

Personal Pronouns and D-Pronouns in German: Connecting Comprehension to Production

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1 Introduction

In addition to p(ersonal)-pronouns, German has demonstrative pronouns and so-called d-pronouns, which are by and large form-identical with the definite determiner. D-pronouns are of special interest because they are somewhat intermediate between p-pronouns and demonstrative pronouns. In particular, it has been observed repeatedly that p-pronouns and d-pronouns have different interpretational preferences in situations of referential ambiguity (cf. Abraham 2002; Bosch & Umbach 2007; Zifonun et al. 1997). In a prototypical example as in (1), the p-pronoun prefers the sentence-initial subject NP *Peter* as antecedent whereas the preferred antecedent of the d-pronoun is the sentence-final object NP *einen Freund*.

- (1) *Peter wollte einen Freund besuchen. Aber er/der ist krank geworden.*
P. wanted a friend visit but he/d-pron is sick become
'Peter wanted to visit a friend. But he became sick.'

In the psycholinguistic literature on pronoun resolution, several heuristics are discussed to govern the selection of the intended antecedent out of a set of competing candidates (e.g., Crawley et al. 1990; Sanford & Garrod 1981). Below, we show the three most important heuristics. These heuristics are usually formulated for p-pronouns, but we have extended them to also include d-pronouns, where the preference of the d-pronoun is always the opposite of the preference for the p-pronoun, as suggested by examples like (1).¹

¹ A fourth heuristic that has attracted a fair amount of attention is the Parallel Function Heuristic. According to this heuristic, a p-pronoun prefers an antecedent with the same syntactic function as itself. This heuristic has not been discussed much in the literature concerned with p- and d-pronouns in German, perhaps because almost all research has involved p- and d-pronouns in subject function. The same is true for the empirical evidence discussed in this paper, and we will therefore also not consider the Parallel Function Heuristic. However, as pointed out by a reviewer, it may well be that the subject preference found for p-pronouns is – to some degree at least – a consequence of this heuristic.

- (2) *The Subject Heuristic*
A p-pronoun prefers a subject, a d-pronoun a non-subject as antecedent.
- (3) *The First Mention Heuristic*
A p-pronoun prefers a first-mentioned NP, a d-pronoun a last-mentioned NP as antecedent.
- (4) *The Topic Heuristic*
A p-pronoun prefers a topic NP, a d-pronoun a non-topic NP as antecedent.

The preferences seen for the example in (1) could be explained by reference to any of the three heuristics listed above, because the preferred antecedent of the p-pronoun is a subject, a topic, and a sentence-initial NP whereas the preferred antecedent of the d-pronoun is an object, a non-topic and a sentence-final NP. This raises the obvious question of which heuristic is responsible for the observed preferences. We have addressed this question both experimentally and by means of a corpus analysis. First, we have run a series of comprehension experiments that tease the different factors apart (Bader & Portele submitted). The main conclusion from these experiments is that the interpretation of p-pronouns is governed by the Subject Heuristic whereas none of the three heuristics alone can account for the interpretation of d-pronouns. We will therefore propose an interpretation rule for d-pronouns that combines the three heuristics. In addition to the experiments, we analyzed the production of p-pronouns and d-pronouns in authentic texts (Portele & Bader 2016). The corpus evidence indicates that the choice between p-pronoun and d-pronoun is affected by all three of the information types embedded in the heuristics discussed above – syntactic functions, linear position, and information structure. We finally discuss the relationship between the comprehension and the production mechanisms.

This paper is organized as follows. In the next section, we review theoretical as well as experimental research concerning the interpretation and the production of the German p-pronoun and its d-pronoun counterpart. In the following Section 3, we summarize the main findings of our experiments investigating the interpretation of p- and d-pronouns and propose an interpretation rule for d-pronouns that combines the three heuristics mentioned above. We complement the interpretation data with corpus data in Section 4. In Section 5, we discuss how the interpretation rule proposed in Section 3 can be converted to a rule for use in language production. We conclude our paper with a general discussion.

2 Prior Research on P-Pronouns and D-Pronouns

The heuristics mentioned in the introduction of this paper have been proposed in psycholinguistic investigations of pronoun resolution, but they are also useful as a starting point when looking at the grammatical literature concerned with the use and interpretation of p- and d-pronouns.

In their comprehensive grammar of German, Zifonun and colleagues (1997) formulate the reference relations of p- and d-pronouns in terms of *theme* and *rheme*. The theme is characterized as what the (current) discourse *speaks about*. The rheme is that part of the utterance telling us something about the theme. According

to Zifonun et al. (1997), p-pronouns as well as d-pronouns can be used when the theme remains the same from one utterance to the next, but whereas the p-pronoun can only be used in contexts with the theme being already established, d-pronouns are used when the antecedent has just been mentioned, belongs to the rheme, or is competing with alternative themes. When we equate theme and topic, this distinction corresponds to the Topic Heuristic in (4).

Beside discourse-structural properties, Zifonun et al. (1997) claim that grammatical functions and linear position, as stated in the Subject Heuristic and the First Position Heuristic, come into play when comparing the different interpretation strategies of the two pronouns. In case of multiple possible antecedents, the p-pronoun checks for a parallel relation to its antecedent in terms of *position* and *subject/object-function*. D-pronouns, in contrast, search the preceding utterance backwards in a linear chain looking for an appropriate rhematic antecedent.

In order to illustrate the different resolution strategies for p- and d-pronouns, consider example (5) taken from Zifonun et al. (1997: 558-559).

- (5) [Peter]_i will [einen Benz]_j kaufen.
 P. wants a Benz buy
 'Peter wants to buy a Benz.'
- a. [Er]_i hat wohl zuviel Geld.
 he (p-pron) has seemingly too-much money
 'He seems to have too much money.'
- b. [Der]_i hat wohl zuviel Geld.
 he (d-pron) has seemingly too-much money
 'He seems to have too much money.'
- c. [Der]_j soll aber nicht so teuer sein.
 it (d-pron) shall however not so expensive be
 'However, it shall not be too expensive.'
- d. [Er]_j soll aber nicht so teuer sein.
 it (p-pron) shall however not so expensive be
 'However, it shall not be too expensive.'

Zifonun and colleagues (1997) state that the interpretation in (5a) follows straightforwardly: the p-pronoun and *Peter* agree in number and gender, they are positioned in parallel, and they form a thematic match. In (5b) however, the d-pronoun first of all checks its immediate vicinity and finds *einen Benz*, which agrees in gender and number. Since the emerging interpretation is highly unlikely, the search is continued to the left until *Peter* is found and identified as a matching object.

Looking at (5c) and (5d) we see the opposite case. The d-pronoun in (5c) detects the newly introduced expression *einen Benz* which fits all criteria. In (5d) however, the grammatically corresponding and positionally parallel expression *Peter* leads to an implausible interpretation. So *einen Benz* is taken as a matching and plausible interpretation.

Abraham (2002) also analyzes p-pronouns as serving a continuation of the current theme. In his view, however, d-pronouns are rhemes and serve as markers of a topic shift by taking the non-theme or new information as antecedent. The characterization of the d-pronoun in terms of disrupting a thematic continuation

leads Abraham to claim that a d-pronoun needs to refer to a full NP whereas a reference to an antecedent established by a p-pronoun is impossible (Abraham 2002: 461).

The interpretation of d-pronouns has also been claimed to be based on the antecedent's syntactic function and linear position. Claims of syntactic function are primarily based on the notion of Centering (Grosz et al. 1995). The reference of the d-pronoun would be determined by choosing a *forward-looking center* as antecedent that is not the *backward-looking center*. When we assume that the center hierarchy for German is based on syntactic functions, with the object following the subject in the hierarchy, the d-pronoun takes the object as antecedent. Rambow (1993) claims that the linear surface position of the respective antecedent also has to be taken into account for defining centerhood.

The following examples given by Bosch & Umbach (2007) and Bosch (2013) show, however, that a d-pronoun may take a first-mentioned subject as antecedent, whether it is a p-pronoun (6) or a proper name (7).

- (6) *Gestern habe ich Karl_k getroffen. Er_k arbeitet jetzt bei IBM.*
 yesterday have I K. met he works now at IBM

Den_k sollten wir mal einladen.
 him (d-pron) should we once invite

'Yesterday I met Karl_k. He_k works for IBM now. We should invite him_k some time.'

- (7) *Woher Karl_i, das weiß? Peter_k hat es ihm_i gesagt. Der_k/Er_{i,k} war gerade*
 how K. that knows P. has it him told he (p/d-pron) was just

hier.
 here

'How does Karl_i know? Peter_k told him_i. He d-pron_k/p-pron_{i,k} has just been here.'

In summary, despite certain differences in detail, work in theoretical linguistics (Abraham 2002; Hinterwimmer 2014; Bosch & Umbach 2007; Zifonun et al. 1997) converges on the conclusion that in situations of ambiguity, d-pronouns prefer a non-topical or rhematic antecedent.

3 Experimental Evidence

Experimental research has shown that the interpretive preferences for d-pronouns are not simply the opposite of the interpretive preferences for p-pronouns. For Finnish, Kaiser & Trueswell (2008) found that p-pronouns prefer subjects as antecedents (independently of position) whereas d-pronouns preferentially choose the newly introduced postverbal NP (independently of grammatical function). Similar results were found for German (summarized in Ellert 2013). Crucially though, discourse status (given/new or topic/comment) and linear position were confounded in these studies, which is why the source of the preference for the d-pronoun remains unclear.

We therefore ran a series of experiments that tested the interpretation and production of p-pronouns and d-pronouns in a more systematic way than was done before (see Bader & Portele submitted). Together, the experiments show that all three heuristics are necessary to account for the comprehension and the production of p-pronouns and d-pronouns.

For reasons of space, we discuss only two experiments from Bader & Portele (submitted). In these sentence completion experiments, we independently varied *grammatical function*, *position* and *topichood*. Participants read short contexts similar to the ones used by Kaiser & Trueswell (2008) and then completed a sentence starting with a p- or d-pronoun. The first context sentence introduced a female character using a proper name and the second context sentence a male character using an indefinite NP (see Table 1). The third sentence, which had either SO or OS order, contained a definite NP referring back to this character and an indefinite NP introducing a second male character. Since the indefinite NP in the third sentence was newly introduced, the given character, which was accompanied by the definite article, always was the backward-looking center in the terminology of Centering Theory. It can thus also be considered the topic of the sentence. So, givenness and topichood converged in our experiments. In Experiment 1, which is a direct replication of Kaiser & Trueswell (2008) for German, the definite NP preceded the indefinite NP; this was reversed in Experiment 2.

Table 1: Experimental design for Experiments 1 and 2

Context sentences 1 and 2, common to Experiment 1 and 2:
Maria war am Sonntag im Zirkus. Vor der Aufführung sah sie schon einen Clown herumlaufen.
 'Maria visited a circus on Sunday. Before the show, she saw a clown walking around.'

Experiment	Order	Context sentence 3	Target pronoun
1	SO	<i>Der Clown umarmte einen Mann.</i> the-NOM clown hugged a-ACC man	Er hat .../Der hat ... p-pron has / d-pron has
1	OS	<i>Den Clown umarmte ein Mann.</i> the-ACC clown hugged a-NOM man	Er hat .../Der hat ...
2	SO	<i>Ein Mann umarmte den Clown.</i> a-NOM man hugged the-ACC clown	Er hat .../Der hat ...
2	OS	<i>Einen Mann umarmte der Clown.</i> a-ACC man hugged the-NOM clown	Er hat .../Der hat ...

Participants' task was to complete the final sentence fragment. Note that world knowledge or plausibility should not influence participants in our items (unlike in example (5) given above). Both possible antecedents were equally plausible as natural continuations in the given contexts. Based on the content of the continuation, the antecedent of the p-pronoun/d-pronoun was determined.

So far, 20 different students participated in each experiment. The results are shown in Fig. 1 and Fig. 2. Fig. 1 shows the results for the p-pronoun. In Experiment 1 (NP1=topic) as well as Experiment 2 (NP2=topic), we replicated the finding from the prior literature that p-pronouns prefer subject antecedents independently of order. The strength of this preference varies considerably, though.

A different pattern is found for the d-pronoun, as can be seen in Fig. 2. In SO sentences, the d-pronoun always prefers the final NP as antecedent. Since the final NP is the topic in Experiment 2 (NP2=topic), this means that in case of two potential antecedents, the d-pronoun can show a preference for the topic NP. This contradicts earlier claims that d-pronouns always prefer the non-topic antecedent. In OS sentences, on the other hand, the d-pronoun prefers the sentence final, non-topical subject NP in Experiment 1 (NP1=topic), whereas in Experiment 2 (NP2=topic), it shows a preference for the initial, non-topical object NP. This shows that the d-pronoun does not always prefer the last-mentioned NP as antecedent. Instead, in OS sentences the non-topical antecedent is preferred.

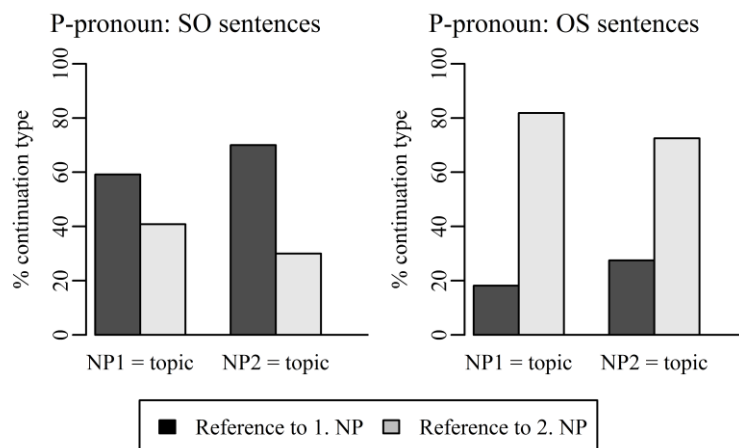


Fig. 1: Percentages of completions in which the p-pronoun referred to either NP1 or NP2 of context sentence 3

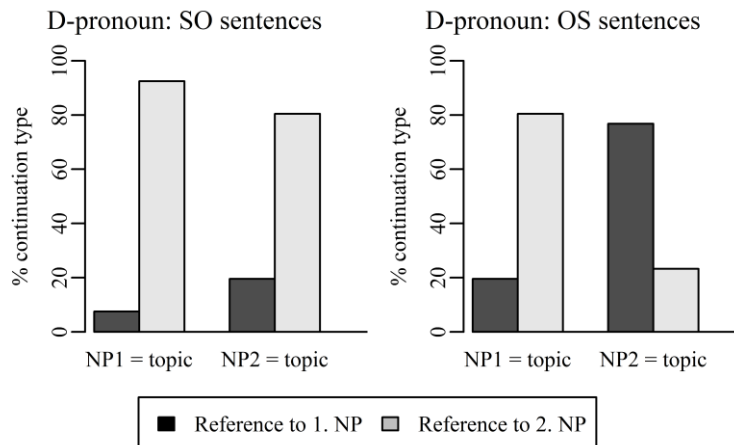


Fig. 2: Percentages of completions in which the d-pronoun referred to either NP1 or NP2 of context sentence 3

Our results confirm a subject preference for p-pronouns. D-pronouns behave in a more complex way. For SO contexts, the object is the preferred antecedent independently of discourse status. Taking into account what is claimed in the literature, it is surprising that the d-pronoun is used to take up a topic antecedent by our participants. This reference induces a *continue* relation, which is unusual for d-pronouns, since they are generally assumed to take a rhematic/new antecedent and establish it as the new topic, thereby inducing a *shift* relation (see section 2). This is

what we found in Experiment 1 and in the OS sentences of Experiment 2. For OS contexts, a discourse-new non-topic antecedent is preferred.

In sum, whereas the preferred interpretation of a referentially ambiguous p-pronoun follows from the Subject Heuristic, none of the heuristics introduced at the beginning can account for all findings for referentially ambiguous d-pronouns. However, when we define a compound prominence property which encompasses all three heuristics, a simple generalization emerges. Table 2 shows how the properties underlying the three heuristics introduced at the beginning are distributed across the four sentence types investigated in Experiment 1 and 2.

Table 2: Distribution of prominence lending features for the sentence types investigated in Experiment 1 and Experiment 2

	Topic First				Topic Second			
	SO		OS		SO		OS	
	S	O	S	O	S	O	S	O
Subject	+	-	+	-	+	-	+	-
First-mentioned	+	-	-	+	+	-	-	+
Topic	+	-	-	+	-	+	+	-

Consider, for example, SO sentences with the topic in first position. For such sentences, the subject NP has plus values in all three dimensions (+subject, +first-mentioned, +topic) whereas the object has minus values in all three dimensions (-subject, -first-mentioned, -topic). According to typological work on prominence hierarchies, subjects are more prominent than non-subjects and topics are more prominent than non-topics. Linear position does not normally figure among the prominence hierarchies, but it makes sense to consider the initial position as more prominent than the final position. Evidence for this assumption comes both from findings concerning the processing of p-pronouns, as captured in the First Mention Heuristic, and from the fact that phrases that are prominent in the other dimensions (e.g., subjects, topics) typically align with the first position.

If we now simply count the prominence lending features for each argument, it turns out that the d-pronoun always prefers as antecedent that argument that has the least prominence features. Given that there are three features, this is the argument that has at least two minus values. This argument is marked by grey cells in Table 2. We therefore arrive at the interpretation rule for d-pronouns in (8).

(8) *Interpretation rule for d-pronouns*

A d-pronoun refers to the least prominent antecedent, with prominence defined in terms of \pm subject, \pm first-mentioned and \pm topic.

If the competing antecedents are contained within a SO context sentence, the object always has two features making it non-prominent – it is not a subject and it is not the first-mentioned argument. The object is thus always less prominent than the subject in a SO sentence, irrespective of whether the subject or the object is the topic. This is in accordance with the finding that the d-pronoun prefers the object as antecedent when the context sentence appears with SO order, whether the object is the topic or not. When the context sentence appears with OS order, in contrast, subject and

object are on a par with respect to the two surface features – the subject is +subject and -first-mentioned and the object is -subject and +first-mentioned. In this case, the interpretation rule for d-pronouns predicts that topichood makes the difference. This is exactly what the experimental results show. Following an OS context sentence in which the object is the topic, the subject is the preferred antecedent of the d-pronoun, and for OS context sentence with a subject topic, the object is the preferred antecedent.

4 Corpus Evidence

To corroborate our experimental findings that we have reviewed in the preceding section, Portele & Bader (2016) conducted a corpus study based on the deWac corpus of German internet texts (Baroni et al. 2009). The corpus study is broader than the experimental study insofar as it is not restricted to contexts containing a competing antecedent NP. We first drew a random selection of 500 sentences starting with *Der* (d-pron) and 500 sentences starting with *Er* (p-pron), always immediately followed by a finite verb. The preceding context was limited to five sentences. After removal of erroneous corpus hits (e.g., non-verbs tagged as verbs, use of *der* as female dative pronoun), we ended up with 465 sentences for *er* and 435 sentences for *der*. In accordance with the three heuristics introduced above, the following properties of the antecedent were coded. In cases where the referent of the p-pronoun/d-pronoun was mentioned several times in the preceding context, the last mentioned one is the antecedent in the definition below.

- *Syntactic function of the antecedent*: subject or non-subject
- *Position of the antecedent*: sentence-initial or non-initial
- *Givenness of the antecedent*: given when the antecedent was mentioned in one of the context sentences preceding it, non-given otherwise²

Several further features were annotated, among them the presence of other referents with the morpho-syntactic features “male” and “singular”. This way, it could be determined whether referential ambiguity had an effect on the choice between p- and d-pronoun. The presence of a competitor to the actual antecedent had no effect when the competitor could occur anywhere in the preceding context. When only cases of a competitor within the same sentence are considered, an effect is observed, but it is not a large one. In sentences with a p-pronoun, a sentence-internal competitor was present in 35.7% of all cases. In sentences with a d-pronoun, this number increased to 46.3%. An authentic example in which a p-pronoun is used although all factors favor the use of a d-pronoun can be found in Portele & Bader (2016: 32).

² In the corpus study, we coded NPs as given or new and not as topic or non-topic because the latter distinction is difficult to code in authentic texts (see Cook & Bildhauer 2013).

Table 3: Percentages of choice of p-pronoun/d-pronoun depending on syntactic function, linear position and givenness of the antecedent (n = 900)

	Syntactic Function		Linear Position		Givenness	
	Subject	Non-subject	Initial	Non-initial	Given	Not given
<i>er</i>	83.9	16.1	77.1	22.9	62.5	37.5
<i>der</i>	28.0	72.0	31.2	68.8	21.2	78.8

Table 3 shows descriptive results for the properties corresponding to the three heuristics introduced at the beginning – syntactic function, position, and givenness. In all three cases, we see the expected pattern: in sentences starting with *er*, the properties favoring the p-pronoun according to the heuristics occur much more frequently than the converse properties. For properties favoring the d-pronoun, it is just the reverse.³ These three properties are not independent of one another, however. In about 25% of all sentences, the antecedent was a subject, was given, and occurred initially. For these sentences, *er* was chosen in 88% of cases. For another 25% of all sentences, the antecedent was a non-subject, was not given and occurred in final position. Here, *der* was chosen in 93% of cases. The remaining 50% of the sentences were distributed across the remaining 6 combinations of the three properties under consideration.

Table 4: Mean percentages of d-pronoun sentences in 1000 corpus samples reflecting the ratio of d-pronoun and p-pronoun in the complete deWac corpus

	Given		New	
	+Subject	-Subject	+Subject	-Subject
+initial	0.7	3.9	1.2	16.6
-initial	1.8	6.8	4.1	38.3

For practical reasons, Portele & Bader (2016) analyzed similar numbers of examples for the p-pronoun *er* and the d-pronoun *der*. In the deWac corpus, however, the p-pronoun was found to occur over twenty times more often than the d-pronoun. In order to estimate the rate of d-pronoun use depending on the three main factors syntactic function, linear position, and givenness of the antecedent, we formed samples which combined all p-pronoun examples analyzed in our study and a random sample of d-pronoun examples in such a way that the new sample reflected the estimated p-pronoun to d-pronoun ratio in the deWac corpus. The average d-pronoun rate in 1000 samples formed in this way are shown in Table 4 (= Table 8 from Portele & Bader 2016). Table 4 reveals that the rate of d-pronoun use is rather low in most conditions. Only when all three factors conspire do we see a substantial number of d-pronouns. However, even in this case the rate only reaches 38.3%, which means that writers use a p-pronoun more than half of the time when all three main factors predict the use of a d-pronoun.

³ With regard to syntactic functions, our corpus results are close to those found in an earlier corpus study by Bosch et al. (2003).

The relevance of the individual factors was determined by means of logistic regression. In order to get estimates reflecting the true ratio of p-pronouns to d-pronouns, we made use of Monte Carlo simulation. Logistic regression models were fitted to the same 1000 corpus samples described above. Table 5 shows mean estimates for the three main factors, mean *t*-values, and the percentages of runs in which the factor was significant. As can be seen, the largest estimate was found for the factor syntactic function, which was significant in almost all runs. The factors givenness and position were also significant in a substantial number of cases. The other factors are not shown here because they were non-significant most of the time. Somer's C was 0.87 on average. When the predicted probabilities were converted into a binary choice between p-pronoun and d-pronoun, the models made the correct choice for 96% of all sentence on average. This looks quite impressive, but the model was only successful in predicting p-pronouns, not in predicting d-pronouns. The main reason for this is the very high baseline rate of p-pronoun use (about 96%).

Table 5: Main results of logistic regression analysis

Factor	Mean estimate	Mean <i>t</i> -value	Percentage significant
Syntactic Function: -subject	0.13600	5.5577	99.7
Givenness: new	0.04577	2.1109	56.6
Position: -initial	0.03616	1.7587	42.9

The experiments summarized in the preceding section revealed that the d-pronoun *der* prefers the object as antecedent in SO sentences even if the object is the sentence topic. This finding runs counter to the claim often made in the literature that d-pronouns preferentially refer to non-topics in cases of ambiguity (Bosch & Umbach 2007; Hinterwimmer 2014). Our corpus studies revealed a number of examples where the d-pronoun refers back to a given antecedent that could be considered the sentence topic. One example of this kind is given in (9).

- (9) Ich beginne mit der Erinnerung an einen Raubüberfall: **Georg Neumark** wollte im Herbst 1640 von Mühlhausen nach Königsberg um Jura zu studieren. Der Weg nach Ostpreußen war weit und im dreißigjährigen Krieg gefährlich. **Neumark** schloß sich deswegen einer großen Fuhre von Kaufleuten an. Doch schon bei Magdeburg in der Altmark wurde der Troß überfallen. **Neumark** verlor alles. Geld und Ziel. Ausgehungert kam **er** in Lübeck an. Ein Flüchtling wie viele damals. Ein thüringischer Landsmann, Pfarrer Nikolaus Becker fand nach langem Warten eine Hauslehrerstelle für **Neumark**. **Der** schrieb zum Dank ein Lied, das trug den Titel: „Trostlied, daß Gott einen jeden zu jeder Zeit versorgen und erhalten will.“
 'Let me begin with the memory of a robbery: In the fall of 1640, **Georg Neumark** wanted to travel from M. to K. in order to study law. The way to East Prussia was far and dangerous during the times of the Thirty Years' War. Thus, **Neumark** joined a group of merchants. But as soon as they reached the area of Magdeburg, they were mugged. **Neumark** lost everything. His money and his goal. When **he** arrived in Lübeck, **he** was famished. Like many people in those times, **he** was a refugee. After having waited for a long time, a Thuringian compatriot, minister N. Becker, found a private teaching position

for **Neumark**. In thanks, **he**[d-pron] wrote a song, entitled “Trostlied, daß Gott einen jeden zu jeder Zeit versorgen und erhalten will.” ’

(http://traisa-lebt.de/downloads/predigt_archiv/1998/1998_03_22_predigt.pdf

last access July 11, 2017)

Here, the d-pronoun *der* is used to refer to *Neumark*. This referent is mentioned several times in the preceding context. It is both the topic of this discourse and the sentence topic of the preceding context sentences.

This and similar examples confirm our experimental findings. In SO sentences, the d-pronoun shows a preference for the object, whether the object is topical or not. Note that this is predicted by the interpretation rule for d-pronouns in (8) because the object in an SO sentence always has at least two properties that decrease its salience: it is an object and it occurs clause-finally. Independent of which argument is the topic, the object is thus always less salient than the subject, making it the preferred target for a d-pronoun.

5 Relating Interpretation to Production

A question that has taken up some prominence recently is how language production and language comprehension are related to each other (e.g., MacDonald 2013; Pickering & Garrod 2004). With regard to pronoun resolution, an important proposal linking language comprehension and language production has been made by Kehler & Rohde (2013). This proposal will be discussed in the General Discussion. In this section, we address the more narrow question of how the interpretation rule for d-pronouns in (8) relates to the corpus findings presented in the preceding section. According to this rule, a d-pronoun prefers the least prominent candidate in cases with several potential antecedents, with prominence defined in terms of \pm subject, \pm first-mentioned and \pm topic.

When converting this rule to a rule for production, one has to take into account that a speaker or writer has to choose a referential form for a given referent whether other referents with the same morpho-syntactic features are present or not. One way to meet this requirement is by simply counting the number of prominence features and to define that a p-pronoun is chosen when the number of prominence feature is large, a d-pronoun otherwise. Because there are three prominence features, a straightforward way to translate the interpretation rule into a production rule is to say that a p-pronoun is used if the referent has two or three properties making it prominent whereas a d-pronoun is used if the referent has none or one property making it prominent.

As intuitive as this rule may be, it is doomed to failure. As shown in Table 4, in the corpus the p-pronoun was always preferred to the d-pronoun, even when all factors favored the use of a d-pronoun. The fact that the corpus data are from a written corpus can be considered a major reason for this low incidence of d-pronoun use. In a corpus study comparing a corpus of written newspaper texts to a corpus of spoken language, Bosch et al. (2007) found a rate of d-pronoun use below 7% in the written corpus but a rate of 80% in the spoken corpus.

Table 6: Distribution of corpus examples with p- or d-pronouns depending on the prominence value of the antecedent NP

Syntactic function	Position	Givenness	Nr. of prominence features	Weighted prominence	% <i>der</i> choice
+su	+initial	+given	3	0.2179	0.72
+su	+initial	-given	2	0.1722	1.24
+su	-initial	+given	2	0.1818	1.78
+su	-initial	-given	1	0.1360	4.08
-su	+initial	+given	2	0.0819	3.91
-su	+initial	-given	1	0.0362	16.59
-su	-initial	+given	1	0.0458	6.84
-su	-initial	-given	0	0.0000	38.28

Note, however, that the estimated rates shown in Table 4 do not seem to be unrelated to the number of prominence lending features. This is most clearly seen for the case where the d-pronoun is favored by all features. In this case, the rate of d-pronoun use reaches its by-far highest value. What is thus needed is a more flexible way to relate prominence to observed corpus frequencies. The relevant information for doing so is already provided by the logistic regression analysis presented in the prior section. Table 6 shows the weighted prominence for each of the eight combinations of \pm subject, \pm initial and \pm topic, where the weighted prominence is defined as the sum of the corresponding estimates in Table 5. The graphic on the left side of Fig. 3 plots weighted prominence against the estimated corpus frequencies of the d-pronoun. The graphic on the right side of Fig. 3 shows the same with prominence on a logarithmic scale (and some noise added to each weight).

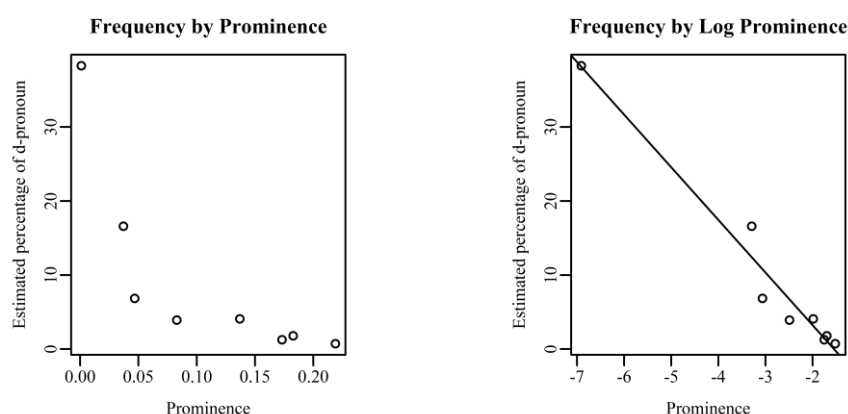


Fig. 3: Relationship between prominence and corpus frequency
 Left side: Prominence weights on the original scale
 Right side: Prominence weights on a logarithmic scale

As can be seen, by and large frequency decreases monotonically with increasing prominence, although not in a linear way, but rather exponentially, as shown by the

approximately linear relationship in the logarithmic plot. Formal means to capture such non-linear relationships have been developed both in psychology (e.g., Anderson et al. 2004) and in linguistics (e.g., Goldwater & Johnson 2003). Such models provide the means to capture the often probabilistic nature of choosing between different referential means and they could be extended by parameters for modality and style, thus capturing the dependency of d-pronoun use on these factors. Applying such formal models to the issues discussed in this paper must be left as a task for future research.

6 General Discussion

The experiments and the corpus study discussed in this paper show that a complex interplay of factors governs the use of p-pronouns and d-pronouns, during interpretation – the resolution of referential ambiguity in written sentence comprehension – as well as during production – the choice of a referential expression in writing. Contrary to a widespread assumption in the literature, we found that d-pronouns do not consistently prefer non-topical antecedents in case of referential ambiguity. Instead, syntactic function, position, and topichood of the antecedent are all taken into account when interpreting a p-pronoun/d-pronoun. Similarly, the choice between p-pronoun/d-pronoun during language production is mainly a function of these three factors.

In their recent model of pronoun interpretation, Kehler & Rohde (2013) propose a close link between interpretation and production. They claim that for the interpretation of a pronoun, a hearer relies on the likelihood of mentioning a particular referent and the likelihood of choosing a pronoun to refer to this referent. These two likelihoods are combined using Bayes' Rule.⁴

For prototypical examples of ambiguous pronoun resolution in German, this prediction is borne out. For purposes of illustration, consider the following example.

- (10) *Peter hat vor dem Zirkuszelt einen Clown fotografiert.*
P. has in-front-of the circus-tent a clown photographed
'In front of the circus tent, Peter took a picture of a clown.'
- a. *Er hat sich sehr darüber gefreut.*
he (p-pron) has himself very this-about pleased
'He was very much pleased about it.'
- b. *Der hat sich sehr darüber gefreut.*
he (d-pron) has himself very this-about pleased
'He was very much pleased about it.'

In an example like (10), the p-pronoun is interpreted referring back to the subject of the prior sentence, whereas the d-pronoun is interpreted as taking the object as its antecedent. We recently conducted a study of referential choice in written language production, using our material from the experimental investigations of comprehension (see section 3). Participants' task was to think of a natural follow-up sentence. They were free to choose the referential form, but they were not free to

⁴ Kehler & Rohde (2013) are mainly concerned with data from English and therefore with p-pronouns. It is an interesting question whether their approach generalizes to d-pronouns.

choose the referent, since we framed one of the two possible antecedents, indicating that they should refer to this one in their continuation sentence. So far, only texts in which the final sentence had SO order were investigated.

Table 7: Preliminary results from a production study investigating referential choice for specified referents

Response	Referent = NP1 (subject)		Referent = NP2 (object)	
	Top first	Top second	Top first	Top second
P-Pronoun	75.0	69.6	42.3	36.8
D-Pronoun	5.0	5.1	19.2	15.8
Definite NP	18.8	25.3	17.9	21.1
Dem. Pronoun	1.2	0.0	20.5	26.3

Note: dem. pronouns = forms of the demonstrative pronoun *dieser* ('this')

The results so far are given in Table 7. When we make the simplifying assumption that in the sentences of our comprehension experiments, the probability of being re-mentioned was about equally high for both NPs, Kehler & Rohde (2013) make the correct predictions. Consider first the case where participants have to find a referent for a p-pronoun. As can be seen in Table 7, subject antecedents are more likely to be referred to by a p-pronoun than are object antecedents (75% versus 42% when the first NP is the topic, 70% versus 37% when the second NP is the topic). The preferred antecedent will therefore be the subject. For d-pronouns, the reverse is true. Objects are much more likely to be referred to by a d-pronoun than are subjects (19% versus 5% when the first NP is the topic, 16% versus 5% when the second NP is the topic). Thus, because the position of the topic has only a small effect on the production data, in particular in comparison to the effect of syntactic function/position (which are confounded in Table 7 because only SO sentences were tested so far), Kehler & Rohde's (2013) theory correctly predicts a subject preference for the p-pronoun and an object-preference for the d-pronoun in the case of SO sentences.

Because of the simplifying assumption that both referents are equally likely to be taken up in the next sentence, these considerations must be taken as tentative. We have recently started to gather the relevant data by letting speakers not only choose the referential expression for referring back to a given referent, but also by letting them choose freely which referent to take up.

A further issue concerns the role of (free) word order in pronoun interpretation as well as production. In a recent study of pronoun resolution in English, Fukumura & van Gompel (2015) found only an effect of syntactic function for personal pronouns and only an effect of linear position for definite NP anaphora. This contrasts with results for free word order languages where several factors have been shown to influence pronoun resolution.

In SO context sentences, d-pronouns always prefer the object as antecedent, whether it is the topic or not. OS context sentences lead to a more variable behavior. Of particular interest is the rather robust finding that in OS sentences in which the clause-initial object is the topic, p- as well as d-pronouns preferentially take the second NP, that is, the subject, as antecedent (cf. Kaiser & Trueswell 2008; Ellert 2013). As shown in Fig. 1 and Fig. 2, this was the only case in our experi-

ments where the interpretational preferences of p-pronoun and d-pronoun were not complementary to each other. In order for Kehler & Rohde's (2013) model to predict this convergent preference, it must be the case that in OS sentences, both p- and d-pronouns are more frequently used to refer to the second NP (the subject) than to the first NP (the object). For this prediction to hold, alternative referential means, in particular definite NPs, should be the preferred means to re-mention the first NP. We are currently running experiments testing this prediction.

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