b). This asymmetry in the resolution preferences for different types of referring expressions has also been observed in studies of English pronominal vs. demonstrative forms, where unstressed *it* showed a theme bias and the demonstrative *that* preferred a conceptual composite as antecedent (Brown-Schmidt et al., 2005) as well as between pronouns and reflexives, where the former was guided by discourse constraints and the latter by locality/coargument relations (*him* vs. *himself*, Burkhardt, 2005, 2007; Kaiser et al., 2009).

Such data suggest, therefore, that it is unlikely that referring expressions like the pronominals *er* and *der* map clearly onto a uniform prominence hierarchy (cf., the *form-specific multiple-constraints* account of Kaiser and Trueswell, 2008), however, given the mixed findings reported above for *er* and *der*, which specific factors the two forms may be sensitive to is as yet unclear. Below, we present the results of a series of experiments that were run to investigate in more detail how German speakers resolve *er* and *der* in discourse, in the context of canonical vs. non-canonical antecedent clauses, specifically in order to chart the effects of word order and type of verb (constraining grammatical function and thematic role assignment), and to see which constraints these referring expressions are sensitive to in these varying contexts.

⁴ The importance of focused information as operationalized by clefting has also been observed in English pronoun resolution (e.g., *It was Anne who called Sarah. She...*) (Cowles et al., 2007).

2. The current study

In the current study, two experiments were run to investigate the referential function of the German pronouns *er* and *der*. We first wanted to test the prediction of mono- vs. multi-cue accounts of pronoun resolution. To this end, grammatical function and topichood have figured prominently as single prominence-lending cues. We wanted to explore whether agentivity – a factor important for the attention system, which possibly developed due to evolutionary demands (cf. e.g., Leslie, 1995; Gelman, 2009) – is a better predictor for pronoun resolution in German. Second, we wanted to assess the functional contribution of personal and demonstrative pronouns in light of complementary vs. form-specific accounts.

In the experiments, we manipulated the order of the potential referents in the earlier antecedent discourse, thus influencing the information status of the potential antecedent entities. In experiment 1, we examined the online resolution preferences of German speakers for personal and demonstrative pronouns when encountering active accusative verbs (e.g., *umarmen*, ‘hug’) in the context of nominative–accusative vs. accusative–nominative antecedent (SVO vs. OVS) clauses. In experiment 2 we investigated the impact of verb type, and examined the effects of resolving the pronouns in the context of arguments of dative experiencer verbs (e.g., *gefallen*, ‘to be pleasing to’); thus in the canonical word order conditions (dative–nominative; cf. Haider, 1993), the nominative-marked entity appears in the second position, rather than being in the initial, unmarked topic position as in experiment 1. Since grammatical and thematic roles are crossed orthogonally, the comparison of experiment 1 and 2 allows us to separately assess the impact of grammatical function and thematic role on pronoun resolution.

We would like to note that there is an alternative analysis of the dative experiencer construction. While Haider (1993) among others considers the dative–nominative order the canonical linearization, some researchers (e.g., Barddal et al., 2014) argue for two alternating argument orders based on the observation that both the nominative and the dative argument carry subject properties (as e.g. reflected by subject-verb inversion, reflexivization or covert realizations in control infinitives). We return to this issue in the discussion of experiment 2.

In a previous behavioral study, the comparison of pronoun resolution involving active accusative and dative experiencer verbs has already proven to be a fruitful endeavor. Sentence completion and forced choice referent identification tasks to assess the interpretive preferences for personal and demonstrative pronouns following active accusative and dative experiencer contexts in both canonical and non-canonical argument order suggest that thematic role information is a stronger predictor for the interpretive preferences than grammatical function during offline comprehension in canonical contexts (Schumacher et al., 2016). This agent preference was also reflected in the offline responses in non-canonical active accusative contexts (but note that this resolution pattern could also be explained by a subject preference). Following the non-canonical dative experiencer contexts, interpretive choices were at chance for both pronoun types indicating that thematic role information alone cannot account for pronoun resolution in German. We discuss these findings in more detail below because they allow us to compare the offline and online behavior during pronoun resolution. In the current research, we assess whether the same constraints guide pronoun resolution in real time.

As far as predictions are concerned, a mono-constraint account would single out one prominence feature as the guiding cue during pronoun resolution. For instance, Diesell's (1999) grammatical function account predicts that *er* should resolve toward the nominative entity and *der* toward the accusative or dative. If alternatively thematic role is the driving force behind pronoun resolution, *er* should resolve toward the agent and *der* toward the patient. An account based on information structure (e.g., Bosch et al., 2007) predicts that *er* should be resolved toward the topic and *der* the non-topic, irrespective of the syntactic or thematic role of the referent. In contrast, a multiple-constraints account would assume an interaction of numerous prominence-lending cues as well as a weighting of resolution cues (cf. e.g., Arnold et al., 2000; Badecker and Straub, 2002; Gordon et al., 1993; Järviö et al., 2005). In this respect, a non-complementary pattern of results would support the form-specific multiple-constraints account since it predicts that the two forms should not be in perfect complementary distribution, but rather they will be sensitive to varying degrees to different prominence cues (see Kaiser and Trueswell, 2008; Hinterwimmer and Bosch, 2016; Wiemer, 1996). We investigated these predictions in two experiments, reported below, using the visual world eye-tracking methodology to assess the time-course of the resolution process during real-time listening comprehension, which are complemented by sentence completion data representing off-line interpretation preferences.

2.1. Experiment 1 – resolving *er* and *der* in active accusative contexts

In experiment 1 active accusative constructions were used in a visual world eye tracking study, thus grammatical and thematic role were aligned (subject/agent vs. object/patient). For thematic roles, we follow the literature on proto-roles assuming two general types of semantic roles, termed agent and patient (Dowty, 1991; Primus, 1999). Proto-agents are characterized by volition, sentience, causation and autonomous movement; proto-patients are defined by change of state and causal affectedness. Each critical item comprised a context sentence that introduced two masculine marked individuals and a feminine or neuter marked inanimate distractor, and varied the word order, such that either the subject

(SVO) or the object was in the first, topical, position (OVS). All the verbs used were active accusative verbs that take a nominative agent and an accusative patient (such as *umarmen*, 'hug', *küssen*, 'kiss', *schlagen*, 'hit').

Previous sentence completion data in which stimuli as in (5) were presented up until the auxiliary in the critical sentence and participants were instructed to write a completion, indicate a clear subject/agent preference for the personal pronoun and an object/patient preference for the demonstrative pronoun (Schumacher et al., 2016). The personal pronoun *er* was preferably interpreted as referring to the nominative marked agent role, while the demonstrative *der* was taken to refer to the accusative marked patient role. These preferences were independent of the word order manipulation, which indicates that subjecthood/agenthood is a strong predictor for pronoun interpretation in these cases.

2.1.1. Method

2.1.1.1. Participants. Thirty-two students from the University of Mainz participated in the visual world eye-tracking study (mean age: 24.8 years, age range: 19–27, 21 women), all of whom were native speakers of German and were paid a small fee for their participation.

2.1.1.2. Materials and stimulus preparation. Thirty-two experimental items were constructed to examine the effects of word order (canonical vs. non-canonical) and grammatical role (subject vs. object)/thematic role (agent vs. patient) on referential processing of the German demonstrative and personal pronouns. The main clause of the context sentence contained two animate masculine referents and was followed by an embedded clause that did not include reference to masculine entities as shown in (5). The critical sentence with the pronoun in nominative case contained a referentially ambiguous continuation to allow resolution toward both antecedents. Pronoun Type (personal vs. demonstrative) and Word Order (canonical (a) vs. non-canonical (b)) were crossed to create four conditions, as shown in (5). These 32 experimental items were mixed amongst 24 fillers of different types that also contained unambiguous pronoun reference and 24 items from experiment 2. Four experimental lists were created, such that each participant saw one version of each experimental item, but none saw the same item more than once. See the appendix for a list of experimental items.

- (5) a. NOM – ACC (canonical linearization)
Der Zauberer wollte den Arzt umarmen, weil die Sonne schien.
The-NOM magician wanted the-ACC doctor to-hug, because the-NOM sun shone.
'The magician wanted to hug the doctor, because the sun was shining.'
b. ACC – NOM (non-canonical linearization)
Den Arzt wollte der Zauberer umarmen, weil die Sonne schien.
The-ACC doctor wanted the-NOM magician to-hug, because the-NOM sun shone.
'The doctor, the magician wanted to hug (him), because the sun was shining.'
c. Critical sentence
Aber er (der) war viel zu klein.
But he-NOM (DEM-NOM) was much too small.
'But he was much too small.'

The experimental items and fillers were read out by a male native German speaker and recorded to computer. Stimuli were read in a natural manner and intonational stress on the topical entity in the antecedent clause or the pronominal was kept to a minimum as far as possible. A trained phonetician checked the acoustic parameters of the material to assure that no extra cues were provided by intonation. Fig. 1 illustrates for (5b) that the sentence-initial object was produced without a pronounced prosodic prominence on the fronted argument and that the sentence's contour remains on one level. The texts were then cut into two separate sound files, such that the first contained the antecedent sentence with the two potential referent NPs, and the second comprised the target utterance, as it contained the ambiguous pronominal (*Aber er/der*).

Each experimental screen (see Fig. 2) displayed three pictures, two depicted each of the antecedent NPs (*magician/doctor*) which were presented in the top left (171,167 pixels) and top right hand corner of the screen (855,167 pixels), and at the bottom center of the screen, a third picture was displayed (512,599 pixels). The position of the two critical pictures was counterbalanced across experimental items. The third picture was a distracter and always depicted the final NP in the antecedent context sentence: a feminine or neuter referent (e.g., *die Sonne*, 'the sun'). This performed the function of a 'launch pad' for subsequent eye-movements, given that it would be the last referent that the participants would hear before the critical sentence containing the pronominal *er* or *der* is encountered.

The experiment was programmed and run using the (head-mounted) Eyelink II system (SR Research), at a sampling rate of 500 Hz to monitor gaze locations every 2 ms, and with a spatial accuracy of at least 0.5°. Only the dominant eye was recorded.

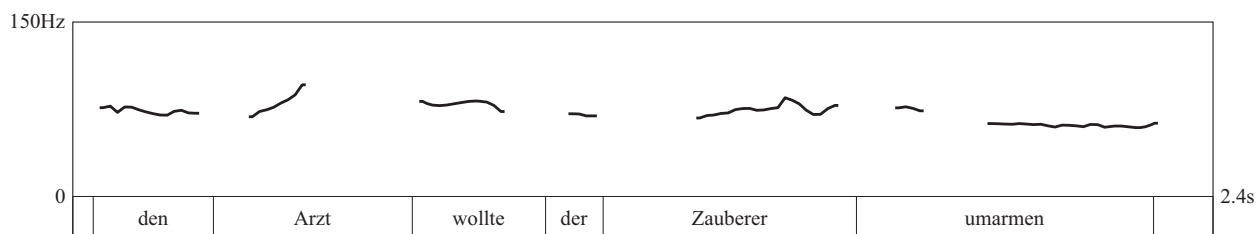


Fig. 1. Prosodic contour of first part of the antecedent clause of (5b). Scale ranges from 0 to 150 Hz.

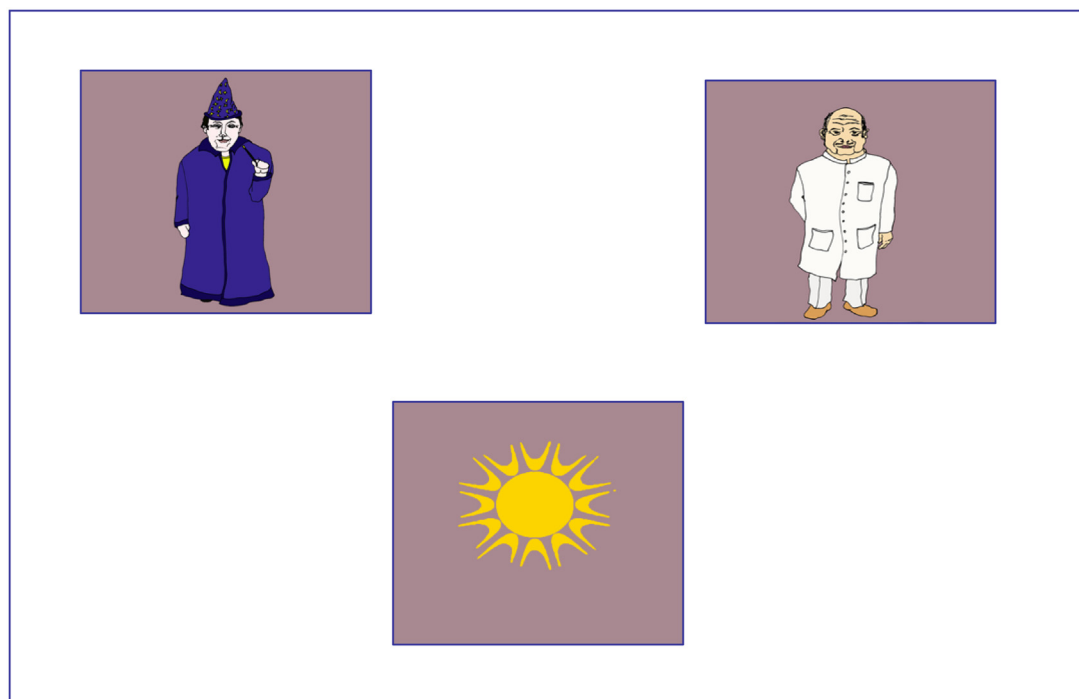


Fig. 2. Visual display accompanying experimental item (6).

2.1.2. Procedure

Each participant was seen individually in a quiet room, seated in front of a computer screen and the session began with a calibration and validation procedure, and then a drift correction to control for head-movements. The total number of experimental and filler items were pseudorandomised on each presentation and the items were played via headphones. In order to familiarize the participants with the procedure, they heard 3 practice items at the beginning of the experimental session. Then the experimental screen was presented for 1000 ms before the playing of the first sound file, in order for the participants to be able to inspect the visual display. They were instructed to listen to the stories, and to answer with a left ('no') or right ('yes') button push a comprehension question which followed some of the stories. The purpose of these comprehension questions was to ensure that the participants would pay attention, and they followed the 24 filler items only (which did not contain ambiguous pronouns). The analysis of the eye-movements was taken from the beginning of the critical sentence (*Aber er/der*), and the assumption underlying this task is that as the auditorily presented story unfolds in real time, listeners look toward an element depicted on the screen as they hear about it in the input (cf., Altmann and Kamide, 1999; Arnold et al., 2000; Cooper, 1974; Ellert, 2011; Järvisikivi et al., 2005; Kaiser and Trueswell, 2004a,b; Kaiser and Trueswell, 2008). In this way, on hearing one of the pronominal forms, looks toward one or the other potential referent is thus an indication of the participant's preferred referent for this pronoun at this moment in time.

2.1.3. Data treatment and results

The interest period for analysis was the onset of the critical sentence (0 ms) which comprised the connective '*Aber*' ('but') immediately followed by the pronoun in every experimental item. On the presentation of this critical sentence, while

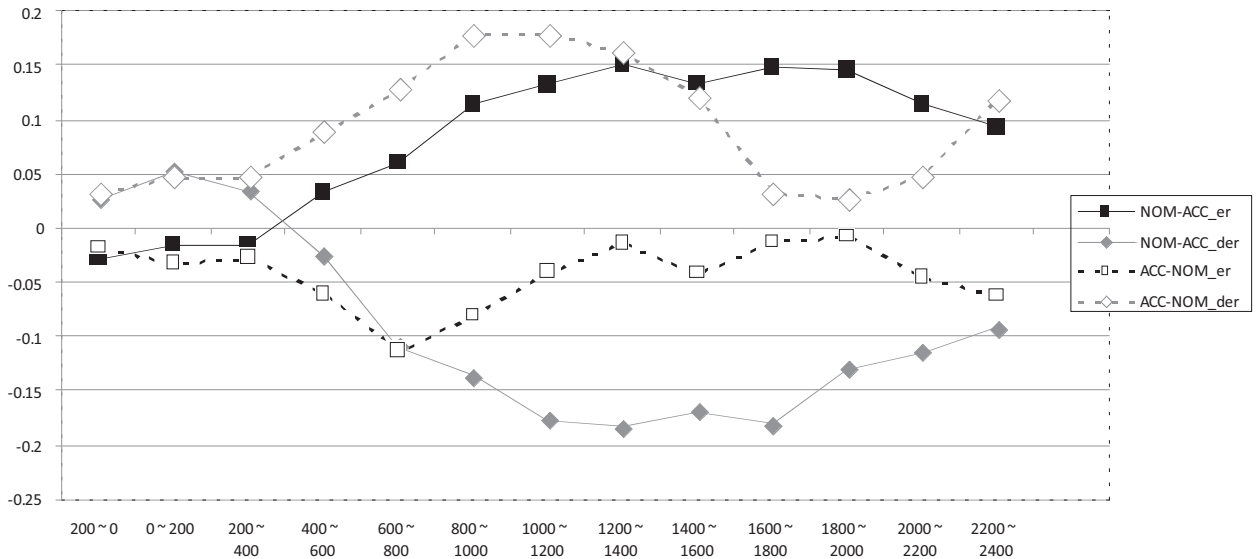


Fig. 3. Difference scores in experiment 1: Probability of fixating the second referent subtracted from fixations to the first mentioned referent, per Pronoun Type and per Word Order condition.

the auditory input was unfolding, the participants' looks were recorded. The fixations to the target pictures were generated for every 4 ms time point between -200 ms until the end of the sentence. Given that the connective *Aber* takes approximately 250–300 ms and the pronominal between 100 and 250 ms to utter, and further, that a saccade launch takes approximately 200 ms, we did not expect any pronoun resolution effects to be visible before 400 ms. Out of the total fixations to the screen (pictures and blanks), the proportions of fixations over time to the pictures of the two potential referents in the experimental conditions were analyzed. The mean empirical logit for each time window (200 ms) per item per subject was calculated separately for the fixations to the first mentioned and to the second mentioned entity from 0 ms until 2400 ms. A difference score was then calculated by subtracting the fixations to the picture of the second mentioned referent from those to the first mentioned, and this was done per item and subject for each time window. All calculations, figures, and statistics were based on this difference score. Using the LME-package in R version 2.1.1, linear mixed-effects models were performed (Bates and Sarkar, 2007; Baayen et al., 2008), with the outcome variable being the difference score per time window and the factors Pronoun Type (*er/der*) and Word Order (NOM-ACC/ACC-NOM) as predictors. Subject and item variability were taken into account by including them as random variables (random intercepts).⁵ *p*-Values were calculated using `pvals.fnc()`, but only *t*-values above 2 were flagged as statistically significant (see e.g., Baayen, 2008; Baayen et al., 2008).

In Fig. 3, the difference score (the probability of fixating the second referent subtracted from fixations to the first mentioned referent) is shown, per pronominal and per word order condition.

The results are highly similar to those found in the sentence completion task (Schumacher et al., 2016), with grammatical role (or thematic role) seemingly the strongest predictor for reference resolution, since *er* elicited more looks to the nominative and *der* to the accusative-marked entity, across both word order type constructions. Thus *er* resolved toward the first-mentioned entity in the canonical word order conditions (NOM-ACC) and *der* to the second mentioned referent, with a reversal in the pattern of looks in evidence in the non-canonical (ACC-NOM) conditions. Table 1 shows the results of the time course analysis for the time windows from 200 ms before the onset of the critical sentence.

As expected, looks diverge significantly from time window 4 (400–600 ms) onwards. In each of the time windows from this point on, there is a significant main effect of Word Order, and a significant interaction of Word Order by Pronoun. There is also a main effect of Pronoun in time windows 4 until 9 (between 400 and 1600 ms). To investigate these interactions, we examined the effects of each of the two pronouns separately, entering Word Order as a predictor. The results are presented in Table 2, where it can be seen that each pronoun is significantly affected by word order (with more looks to the nominative marked entity for *er* and to the accusative marked referent for *der*). This effect is visible in the earlier time-window of 400–600 ms for *der*, but the effect continues to the end of the analyzed time windows for both pronouns.

⁵ Since the difference scores were already calculated in terms of the empirical logit and aggregated into time windows, logistic regression was not used (see Barr, 2008).

Table 1

Results of the time course analysis for experiment 1, from 200 ms before the onset of the critical sentence for the fixed factors Pronoun (*er/der*) and Word Order (ACC-NOM/NOM-ACC). NB. First numbers are coefficients and numbers in parentheses are *t*-values.

Time window	In ms	Fixed predictors		
		Pronoun: <i>er</i>	Word order: NOM-ACC	Interaction
1	–200 to 0	–0.049 (–1.012)	–0.007 (–0.145)	–0.007 (–0.103)
2	0 to 200	–0.079 (–1.646)	0.006 (0.117)	0.006 (0.117)
3	200 to 400	–0.073 (–1.497)	–0.012 (–0.024)	0.018 (0.267)
4	400 to 600	–0.147 (–2.900)**	–0.112 (–2.206)*	0.280 (–2.900)**
5	600 to 800	–0.240 (–4.150)***	–0.237 (–4.090)***	0.406 (4.960)***
6	800 to 1000	–0.260 (–4.700)***	–0.315 (–5.70)***	0.508 (6.492)***
7	1000 to 1200	–0.220 (–3.865)***	–0.357 (–6.258)***	0.530 (6.568)***
8	1200 to 1400	–0.176 (–3.034)**	–0.346 (–5.956)***	0.511 (6.220)***
9	1400 to 1600	–0.161 (–2.654)**	–0.290 (–4.770)***	0.464 (5.386)***
10	1600 to 1800	–0.046 (–0.727)	–0.214 (–3.403)***	0.374 (4.197)***
11	1800 to 2000	–0.036 (–0.570)	–0.159 (–2.512)*	0.312 (3.488)***
12	2000 to 2200	–0.094 (–1.513)	–0.164 (–2.618)**	0.323 (3.652)***
13	2200 to 2400	–0.183 (–2.904)**	–0.211 (–3.359)***	0.368 (4.130)***

* $p < .05$.

** $p < .01$.

*** $p < 0.001$.

Table 2

Experiment 1: Results of individual time course analyses per pronoun with Word Order (NOM-ACC/ACC-NOM) as predictor. First numbers are coefficients and numbers in parentheses are *t*-values.

Time window	In ms	<i>er</i>	<i>der</i>
1	–200 to 0	0.011 (0.229)	–0.098 (–0.171)
2	0 to 200	0.0154 (0.316)	0.006 (0.128)
3	200 to 400	0.0100 (0.214)	–0.009 (–0.181)
4	400 to 600	0.094 (1.839)	–0.104 (–2.078)*
5	600 to 800	0.172 (3.028)**	–0.233 (–3.975)***
6	800 to 1000	0.195 (3.427)***	–0.312 (–5.826)***
7	1000 to 1200	0.173 (3.041)***	–0.356 (–6.262)***
8	1200 to 1400	0.165 (2.984)**	–0.346 (–5.927)***
9	1400 to 1600	0.174 (2.900)**	–0.294 (–4.788)***
10	1600 to 1800	0.160 (2.578)*	–0.280 (–3.656)***
11	1800 to 2000	0.153 (2.497)*	–0.168 (–2.616)**
12	2000 to 2200	0.159 (2.653)**	–0.168 (–2.615)**
13	2200 to 2400	0.156 (2.483)*	–0.214 (–3.420)***

* $p < .05$.

** $p < .01$.

*** $p < 0.001$.

2.1.4. Discussion

Taking the on-line results of experiment 1 together with previous offline data, overall they support the predictions of a syntactic account for reference resolution (Diessel, 1999), given that *er* was interpreted preferentially as resolving toward the grammatical subject and *der* toward the grammatical object, irrespective of (canonical vs. non-canonical) word order, and differ from earlier studies which have observed a second-mentioned effect or lack of a preference for demonstrative pronouns following non-canonical word order antecedents (Bosch et al., 2003; Kaiser and Trueswell, 2008; Wilson, 2009; see also Krasavina and Chiarcos, 2007). However, the data overall are also in line with Kaiser and Trueswell's (2008) form-specific multiple-constraints account, since the relative influence of word order and grammatical role appeared to be differently weighted for the two pronominals. That is, rather than being in complete complementary distribution, the personal pronoun elicited a less robust effect in the context of the non-canonical antecedent sentences (contra Gundel, 2003), where the effect was observed at a later point in time (600–800 ms) than for *der* (400–600 ms). These early time course profiles thus reveal important insights into the mechanisms guiding pronoun resolution in real time. Eye movement patterns observed further downstream may well be affected by additional information made available by the target sentence.

Although grammatical role appears to be the best predictor for reference resolution in this experimental design, one cannot rule out an effect of thematic role with these materials, given that in the canonical word order condition (SVO), the nominative-marked referent is also the agent and the topic. To further tease apart the effects of grammatical role from those of thematic role, it is necessary to look at canonical word order contexts in which the referent occupying the first position is not also the nominative-marked referent. We investigate exactly this in experiment 2, by using dative experiencer verbs, which show a canonical dative–nominative linearization.

2.2. Experiment 2 – resolving *er* and *der* in dative experiencer contexts

To further investigate the effects of grammatical role and word order in the resolution of *er* and *der*, in experiment 2 we investigated the effect of dative experiencer verbs (6) that take as arguments a dative experiencer and a nominative patient (such as *gefallen*, ‘to be pleasing to’, *auffallen*, ‘to be striking to’). The linguistics literature assumes that for dative object-experiencer verbs, the dative argument is thematically higher than the nominative argument and represents the agent protorole (e.g., Fanselow, 2000; Primus, 1999; Wunderlich, 1997). We assume in this experiment that dative–nominative is the unmarked, canonical word order (cf. Haider, 1993). We thus were able to further tease apart the role of syntactic role from that of thematic role, since, in contrast to the items used in experiment 1 with active accusative verbs, in the canonical condition in experiment 2, the nominative marked argument is the proto-patient and the second mentioned referent. If grammatical role is the strongest predictor of reference resolution and *er* prefers nominative entities then it should resolve toward the second-mentioned nominative-marked entity in the canonical dative–nominative condition, whereas if it is an agent or topic that attracts *er*, then the opposite should hold.

Sentence completion data with dative experiencer contexts (Schumacher et al., 2016) indicate that in the canonical word order, the pronoun *er* prefers the initial argument (i.e., the dative marked experiencer) and the demonstrative *der* shows a preference for the nominative-marked proto-patient. For both pronominals, reference resolution is subject to chance performance in the non-canonical word order following a context with a dative experiencer verb.

2.2.1. Method

2.2.1.1. *Participants.* The same participants from experiment 1 undertook experiment 2.

2.2.1.2. *Materials and stimulus preparation.* As in experiment 1, we manipulated word order (canonical (a) vs. non-canonical (b)), per pronominal form, as shown in (6).

- (6) a. DATIVE–NOMINATIVE (canonical linearization)
Dem Gärtner gefällt der Kapitän, der ein Eis isst.
The-DAT gardener is-pleasing-to the-NOM skipper who an-NOM ice cream eats.
‘The skipper who eats ice cream is pleasing to the gardener.’
b. NOMINATIVE–DATIVE (non-canonical linearization)
Der Kapitän gefällt dem Gärtner, der ein Eis isst.
The-NOM skipper is-pleasing-to the-DAT gardener who an-NOM ice cream eats.
‘The skipper, he is pleasing to the gardener who eats ice cream.’
c. Critical sentence
Aber er (der) redet gerade mit zwei Damen.
But he-NOM (DEM-NOM) talks now with two ladies.
‘But he is talking to two ladies right now.’

Twenty-four critical items for the dative experiencer verbs were created, according to the conditions set out in (6). The number of dative experiencer verbs that also take two animate arguments is very low in German, so that we were forced to use only 6 different verbs across all items (*gefallen*, ‘to be pleasing to’, *auffallen*, ‘to be striking to’, *entgehen* ‘to escape’, *behagen* ‘to be to the liking of’, *mißfallen* ‘to be displeasing to’, *imponieren* ‘to impress’). The critical items were distributed across 4 lists and randomized with an additional 56 filler items. They served as fillers in experiment 1.

Procedure. The same experimental procedure was applied as in experiment 1.

2.2.2. Data treatment and results

The same treatment and analyses as applied to the data in experiment 1 were applied to the results of this experiment. In Fig. 4, the probability of fixating the second referent subtracted from fixations to the first mentioned referent is shown, per pronominal and per word order condition. As can be seen, in canonical, dative–nominative word order contexts, *er* elicits more looks toward the first mentioned, dative-marked argument, and *der* elicits more looks to the second mentioned, nominative entity. In contrast—and similarly to the pattern observed in the sentence completion task—in the

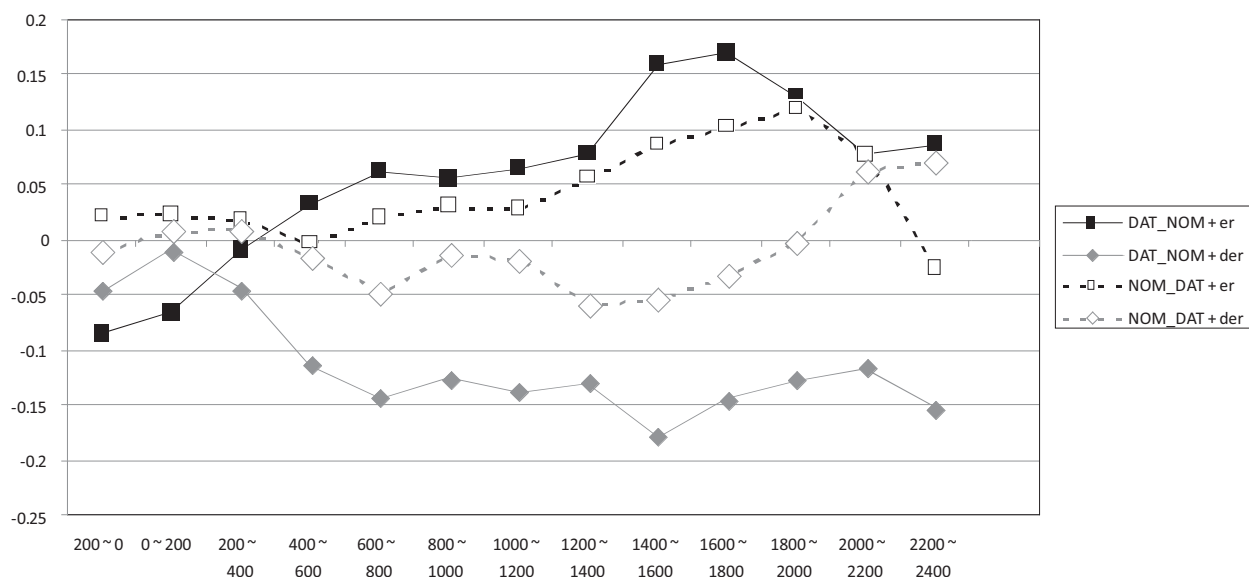


Fig. 4. Difference scores in experiment 2: Probability of fixating the second referent subtracted from fixations to the first mentioned referent, per pronominal and per word order condition.

non-canonical condition, looks meander at chance level for the first 1200 ms and then show a trend toward the first mentioned referent in the *er* condition and the second mentioned referent in the *der* condition. As late as in the 2000–2200 ms window, *der* registers enhanced looks to the first mentioned referent.

As in experiment 1, linear mixed-effects models were run on the data with the difference scores (the fixations to the second mentioned picture subtracted from those to the first) as the dependent variable and with Pronoun Type and Word Order being the independent variables. Subject and item variability were again taken into account by including them as random variables (random intercepts). These results are presented in Table 3.

There was a significant main effect of Pronoun from time window 4 (400–600 ms) onwards, which reflects the fact that irrespective of grammatical role, *er* elicits a majority of looks toward the first mentioned and *der* toward the second mentioned referent. The later interaction arises from the mixed behavior of *der*, which in the non-canonical (nominative–dative) word order condition starts to develop a preference toward the second mentioned referent, most pronounced in time window 9 (1400–1600 ms). The interaction in time window 12 (2000 ms) reflects the fact that again in the non-canonical condition, the preference for the demonstrative pronoun reverses, in that the pattern of looks switch from the second toward the first mentioned entity. To investigate the observed interactions, additional analyses were run to examine the effects of each of the two pronouns separately, with Word Order as a predictor, from time window 9 (1400–1600 ms) to time window 13 (2200–2400). The results (Table 4) show that the interactions are indeed driven by *der*, although the effects are significantly depending on word order from 2000 ms onwards, where there is a change in preferred referent from second to first mentioned in the non-canonical nominative–dative order.

2.2.3. Discussion

For the canonical dative–nominative word order, the results of both previously reported off-line data and the present on-line task overall show the comprehenders' preference to resolve *er* toward the first mentioned (dative experiencer) and *der* toward the second mentioned referent (nominative proto-patient). Therefore when looking at the results of the canonical word order conditions in experiments 1 and 2 together, it appears that *er* is attracted to the proto-agent, rather than specifically to a nominative-marked referent, and *der* to the proto-patient. (Note that experiment 2's data could also be interpreted in favor of a topic preference for *er* and non-topic bias for *der*, but the data from experiment 1 discourage such a view.) These preferences are observed within the same interval as in experiment 1, i.e., as early as 400 ms after the target sentence onset. Thus these data together with the findings from experiment 1 suggest that thematic role information represents a more powerful cue during pronoun resolution than grammatical function.

Yet, the pattern that emerges is more complex when considering the marked, nominative–dative word order antecedent contexts. In this case, the participants' preferences were less robust for both pronominal forms, in contrast to experiment 1. This indicates that the interpretive system is weakened when the three prominence-leading factors

Table 3

Results of the time course analysis for experiment 2, from 200 ms before the onset of the critical sentence for the fixed factors Pronoun (*er/der*) and Word Order (DAT-NOM/NOM-DAT). NB. First numbers are coefficients and numbers in parentheses are *t*-values.

Time window	In ms	Fixed predictors		
		Pronoun: <i>er</i>	Word order: dative–nominative	Interaction
1	–200 to 0	–0.040 (–0.768)	0.037 (0.697)	0.072 (0.968)
2	0 to 200	–0.056 (–1.069)	0.017 (0.328)	0.071 (0.955)
3	200 to 400	0.035 (0.635)	0.054 (–0.024)	–0.027 (–0.342)
4	400 to 600	0.146 (2.433)*	0.097 (1.605)	–0.131 (–1.553)
5	600 to 800	0.205 (3.321)*	0.097 (1.536)	–0.096 (–1.566)
6	800 to 1000	0.1810 (2.946)**	0.114 (1.830)*	–0.138 (–1.579)
7	1000 to 1200	0.205 (3.228)**	0.123 (1.915)*	–0.161 (–1.786)*
8	1200 to 1400	0.215 (3.281)**	0.0746 (1.123)	–0.099 (–1.058)
9	1400 to 1600	0.343 (5.224)***	0.127 (1.904)*	–0.200 (–2.144)*
10	1600 to 1800	0.320 (4.724)***	0.116 (1.683)	–0.183 (–1.902)*
11	1800 to 2000	0.258 (3.779)***	0.125 (1.811)*	–0.136 (–1.400)
12	2000 to 2200	0.193 (2.637)**	0.179 (2.420)*	–0.181 (3.652)***
13	2200 to 2400	0.239 (3.124)**	0.224 (2.894)**	–0.337 (–3.105)**

* $p < .06$.

* $p < .05$.

** $p < .01$.

*** $p < 0.001$.

Table 4

Experiment 2: Results of individual time course analyses per pronoun with Word Order (DAT-NOM/NOM-DAT) as predictor. First numbers are coefficients and numbers in parentheses are *t*-values.

Time window	in ms	<i>er</i>	<i>der</i>
9	1400–1600	–0.072 (–1.190)	0.138 (1.964)*
10	1600–1800	–0.067 (–1.104)	0.117 (1.614)
11	1800–2000	–0.009 (–0.144)	0.129 (1.745)
12	2000–2200	–0.005 (–0.076)	0.180 (–2.231)*
13	2200–2400	–0.124 (–1.872)	0.224 (–2.621)**

* $p < .06$.

* $p < .05$.

** $p < .01$.

grammatical function, thematic role and surface position (indicating sentence-topic) are not aligned (i.e., when the highest thematic role does not map onto the highest grammatical function nor onto the initial syntactic position). In the off-line data, this resulted in chance performance. In the on-line data, the uncertainty of the interpretive system is reflected in the absence of a clear referential bias within the first 1000 ms. Also, similarly to experiment 1, in the non-canonical word order, there was a stronger effect for the demonstrative than for the pronoun.⁶

⁶ Two anonymous reviewers observe that noun phrase complexity could be considered as an alternative explanation of our findings. In experiment 2, we introduced a modifying phrase (the relative clause in (6)) to introduce a third referent that serves as a launch pad for eye fixations prior to encountering the critical pronoun. In German, the relative clause modifies the preceding determiner phrase. This modification yields a simple first-mentioned referent and structurally more complex second referent. Could this explain our observed effects? First, as far as we know, the literature has not addressed this issue yet. Ariel (2001) argues that a modified DP refers to an entity that is less accessible at the point where the modified DP is used but she does not make any claims about the referential status of that entity in subsequent discourse. Coherence-based theories (e.g., Kehler et al., 2008) might suggest that the likelihood of remention increases the richer the content of a referential expression is. This predicts a last mention-bias for the personal pronoun, which is not supported by our data. Within Centering Theory, a working hypothesis has been the Complex NP Assumption that breaks up the complex DP and introduces the individual referents from left to right (Walker and Prince, 1995). So in our case, the presence of the relative clause would not have an impact on the relative prominence of the main clause arguments. In addition, we have independent evidence from an unpublished master thesis (Backhaus, 2015, University of Cologne master thesis). In this research, participants were asked to write 6 continuation sentences following a context sentence with two unmodified arguments and a referentially ambiguous target sentence with a personal or demonstrative pronoun. The number of rementions of the first and second argument pattern with our results, suggesting that the observed effects are independent of DP complexity.

While the findings from the canonical order suggest that thematic role information is a highly ranked cue during pronoun resolution in German, the data from the non-canonical conditions indicate that thematic role alone does not suffice for referential resolution. The prominence cues thematic role, grammatical function and surface position appear to compete with each other. In the case where thematic and grammatical roles are not aligned and the proto-agent maps onto the initial position, thematic role is still a decisive resolution cue. But when the agent surfaces non-initially while the initial position holds the subject, the system is challenged by this competition for prominence, yielding weaker interpretive preferences. This competition is most severe for the demonstrative, possibly because it seeks to exclude the most prominent referent from its candidate set and thus relies more strongly on a ranking of referential candidates (Comrie, 1997). This view provides novel evidence for multiple, weighted constraints during pronoun interpretation (e.g., Arnold et al., 2000; Badecker and Straub, 2002; Järvikivi et al., 2005, 2014; Kaiser and Trueswell, 2008).⁷

3. General discussion

Overall, the results of this set of experiments suggest different functions for *er* and *der*. They further indicate that a single prominence-lending cue cannot account for resolution preferences; in experiment 1 and 2, thematic role was the best predictor for interpretive preferences in the majority of contexts, but when the cues are not aligned (such as in the case of the non-canonical dative experiencer contexts) interpretive preferences are weakened. The demonstrative is more severely affected by the interplay of multiple cues, as suggested by the observation that the interactions are driven by the demonstrative (cf. Tables 2 and 4), supporting form-specific interpretive behavior.

The eyetracking data demonstrate that initial referential biases are observable around 400 ms after sentence onset. At this time, the influence of prominence-lending cues depends on the contextual environment. In the relatively context-free situation in experiment 1 and 2, thematic information impacts processing decisions. But even in this situation we see that unlicensed word order variation in the context sentence encumbers referential resolution (cf. the results from the non-canonical conditions in experiment 2). The data further indicate that an accumulation of competing prominence cues results in later instability in the system, reflected by changing interpretive tendencies further downstream. When prominence cues are not aligned, the system is impaired immediately, mirrored by the absence of initial interpretive biases.

In the introduction we reviewed an extensive list of factors that have been claimed to influence the resolution of personal and demonstrative pronouns. In our studies, we started to combine some of these factors in order to assess the relative ranking of these cues during referential resolution. The results of experiment 2 suggest to us that thematic role is a highly ranked cue during prominence computation of two-antecedent clauses in German and that agentivity has the capacity to outrank subjecthood and surface position in the contexts used in our design. We therefore propose that agentivity should be considered a highly ranked constraint on pronoun resolution that is clearly rated more essential than subjecthood. With regard to topicness, our proposal is more modest given that the current experiments included only one sentence as context. Thus the aboutness topic indicated by the argument in first position of the context sentence might have been too weak to promote the referent's topic status. Critically, the claims of a topic bias of the personal pronoun and anti-topic bias of the demonstrative come from experimental vignettes with richer contexts (e.g., Bosch and Umbach, 2007). Future research should therefore look at more elaborate contexts that have a discourse topic rather than a mere sentence/aboutness topic. These findings complement previous research on argument ordering that indicate that thematic role information is a central feature in incremental argument processing (cf. e.g., Ferreira, 2003; Bornkessel-Schlesewsky and Schlesewsky, 2009). Even more generally, the importance of agentivity features in our studies lends support to the claim from cognitive sciences that the notion of agentivity represents core knowledge of the human attention system (Leslie, 1995; Gelman, 2009).

Our research further showed that the misalignment of prominence lending cues impairs the processing system to the extent that interpretive biases diminish. Such system failure only emerges when multiple cues are combined and misaligned, indicating that the processing system utilizes multiple ranked constraints during pronoun resolution. To illustrate this, when following non-canonical word-order antecedent clauses, different patterns of preferences were observed across the experiments for both pronominal types. We attribute this to competing prominence hierarchies:

⁷ Regarding the classification of the argument orders, the processing patterns for the dative experiencer construction side more strongly with the canonicity view (e.g., Haider, 1993). If the two orders were of the alternating type (as suggested by e.g., Barddal et al., 2014), we would not expect such clear differences in the interpretation between the nominative–dative and dative–nominative linearization. However, a conclusive argument would require a closer look at the subject properties of the arguments in the individual constructions occurring in the experimental materials, as this is the decisive factor for the claim of alternating argument orders.

Table 5

Properties of the first noun phrase in antecedent clause. Features of high prominence are in bold, of low prominence in italic font.

	Experiment 1		Experiment 2	
	Canonical	Non-canonical	Canonical	Non-canonical
Thematic role	Agent	<i>Patient</i>	(Proto)Agent	<i>Patient</i>
Gram. function	Subject	<i>Object</i>	<i>Object</i>	Subject
Sentence topic	Topic	Topic	Topic	Topic

(9) Prominence hierarchies for two competing antecedents:

Thematic role: agent ⇔ patient
 Grammatical function: subject ⇔ object
 Surface position: initial ⇔ non-initial
 Sentence topic: topic ⇔ non-topic

In particular, we investigated the interaction of different prominence hierarchies and used the factor canonicity (word order) to vary the linear order of arguments in antecedent clauses. Table 5 illustrates the alignment of prominence hierarchies in the two experiments. In experiment 1, thematic role and grammatical function converged, i.e., the highest thematic role also carried the highest grammatical function. In the canonical condition, sentence-topic (marked by initial position) also aligned with the thematic role and grammatical function hierarchy. In the non-canonical condition, the nominative-marked agent represented the non-initial non-topic, i.e., the overall prominence cue alignment was reduced. This misalignment however did not prevent the emergence of interpretive biases. In experiment 2, thematic role and grammatical function were crossed orthogonally. When the highest thematic role (the experiencer argument) aligned with sentence-topic, interpretive preferences were guided by thematic role more than by grammatical function. Yet when subject and sentence-topic were aligned but carried the less prominent thematic role in the non-canonical manipulation, referential preferences were encumbered. This indicates that grammatical function as a cue is still active and that the three prominence-lending cues are intertwined and compete with each other during reference resolution. We conclude that a misalignment of thematic role and grammatical function weakens interpretive processes during pronoun resolution. When such a misalignment takes place at the expense of the agent surfacing as sentence-topic, the system has sufficient cues to compute a referential preference (cf. experiment 2, canonical conditions). However, fronting of the proto-patient, at least in a contextually unlicensed situation, encumbers the underlying resolution processes. This explanation is reminiscent of findings from the real-time processing of subject-object ambiguities in Dutch, in which processing difficulty is exacerbated when cues to agentivity are in competition (e.g., Mak et al., 2006).

As far as the comparison of personal and demonstrative pronouns is concerned, our findings concur with the idea that *er* is indeed the more neutral referring expression, in the sense that it is pragmatically unmarked in comparison to *der* (cf., Levinson, 1991). Overall the strongest and most consistent preferences were observed when *er* was resolved toward the first-mentioned, canonical entity, irrespective of whether the entity was a nominative-marked agentive NP (experiment 1) or a dative experiencer (experiment 2). However, it seems that this is only the case in contexts that are canonical and thus information-structurally unmarked, given that the preferences for *er* become less robust both in timing and in ultimate interpretation following non-canonical constructions. Similarly, the job of *der* appears to be to co-refer with the non-agent, as linguistic accounts of the functional difference between the two pronominal forms might predict (Ahrenholz, 2007; Bosch et al., 2007; Comrie, 1997; Lambrecht, 1994) but as with *er*, this may only be a reliable predictor for the interpretation of *der* when there are two canonically-ordered entities in the antecedent clause from which to choose. In general interpretive biases for *der* are however less flexible than for *er*. Here we have concentrated on interpretive preferences but we would like to point out that the demonstrative has a second important function that is to signal a shift in the overall discourse structure whereby its referent has the potential to become a topic in the following discourse (cf. Schumacher et al., 2015).

4. Conclusion

Overall, the findings of the above experiments on the resolution preferences of *er* and *der* support multiple weighted cue accounts (cf. e.g., Arnold et al., 2000; Järvikivi et al., 2005). They also add to the form-specific multiple-constraints approach to reference resolution (e.g., Kaiser and Trueswell, 2008), which states that different referring expressions are

not equally sensitive to the various constraints that affect antecedent prominence. Our data suggest that the two forms are sensitive to both information structure cues (aboutness topic implemented by word order) as well as thematic role cues, but to different degrees. However, taken together, our results show that in unmarked information structure contexts, the function of *er* is to maintain reference to the highest thematic antecedent, and *der* the less thematically prominent referent, irrespective of grammatical role, but when preceded by non-canonical word-order antecedent contexts, the prominence status of the potential referents becomes less clear and the personal pronoun is more prone to instability.

Acknowledgements

This joint research was carried out at the Max Planck Institute for Psycholinguistics in Nijmegen. We are grateful to Wolfgang Klein for inspiring discussion.

Appendix

Critical stimuli for Experiment 1 (canonical order)

- 1 Der Zauberer wollte den Arzt umarmen, weil die Sonne schien. Aber er (der) war viel zu klein.
- 2 Der Großvater sollte den Jungen waschen, und zwar mit der Bürste. Aber er (der) ist plötzlich eingeschlafen.
- 3 Der Polizist will den Clown anhalten, weil das Auto raucht. Aber er (der) ist zu sehr abgelenkt.
- 4 Der Maler wollte den Jäger schlagen, und zwar mit einer Farbpalette. Aber er (der) wurde plötzlich angerufen.
- 5 Der Feuerwehrmann will den Jungen retten, weil das Haus brennt. Aber er (der) ist viel zu aufgeregt.
- 6 Der Hund wollte den Papagei ärgern, weil das Fressen verschwunden war. Aber er (der) schlief ganz schnell ein.
- 7 Der Hai wollte den Goldfisch fangen, weil das Mädchen zuschaute. Aber er (der) ist zu weit weggeschwommen.
- 8 Der Fußballer wollte den Tennisspieler treffen, um die Bälle abzuholen. Aber er (der) musste sehr dringend weg.
- 9 Der Lehrer sollte den Schüler sprechen, weil die Hausaufgaben falsch waren. Aber er (der) war zu beschäftigt.
- 10 Der Affe wollte den Hund erschrecken, und zwar mit einer Trompete. Aber er (der) ging einfach weg.
- 11 Der Vater wollte den Sohn beglückwünschen, weil die CD sehr erfolgreich war. Aber er (der) kam zu spät nach Hause.
- 12 Der Arzt wollte den Patienten verabschieden, weil das Telefon klingelte. Aber er (der) musste noch etwas fragen.
- 13 Der Koch wollte der Kellner überraschen, weil das Gericht so gelungen war. Aber er (der) ist heute schlechter Laune.
- 14 Der Bär wollte den Esel grüßen, weil die Ente dabei war. Aber er (der) hat es nicht gesehen.
- 15 Der Polizist wollte den Briefträger einladen, und zwar zu einem Fest. Aber er (der) hatte dann keine Lust.
- 16 Der Hausmeister wollte den Maler anrufen, um die Schlüssel zu bekommen. Aber er (der) hatte Anderes zu tun.
- 17 Der Nachbar wollte den Opa belauschen, weil die Oma nicht hinsah. Aber er (der) wurde unterbrochen.
- 18 Der Onkel wollte den Enkel besuchen, um ein Geschenk vorbeizubringen. Aber er (der) ist leider erkrankt.
- 19 Der Lehrer wollte den Vater anrufen, weil das Mädchen weinte. Aber er (der) hatte keine Zeit.
- 20 Der Wächter sollte den Mann beschützen, weil sich das Feuer ausbreitete. Aber er (der) lief einfach weg.
- 21 Der Clown will den Jungen kneifen, damit die Menschen lachen. Aber er (der) wendet sich plötzlich ab.
- 22 Der Italiener will den Franzosen schlagen, und zwar wegen des Mädchens. Aber er (der) ist viel zu freundlich.
- 23 Der Tänzer sollte den Cowboy küssen, und zwar auf die Hand. Aber er (der) weigert sich.
- 24 Der Astronaut sollte den Mechaniker rufen, um die Rakete zu testen. Aber er (der) war zu beschäftigt.
- 25 Der Einbrecher wollte den Türsteher erschlagen, um ins Haus zu kommen. Aber er (der) fiel plötzlich hin.
- 26 Der Zauberer wollte den Zwerg besuchen, um seine Tochter zu sehen. Aber er (der) war nicht pünktlich.
- 27 Der Bäcker sollte den Kunden erinnern, und zwar an das Geld. Aber er (der) wurde plötzlich angerufen.
- 28 Der Kameramann wollte den Schauspieler filmen, und zwar auf dem Fahrrad. Aber er (der) hat Wichtigeres zu tun.
- 29 Der Kellner wollte den Gast bedienen, weil die Chefin zuschaute. Aber er (der) ist heute ganz besonders abgelenkt.
- 30 Der Zahnarzt will den Hausmeister treffen, und zwar hinter der Tür. Aber er (der) hat tatsächlich die Verabredung vergessen.
- 31 Der Torwart wollte den Trainer umarmen, weil die Torte so lecker war. Aber er (der) war viel zu klein.
- 32 Der König wollte den Ritter belohnen, und zwar mit einer Schatztruhe. Aber er (der) musste dringend weg.

Critical stimuli for Experiment 2 (canonical order)

- 1 Dem Gärtner gefällt der Kapitän, der ein Eis isst. Aber er (der) redet gerade mit zwei Damen.
- 2 Dem Feuerwehrmann ist der Polizist vor dem Haus aufgefallen. Aber er (der) hat gerade telefoniert.
- 3 Dem Cowboy entging der Indianer, der hinter einer Palme stand. Aber er (der) hat es nicht bemerkt.
- 4 Dem König imponierte der Koch, der eine Gitarre besaß. Aber er (der) würde niemals darüber reden.

- 5 Dem Matrosen behagte der Kellner, der Ananas mochte. Aber er (der) wollte bald gehen.
- 6 Dem Piraten missfiel der Zahnarzt, der Briefmarken sammelte. Aber er (der) lächelte trotzdem.
- 7 Dem Dirigenten gefällt der Trompeter, der eine Tasche verloren hat. Aber er (der) schaut trotzdem grimmig.
- 8 Dem Professor ist der Student neben der Lokomotive aufgefallen. Aber er (der) lass gerade ein interessantes Buch.
- 9 Dem Rennfahrer entging der Mechaniker, der ein Messer hatte. Aber er (der) bemerkte nur ein komisches Geräusch.
- 10 Dem Boxer imponierte der Musiker, der Pizza mochte. Aber er (der) wollte das nicht wahr haben.
- 11 Dem Urlauber behagte der Pilot, der eine Katze besaß. Aber er (der) verstand nur wenig Deutsch.
- 12 Dem Gärtner missfiel der Koch, der ein Gemälde verkaufte. Aber er (der) erzählte trotzdem vom letzten Urlaub.
- 13 Dem Clown ist der Indianer in dem Auto aufgefallen. Aber er (der) hat ihn nicht angesehen.
- 14 Dem Hund gefällt der Vogel, der unter der Lampe sitzt. Aber er sieht nur noch sehr schlecht.
- 15 Dem Doktor entging der Pfleger, der eine Perücke trug. Aber er (der) bemerkte dies überhaupt nicht.
- 16 Dem Kindergärtner imponierte der Junge, der eine Cola trank. Aber er (der) spielte gerade mit einem Mädchen.
- 17 Dem Reiter behagte der Tierpfleger, der Blumen pflückte. Aber er (der) hatte keine Zeit zum Reden.
- 18 Dem Astronauten missfiel der Besucher, der eine Tasche trug. Aber er (der) lächelte sehr höflich.
- 19 Dem Maler ist der Dichter aufgefallen, der Geige spielte. Aber er (der) wollte bald schlafen.
- 20 Dem Polizisten gefällt der Mechaniker, der Kirschen mag. Aber er (der) muss dringend zu einer Besprechung.
- 21 Dem Lehrer entging der Sportler, der mit der Straßenbahn fuhr. Aber er (der) verschwieg dies lange Zeit.
- 22 Dem Hund imponierte der Bär, der die Birne aß. Aber er (der) ging einfach weg.
- 23 Dem Elefant behagte der Affe, der die Sonne genoss. Aber er (der) schlief sofort ein.
- 24 Dem Künstler missfiel der Kellner, der ein Auto besaß. Aber er (der) ging auch bald.

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