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Its prominence is her prominence: On the relationship between propositional and individual anaphoric reference

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ABSTRACT

The same proposition can be encoded e.g. as a main clause or as a subordinate clause in a complex sentence. Such structural configurations influence whether and how a proposition is subsequently built upon in the discourse, e.g. by anaphoric referral. It is an open question to what extent anaphoric reference to individuals and propositions works in the same way: are the same mechanisms responsible for whether a proposition can be referred to as for whether an individual referent can be referred to? Do they affect both similarly?

We present three sets of paired anaphor resolution experiments in German manipulating the prominence relation between two competing entities: in each pair we tested the influence of how two clauses are structurally integrated on individual reference in one experiment, and on propositional reference in the other. The manipulations (syntactic configuration and typography) were the same in each pair, but between experiment pairs, we varied the type of discourse relation between the two clauses (*backward causality, forward causality, violation of expectation*). We find a basic pattern of correspondence between the prominence level of the proposition and of the individual referents, independent of the type of rhetorical relation between the two clauses. We propose that this is due to a process we dub *Prominence Inheritance*: individual referents "inherit" the relative prominence of the larger units they are part of. Our study investigates individual and propositional prominence in parallel for the first time, providing new insights into the differences and similarities between them, and into how structural and pragmatic factors impact accessibility and anaphor resolution.

1. Introduction

Language provides us with different ways on how to introduce and position a proposition in a discourse. The same proposition can for instance be encoded as a nominalization, as an independent clause, as a main clause in a larger sentential complex, or as one of many different types of subordinate clauses in a complex sentence. Such structural configurations influence how the discourse develops further downstream: the chances of a proposition being subsequently built upon, e.g. by anaphoric referral in a narrative or by an interlocutor reacting to it, presumably differ depending on whether that proposition is for instance asserted on its own, or denoted by a concessive clause in a multiclausal sentence, or by a

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consequence clause. To illustrate: the propositional anaphoric demonstrative *that* in (3) seems more likely to refer to *Alex has repaired her bike* if it follows directly on (1b) rather than (1a). In addition, the form of the proposition also affects whether and in what way any individual referents that might be part of it can be talked about in the future progression of the discourse. Intuitively, the pronoun *she* in (2) is also much more likely to refer to *Alex* when (2) follows (1b) in the discourse than when it follows (1a).

(1) a. Alex has repaired her bike. Zoe wants to go racing.
b. Alex has repaired her bike, because Zoe wants to go racing.
(2) She is excited.
(3) That shows dedication.

While the intuitions for increased likelihood of anaphoric reference to the first clause in (1b) align for (2) and (3), it is an open question to what extent anaphoric reference to individuals and propositions works in the same way: are the same mechanisms responsible for whether a proposition can be referred to as for whether an individual referent can be referred to in contexts with competing entities? Do these mechanisms affect both kinds of reference in the exact same way? In this paper we show that at least a set of structural factors acting on clausal integration in written language, namely syntactic subordination and coordination and the type of typographic boundary, affects both kinds of reference in very similar ways, independent of the type of rhetorical relation between the two clauses. We show this via three sets of paired anaphor resolution experiments in German, where in each pair of experiments we tested the influence of how two clauses are structurally integrated - on individual reference in one experiment, and on propositional reference in the other. The manipulations (syntactic configuration and typography) were the same in each pair of experiments, but between experiment pairs, we varied the type of discourse relation between the two clauses (*backward causality, forward causality, violation of expectation*). Our results show a basic pattern of correspondence between the prominence level of the proposition and that of the individual referents. We propose that this similarity is due to a process we dub *Prominence Inheritance*: individual referents "inherit" the relative prominence of the larger units they are a part of. In addition to this process, there are also features that seem to affect the prominence of one type of referent (individual or propositional), but not the other (or to a lesser extent). In particular, our third pair of experiments reveals additional pragmatic processes that affect propositional anaphora more than individual anaphora. Our study investigates individual and propositional prominence in parallel for the first time, providing new insights into the differences and similarities between them, and, more generally, into how structural and pragmatic factors impact accessibility and anaphor resolution.

1.1. Literature review

There is an extensive literature on individual (pronominal) anaphora, showing for instance that factors that can affect to which referent anaphora are resolved include thematic role (e.g Stevenson et al., 1994, Arnold, 2001, Schumacher et al., 2016, Patterson and Schumacher, 2021), grammatical role (e.g Arnold, 2001, Stevenson et al., 1994, Bosch et al., 2007, Fukumura and van Gompel, 2010), topicality (e.g Cowles and Ferreira, 2012, Buchholz and von Heusinger, 2024), animacy (e.g Fukumura and van Gompel, 2011, Vogels et al., 2014), and definiteness (e.g. Brocher and von Heusinger, 2018). A guiding principle here seems to be that individual referents that are very prominent at the current point in the discourse can be referred to via reduced referring expressions (e.g., personal pronouns, demonstrative pronouns), while less prominent ones need more informative referential expressions (e.g., full definite or indefinite noun phrases) (cf. von Heusinger and Schumacher, 2019 building on Ariel, 1990, Ariel, 1991, Gundel et al., 1993).

In addition, coreference to individual referents can be affected by factors that are more related to the structural properties of the discourse. These include linear distance between the antecedent and its pronoun (Bosch and Hinterwimmer, 2016), but especially also structural distance: discourse is often conceived of as having a hierarchical structure (Mann and Thompson, 1988, Asher and Lascarides, 2003), with its units (*elementary discourse units* or EDUs usually corresponding to a clause, see Hoek et al., 2018 for discussion) being in either a coordinating or subordinating relation to each other. Coordinated discourse units form a horizontal queue from left to right, while subordinated units form a vertical stack: this means that with an addition of a coordinated segment, the right frontier (RF) of the discourse moves forward. Polanyi (1988) proposes that only units at the RF are accessible: i.e. the most recently added unit plus any units superordinate to it. The predictions of the Right Frontier Constraint have been experimentally shown to hold for pronoun resolution[1] (Holler and Irmen, 2007, Wilke and Hoek, 2024). Thus, individual referents that are not at the RF seem not prominent enough to be picked up by a reduced referring expression like a pronoun (unless they are globally prominent like e.g. protagonists in a narrative, cf. Schumacher et al., 2024).

In addition to discourse structure, how clauses are formally connected to each other also has been shown to affect the prominence of individual referents. Cooreman and Sanford (1996) found in a completion task that in discourses like (4), ambiguous pronouns overwhelmingly were interpreted as referring to the subject of the preceding main clause, even if a subordinate clause with a different subject intervened between the main clause and the right frontier of discourse.

[1] In an early corpus study on non-anaphoric attachment in discourse, Lee et al. (2008) also found that for a subordinate clause, rather than a main clause, to (exceptionally) serve as the sole attachment anchor for subsequent discourse, a necessary condition was that the subordinate clause followed the main clause, not the other way round.

(4) The conductor sneezed three times after the tenor opened his music score. He…

More recently, Buchholz, Hoek and von Heusinger (under review), investigated the effects of syntactic subordination, the presence of a connective, and typographic and prosodic boundaries on pronoun resolution across four forced-choice tasks in German. In short discourses like (5), they consistently found effects of syntactic subordination and typographic boundary: participants resolved an ambiguous singular pronoun (*sie* as subject of the nonce-verb predicate *daupte*)[2] more to the first-clause subject (*Nadja*) in (5a), where the second clause is syntactically subordinate to the first, than in (5b), where it is syntactically coordinated; and more in (5b) than in (5c), where a full stop rather than a comma intervenes between the two clauses.

(5) a. Nadja hat vegane Burger gekauft, weil Sabine kein Fleisch isst. Sie *daupte.*
Nadja has vegan burgers bought, because Sabine no meat eats. She *dauped.*
b. Nadja hat vegane Burger gekauft, denn Sabine isst kein Fleisch. Sie *daupte.*
Nadja has vegan burgers bought, because Sabine eats no meat. She *dauped.*
c. Nadja hat vegane Burger gekauft. Sabine isst kein Fleisch. Sie *daupte.*
Nadja has vegan burgers bought. Sabine eats no meat. She *dauped.*

The discourse-structural relation was kept the same across the conditions: it was always *explanation/backward causality*, which is discourse-subordinating. Crucially, this holds also for the condition in (5c) with the full stop. The EDU corresponding to the second clause is the most recent (*Last* in SDRT terms), but it is connected to the first via a subordinating relation (namely *explanation*) that is expected to be inferred even in the absence of a connective. The EDUs corresponding to the first and the second clause therefore form a vertical stack and the first clause remains accessible at the right frontier. Thus in both Cooreman and Sanford, 1996 and Buchholz, Hoek and von Heusinger (under review), both clauses were always at the right frontier,[3] so that the Right Frontier Constraint does not predict any differences between the conditions here. What these results suggest then is not only that main clauses are more prominent than subordinate clauses (cf. Hooper and Thompson, 1973, Smaby, 1974, Mann and Thompson, 1988, Matsuda, 1998, Bybee, 2001), but that other factors like typography and connectives also affect the degree of integration or independence of a clause (cf. Bredel, 2008, Jasinskaja, 2016) – and that this somehow affects the prominence of referents as well.

It is not clear by what theoretical mechanism these phenomena related to clause-combining at the discourse level should actually act on the prominence of individual referents. Our theoretical proposal here is quite simple: we assume that discourse prominence as a structuring principle (von Heusinger and Schumacher, 2019) can act on different kinds of units in a discourse. Larger-scale structural factors like integration directly affect the prominence of propositional discourse referents: the proposition denoted by a subordinate clause or one that is formally more integrated is less prominent than that denoted by an independent and main clause, even if both are at the right frontier of discourse. We then propose that the relative prominence of these propositional discourse referents is "inherited" by the individual referents contained within them.[4]

To test this proposal, we need to test how the prominence level of propositions relates to the prominence level of individual referents inside those propositions: do they align? Compared to individual reference, propositional reference and anaphors with non-nominal antecedents have been much less extensively studied (but see Kolhatkar et al., 2018 for an overview) Eckert and Strube (2000) find that about 23 % of all anaphors in their corpus study have antecedents that are either verb phrases, entire clauses or sequences of clauses. They propose that demonstrative neuter pronouns (*that*) in English establish (*coerce*) the complex discourse referent[5] they refer to (cf. also Kaiser and Trueswell, 2008). Their anaphor resolution algorithm for propositional anaphora incorporates a version of the Right Frontier constraint (cf. Webber, 1991): *that* is argued to only be able to pick up an antecedent that is at the right frontier of the discourse. This is then on a par with individual anaphora, which, as discussed above, have been argued (and, to a limited extent have been experimentally shown) to operate under the same constraint.

A lot of the literature on propositional anaphora focuses on *how* complex referents can be referred to, with research on English converging on propositions, or complex referents, being preferentially (though not exclusively) picked up by *that* as compared to by *it*, at least upon first reference (e.g Eckert and Strube, 2000, Brown-Schmidt et al., 2005, Çokal et al., 2016, Hegarty et al., 2001, Wittenberg et al., 2021). German seems more limited in how propositions are picked up: in their corpus study Consten et al. (2007) found that while the demonstratives *dies* and *das* were complex anaphors in the majority of their occurrences (referring to propositionally structured referents), the personal pronoun *es* was never used in that way. Crucially, however, none of the studies mentioned above have tested how *that* or *das* act when the competition is not between individual

[2] Note that *sie* in the continuation sentence (*sie daupte*) has to be interpreted as a singular feminine pronoun (and not a plural pronoun) since the nonce verb *daup-te* has a clearly identifiable 3rd Pers. Sg. Past ending, like any other weak verb in German (e.g. *sag-te* 'say-3.SG.PAST').

[3] A reviewer encourages us to elucidate alternative theoretical possibilities about which discourse unit might be most recent in the discourse structure and how our experiments speak to these possibilities. We do this in the context of the presentation of our hypotheses in section 2.2.

[4] This does not mean we assume that all referents within a single proposition are necessarily equally prominent. Instead, we assume that the relative prominence hierarchy between individual referents within a single proposition is preserved, and that the 'inherited' prominence operates mainly between propositions. Crucially, all our experimental materials only include one individual (human) referent per proposition, in our case always the subject. If indeed our prominence inheritance hypothesis is borne out, we would predict to get a similar relation also between two instances of a different argument in the two clauses, say a direct object. How the different prominence levels interact/compete remains a question for future research (e.g., most prominent individual referent within the second-most prominent proposition vs. the second-most prominent individual referent within the most prominent proposition).

[5] Such a complex discourse referent can be an event, a fact, a concept, or a proposition (cf. (Asher, 1993)). In our experiments, they are always propositions since the predicates in our continuation sentences select for propositions, and they can most easily be referred to with the anaphor *das*.

and propositional referents as antecedents, but between several propositions. This is, however, a prerequisite for testing our Prominence Inheritance Hypothesis: only when there are several propositions to choose from, each with their own individual referents, can we test whether the same manipulations affect propositional and individual reference in the same way.

One line of research that touches on the availability of propositions expressed in separate clauses is the at-issueness literature. We follow Koev (2018) in identifying three different theoretical strands in this research tradition, which make somewhat different predictions for our current topic. On the one hand, the p(roposal)- and q(uestion)-at-issueness literature prototypically uses the assent/dissent test to establish the at-issueness status of propositions in a discourse, which can be defined as "that part of the sentence meaning that is intuitively felt to express the "main point" when the sentence is uttered in a given context" (Koev, 2018, p.1). This test is based on the idea that you can only directly negate a proposition that is at issue (cf. Tonhauser, 2012). Parts of complex sentences are asserted (p-at-issue, cf. Koev, 2018) or the answer to the Question under Discussion (q-at-issue, cf. Simons et al., 2010), while other parts are assumed to be given and not up for discussion. In (6), taken from Koev (2018, p.6 – after Amaral et al., 2007), it is possible to directly refute the content expressed in the main clause (B1), but not the proposition expressed by the appositive (B2).

(6) A: Edna, a fearless leader, started the descent.
B1: That's not true—Edna has not started the descent.
B2: # That's not true—Edna is not a fearless leader.

Crucially for the topic of the current paper, this line of research could be interpreted as evidence that propositional anaphora (*that* in (6 B1)) preferentially refer to main clause content over subordinate clause content, especially if that subordinate clause occurs early in the sentence. This then seems similar to one of the main findings for individual anaphora in Buchholz, Hoek and von Heusinger (under review), discussed above. On the other hand, the c(oherence)-at-issueness literature directly connects at-issueness with the right frontier constraint. As a reviewer points out, it crucially connects the accessibility of individual and propositional referents: only those propositions corresponding to discourse units that are at the right frontier are accessible for anaphora, and only those individual referents mentioned in these discourse units at the right frontier are, too (cf. Hunter and Asher, 2016, Koev, 2018). For non-final appositives like in (6), the c-at-issueness literature makes the same predictions as p- and q-at-issueness, albeit for a different reason, namely that the discourse unit corresponding to the appositive is not at the right frontier anymore by the time the second part of the main clause is processed. In addition, it states a direct connection between the accessibility of individual and propositional referents, and in this respect is highly compatible with our Prominence Inheritance Hypothesis. However, c-at-issueness is formulated in terms of discourse units, which only have an indirect relation to formal parameters like syntactic subordination/coordination or typography, and does not predict that they should have an independent effect on prominence and accessibility. Overall, the at-issueness claims have received only limited empirical attention (though see Syrett and Koev, 2015, Granger et al., 2022), and the correspondence between at-issueness (at least p- and q-at issueness) and anaphoric potential has been questioned (e.g. Snider, 2017).

Even though individual and propositional anaphora have been shown to be impacted by similar factors, no paper has compared the two directly in a single study. In this study, we test the Prominence Inheritance Hypothesis directly. If it holds, individual anaphora should respond in a similar way as propositional anaphora to changes in the discourse that impact the prominence of clauses, such as syntactic subordination/coordination, typography, and the presence of connectives (which we all manipulate within each experiment pair, following Buchholz, Hoek and von Heusinger, under review, see (5)). In addition, both types of anaphoric reference should respond similarly to changes in the discourse structure (i.e., coordinating vs. subordinating), which we test between experiment pairs. Finally, the effects should be largely robust to changes in the specific coherence relation that holds between the two clauses, which we also test between experiment pairs. Even if the Prominence Inheritance Hypothesis holds, however, it is probably implausible to expect a 100 % correspondence in coreference patterns for individual and propositional anaphora: we for instance know that the anaphoric forms that are used to pick up prominent individual versus propositional referents in German are preferentially different, and we also know that there are factors that impact one type but not the other (e.g., grammatical role impacts the prominence of individual referents but is unlikely to affect the prominence of propositions). Even though we try to control for these factors as much as possible, especially for propositional anaphora the current knowledge about how they behave exactly is not exhaustive. Our main focus will therefore be on the relative difference in coreference patterns between conditions for each type of anaphor: if coreference rates shift for the propositional anaphora, do they shift in a similar way for individual anaphora? If yes, this will provide support for our hypothesis. Deviations from a joint pattern might require additional scrutiny.

2. The current study

2.1. Overall structure of the experiments

We tested the relation between individual and propositional anaphoric reference in ambiguous contexts with two potential antecedents in German. We conducted three pairs of forced-choice anaphor resolution experiments, six experiments in total. We reported on Experiment 1 already in the context of another study submitted elsewhere (Buchholz, Hoek and von Heusinger, under review), but for ease of exposition and coherence we describe it here as well. Each experiment pair tested the effect of clause structure on individual reference (Experiments 1, 3, 5) and propositional reference (Experiments 2, 4, 6) on a different discourse relation: backward causality (in English for instance prototypically marked by *because*) in Experiments 1

& 2, forward causality (e.g., *so*) in Experiments 3 & 4, and violation of expectation (e.g., *even though*) in Experiments 5 & 6. See Table 1 for an overview over the experimental structure.

Table 1
Overview over the experimental structure.

Discourse relation	*Individual reference*	*Propositional reference*
Backward causality	Experiment 1	Experiment 2
Forward causality	Experiment 3	Experiment 4
Violation of expectation	Experiment 5	Experiment 6
What is measured?	Resolution to the first clause subject referent	Resolution to *first* (the referent corresponding to the first clause)

Since many aspects of procedure and analysis were the same across all six experiments, we discuss them here centrally and only mention them in the specific experimental sections when they deviate from what is described here.

In all experiments, critical items consisted of biclausal constructions with a different human subject of the same gender in each clause, followed by a continuation sentence with an ambiguous anaphor (a personal pronoun in the individual reference experiments, the propositional anaphor *das* in the propositional reference experiments) that participants had to resolve. Each experiment pair had the same three conditions, manipulating syntactic sub-/coordination (7a vs. 7b & 7c) and typographical boundary (7a & 7b vs 7c)[6]:

(7) a. *subordinating condition*: a subordinating connective, subordinate clause word order in the second clause, and a comma between the two clauses. Example:
Nadja hat vegane Burger gekauft, weil Sabine kein Fleisch isst.
Nadja has vegan burgers bought, because Sabine no meat eats

b. *coordinating comma condition*: a coordinating connective, main clause word order in the second clause, and a comma between the two clauses. Example:
Nadja hat vegane Burger gekauft, denn Sabine isst kein Fleisch.
Nadja has vegan burgers bought, because Sabine eats no meat

c. *coordinating full stop condition*: main clause word order in the second clause, a full stop between the two clauses and no connective directly at the boundary between the two clauses. Example:
Nadja hat vegane Burger gekauft. Sabine isst kein Fleisch.
Nadja has vegan burgers bought. Sabine eats no meat

In (7), 'subordinate clause word order' and 'main clause word order' refer to a peculiarity of German syntax: in syntactically subordinate clauses, the finite verb is in clause-final position, while in main clauses, it is in second position in the sentence. See the differences in finite verb (*isst* 'eats') position between the examples in (7a) vs. (7b) and (7c)[7]. It is a further fact of German that not all connectives require a subordinate clause; in fact, there are several pairs of connectives with very similar meanings that differ in whether they head syntactically subordinate or main clauses, like *weil* and *denn*. This fact we crucially exploit for our experimental setup. The sections on the individual experiments detail how these conditions were specifically implemented for each experiment pair. Please note that there are two different notions of subordination/coordination that are relevant for our study: syntactic and discourse-structural. Theories of discourse relations do not fully agree on whether the discourse relations of *forward causality* (Experiments 3 & 4) and *violation of expectation* (Experiments 5 & 6) are (discourse-)subordinating or coordinating (see introduction and discussion in sections 4 and 5). However, importantly, we varied the discourse relation and thus whether it is (discourse-)subordinating or coordinating only *across* experiment pairs, cf. Table 1, never *within* experiments. *Within* experiments, we only varied whether conditions were *syntactically* subordinating or coordinating (cf. (7)).

Within each experiment pair, the individual reference experiment and the propositional reference experiment did not differ in the biclausal construction, only in the continuation sentence and the choices participants were given. In the individual reference-experiments, the continuation sentence was a nonce-verb predicate with an ambiguous personal pronoun as its subject, of the same gender as the subject referents in the biclausal construction. We chose nonce verbs to make sure that the verb semantics would not influence resolution. The personal pronoun could thus refer to either of the two subject referents. We took care not to include other potential referents (of the same gender as the subject references) for the personal pronouns in the biclausal constructions.

In each propositional reference experiment, we used exactly the same biclausal constructions as in the matching individual reference experiment to ensure comparability between the individual and propositional reference experiments. However, we wanted to ensure that *das* could not take neutral individual referents as antecedents, or other abstract objects like concepts or predicates. We therefore did not use nonce verb predicates as continuations. Instead, the continuation sentence was always *das finde ich überraschend* or *das finde ich typisch* 'I find that surprising/typical', with the demonstrative *das* as a direct object in topic position. By using these predicates that take propositional objects in the continuation sentences,

[6] In Experiments 1–4, the *full stop*-condition did not include any connective, while in Experiments 5–6, there was a connective, but it followed the subject in the second clause. Buchholz, Hoek and von Heusinger (under review) tested the effect of typographical boundary and the presence/absence of a connective independently and found only additive, but not interacting, effects.

[7] The coordinator *denn* 'because', like *und* 'and', occupies a position even before the first element in the sentence (German: *Vorvorfeld* 'pre-prefield') and thus does not count as being in the first position, which is occupied by the subject *Sabine*.

we made sure that the demonstrative anaphor *das* could refer to only propositions (cf. Eckert and Strube, 2000). We varied the continuation (*typisch/überraschend*) by item in a balanced way: each odd-numbered item had the *überraschend*-continuation, each even-numbered item had *typisch*.

In all experiments, the task for the participants consisted in resolving the ambiguous anaphor (personal pronoun in the individual reference-experiments, demonstrative *das* in the propositional reference-experiments). In the individual reference experiments, they were asked who performed the action denoted by the nonce verb and presented with a choice between the two subject referents. In the propositional reference experiments, the anaphor *das* was technically ambiguous between three referents, which is why the question what *das* referred to had three answer options: participants were asked to choose between three versions of the biclausal construction, in which either the first clause (*first*), the second clause (*second*), or the entire complex sentence *(both*) were underlined (see Fig. 1 for example screenshots from Experiments 2 and 5).[8]

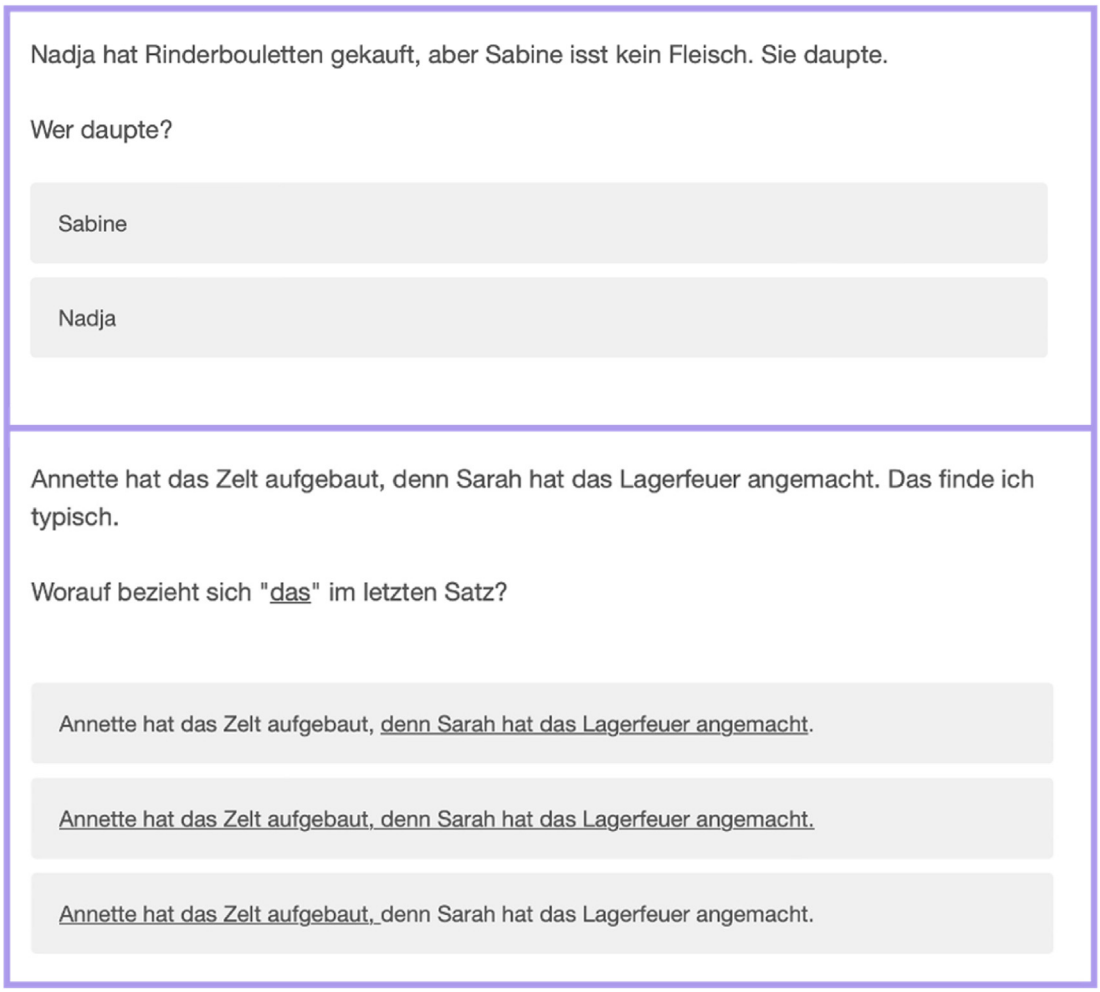

Fig. 1. Example screenshots of how the items and choices were presented to the participants in the individual (top) and propositional (bottom) reference experiments. The order in which the choices were presented was always randomized.

[8] A reviewer points out that the task questions in the individual and propositional experiments differ in how metalinguistic they are: in the individual reference experiments, participants were asked who performed the action denoted by the nonce verb, which is something that an interlocutor might ask, while in the propositional reference experiments, they were asked what the anaphor *das* referred to, which we agree is somewhat more metalinguistic. The reviewer suggests that a more naturalistic alternative would have been to ask e.g. *Was findet der/die Redner/in typisch?* "what does the speaker find more typical?". When we designed the experiments, we considered doing something like this. In the end, we decided on our choice because on the one hand, we do not think the difference is that large in terms of naturalness; and more crucially, we were worried that asking about the mental state of the hypothetical speaker would be too complex and might obscure the structural effects we are after. In the individual reference experiments, asking *wer daupte?* does not require participants to think about the mental state of the speaker. However, we thank the reviewer for suggesting this alternative and agree that it requires further research to see whether it would create systematic differences in the participants' responses.

In addition to the 24 target items, participants in each experiment were shown 16 (in the individual reference-experiments) or 24 (in the propositional reference-experiments) filler items and 8 "catch" filler items. Fillers were similar to the experimental items in that the first two clauses also contained two different subjects, but they featured a variety of different connectives, and contained both (discourse-structurally) coordinating and subordinating discourse relations. In the individual reference-experiments, catch fillers were like the other filler items, except that the subjects of the first two clauses were of different genders so that the reference of the pronominal subject of the nonce verb in the continuation sentence was unambiguous.

In the propositional reference experiments, the catch fillers were meaning-based.[9] Both subject referents had the same gender, as in the experimental items, but the predicate of the continuation sentence semantically only matched one of the two clauses (cf. (8) for a catch filler from Experiment 2). Catch fillers were used to exclude data from inattentive participants.

(8) Sören hat weitergeschlafen, obwohl Felix bei ihm sturmgeklingelt hat. Das finde ich ziemlich aufdringlich von ihm. *Sören slept on, even though Felix rang his doorbell like crazy. I find that pretty obtrusive of him.*

We prepared each experimental item three times, once in each condition, for a total of 3 x 24 = 72 items per experiment. Each experiment had three lists of 24 items, over which the 72 items were distributed via Latin-square design. Each list also contained all the filler and catch filler items. Items in each list were presented in randomized order and lists were distributed equally across participants.

2.2. Hypotheses

All our experiments manipulate higher-level (clause-level) structures and investigate effects on the prominence of subject referents within those structures or on the prominence of those structures themselves. Our hypothesis on how the high-level manipulations affect the prominence of individual referents is the following:

(9) The (relative) prominence of higher-level units (clauses or propositions) is passed down to the lower-level units (arguments or individuals) contained within them

We call (9) the "Prominence Inheritance Hypothesis", because the lower-level units "inherit" the prominence status of the higher-level units. The hypothesis predicts that all else being equal, the prominence relation between two lower-level units *a* and *b*, contained within the higher-level units *A* and *B*, respectively, should reflect the prominence relation between *A* and *B*. The Prominence Inheritance Hypothesis shares the assumption that the accessibility of individual and propositional referents is related with the c-at-issueness approach (Hunter and Asher, 2016, Jasinskaja, 2016), as indicated above. However, that approach equates accessibility with being at the right frontier, which is categorical: a discourse unit is either at the right frontier or not. It also does not predict that formal parameters like syntactic subordination/coordination or typography should have an effect on prominence and accessibility that is independent of the status of the discourse units they correspond to. In contrast, the concept of discourse prominence (von Heusinger and Schumacher, 2019) which the Prominence Inheritance Hypothesis builds on takes into account prominence-lending cues from different formal domains and is a more gradient, relational notion. This is not to say that in this account the right frontier is unimportant: in our conception, it is a very strong constraint and forms something of a necessary condition on accessibility. However, once referents are at the right frontier, the c-at-issueness account does not predict any further differences in accessibility between them, while the prominence account and the Inheritance Hypothesis do[10].

We hypothesize that both syntactic subordination and a weak typographic boundary (comma) contribute to a stronger integration between the two clauses, making the first clause or the whole construction more prominent. Conversely, both syntactic coordination and a strong typographic boundary (full stop) make the second clause more independent and thus relatively more prominent. We hypothesize that the contributions of syntax and typography here are independent of each other and additive. This predicts for all experiments here that the first clause is most prominent in the *subordinating* condition, less prominent in the *coordinating comma*-condition (because of syntactic coordination but a weak typographic boundary), and least prominent in the *coordinating full stop*-condition (because of both syntactic coordination and a strong

[9] Originally, we had a second set of catch fillers that were gender-based as in the individual reference experiments. In them, the two subject referents were of different genders, and the predicate in the continuation sentence was explicitly connected to one of the subject referents via a prepositional phrase, e.g. *das finde ich cool von ihm/ihr* 'I found that cool of him/her'. This was intended to unambiguously tie resolution to the clause which had the subject referent with matching gender. We decided to not use these fillers as catch fillers because the only disambiguating feature in them, the graphene difference between <m> and <r>, in *von ihr/ihm* which always occurred in final position in the last sentence, was apparently too easy to overlook even for otherwise attentive participants. For instance, in Experiment 2, only 45.4 % of participants (59 out of 130 German natives with complete data) got all gender-based catch fillers right, while in the individual reference-experiments, the equally gender-based catch fillers always left about 60–70 % of participants. We treated these items simply as fillers.

[10] We thank reviewer Todd Snider for encouraging us to make these theoretical differences clearer.

typographic boundary). Buchholz, Hoek and von Heusinger (under review) showed that this is the case for *backward causality* and affects individual reference, but we here generalize this claim across discourse relations and for both individual and propositional reference. We hypothesize that this prominence relation between the levels of our experimental manipulation should essentially hold across all experiments, i.e. independent of the different discourse relations in the experiment pairs.

The Inheritance Hypothesis predicts that the prominence of the clauses gets inherited by the referents contained within them, so that we should see the same prominence relations between the conditions in the individual reference experiments (Experiments 1, 3, 5) as in their corresponding propositional reference experiments (Experiments 2, 4, 6). In terms of experimental measurements, we expect to see the decreasing prominence of the first clause across the three conditions (subordinating, comma-coordinating, full stop-coordinating) reflected in a decrease of resolutions to the first referent in the individual reference experiments and a decrease of resolutions to *first* in the propositional reference experiments.

Even though this main prediction is formulated in terms of a correspondence between resolution to *first* and the first clause subject referent, we will also look at resolution results to *second* and *both* in the propositional reference experiments. Generally, this will allow us to better understand propositional reference in contexts with several potential antecedents. Since this is still an understudied field, these results will thus be of general benefit for future research. Potentially, this might for instance allow us to also identify phenomena that affect individual and propositional reference differently.

More specifically, looking at the results for *both* allows us to further position our research in relation to some existing hypotheses. Propositional anaphors have been proposed to be universal bundlers (Wittenberg et al., 2021), i.e. to have the tendency to maximize their reference. If *das* really is a bundler, we should expect a majority resolution to *both*, which has maximal reference, independent of our conditions. Equally, Recasen's sloppiness hypothesis for propositional reference Recasens, 2008 can be interpreted to predict that since reference is formally ambiguous, *both* is the option that participants should choose if they want to hedge their bets. Arguably, it is often the least specific and thus most uncontroversial option.

This is why it is crucial to include *both* as an option in our propositional reference experiments: otherwise, any correspondence between individual and propositional reference might be due simply to the fact that participants could not go for the choice that might have been most natural to them. Conversely, if we do find resolution differences due to our conditions, and especially majority preferences for either of the two specific options *first* or *second*, this will mean that at the least, the discourse prominence of propositions is strong enough to constrain any bundling or sloppiness effects.

Comparing between the resolutions to *first* and *both* is also relevant for distinguishing between potential alternative discourse-structural analyses of our items. As one reviewer encourages us to point out, it is theoretically possible to conceive of the relation between the two discourse units corresponding to our first and second clause in different ways. Our assumption is that apart from those two, there always exists also a complex discourse unit (CDU) formed from the combination of these two discourse units together which semantically contributes the relation between the two. Now, there are several scenarios regarding the role this CDU plays in relation to the other DUs. In the first scenario, it could be that contrary to our assumption that the second clause is most recent, this CDU is actually the most recent discourse unit in the structure, and would then be alone at the right frontier since it is discourse-superordinate to the two simpler units. A second scenario is that independent of its recency status, this CDU only comes into existence in our two comma-conditions, but not in the full stop-condition, in which there are two full sentences. A third alternative scenario is that actually the relation between the discourse units corresponding to the two clauses is such that the DU corresponding to the first clause is not actually complete until the DU of the second clause is processed. In this scenario the DU of the first clause should be alone at the right frontier, since it is most recent and it is superordinate to the DU of the second clause. The last scenario is Hunter and Asher's (2016) analysis for embedded (medial) appositives, but since in our case the subordinate clause only begins once the first clause is complete, we assume that our examples are more similar to final (non-embedded) appositives, for which Hunter & Asher also propose that the DU corresponding to the final clause is most recent. Our experiments speak to this in the following way: if the superordinate CDU exists, it seems a safe assumption that *both* will target this CDU. Then, we can test the prediction made from the first scenario: if this CDU is really most recent and alone at the right frontier, we should see overwhelming resolution to *both* independent of our conditions. Similarly, the prediction made from the second scenario is that if this CDU does not exist in the full stop-condition, then resolution to *both* should dramatically decrease in that condition. And lastly regarding the third scenario, if the DU of the first clause is actually most recent in the discourse structure, then we should see overwhelming resolution to *first* whenever we have a discourse-structural subordination, which is unambiguously the case at least for the experiments using *backward* causality (Experiments 1 & 2). Since these considerations large apply to all of our experiments, we will return to what our results allow us to say about them only in the general discussion at the end of the paper.

2.3. Data availability and statistical analysis

The data and *R* markdown scripts as well as the full list of items for all experiments are available at the accompanying repository on *OSF*, at https://doi.org/10.17605/OSF.IO/ENCU4. Our statistical procedure was very similar across experiments: after data exclusion, we fitted Bayesian generalized mixed-effects models to the data using *brms* (Bürkner, 2017, Bürkner,

2018) in *R* (R Core Team, 2023). The models used weakly informative priors that do not skew the results in any direction but plausibly reduce the parameter search space so that convergence issues do not occur (cf. McElreath, 2020, Vasishth et al., 2018). For the individual reference data (Experiments 1, 3, 5), the model used a binomial link function, while for the propositional reference data (Experiments 2, 4, 6), it used a categorical link function because of the three outcome variables. Both models were treatment-coded, using the subordinated comma-condition as the intercept/reference category. The models included the three-level condition (*subordinated comma/coordinated comma/coordinated full stop*) as fixed effect, as well as random intercepts and slopes and their correlations for participant and item.

We used Bayesian statistics throughout the experiments because this allows us to fit complex models including all relevant random effects with relative ease. In addition, they provide us with a quantification of the uncertainty about our effects of interest via Credible Intervals (CrIs). The 95 %-CrI in Bayesian statistics indicates the interval within which values for the estimated parameter drawn from the posterior distribution lie with 95 % certainty, given the model and the data, thus providing a much more accessible interpretation of model results than in frequentist statistics. When the CrI does not include zero, we take that as evidence that the effect in question is reliable, again given the model and the data. In addition, we conduct one-sided hypothesis tests based on the posterior distribution. The hypothesis tests indicate the probability that an effect is either negative or positive, depending on the sign of the estimated parameter, based on the proportion of the corresponding posterior distribution that is negative or positive. In the result tables for the experiments we will present the results of the hypothesis tests in the following format: "p(*hypothesis tested*) = *value*", where *p* stands for probability, and the *hypothesis tested* is a statement about some relation between the estimated model parameters in the form of a larger-than- or smaller-than-inequality. The *value* given is the probability that this statement is valid based on the posterior distribution of the model. Thus e.g. if the table states "p (*denn* < 0) = 0.99", then this can be read as "the parameter value for the condition *denn* is smaller than zero (=negative) with a probability of 0.99, based on the posterior distribution", or "99 % of the values of the posterior distribution for the parameter value estimated for the condition *denn* are below zero (=negative)". The hypothesis tests can also assess statements about the relation between two different estimate distributions. For instance, if the table states "p (*first* in *weil* > *first* in *denn*) = 0.97", then this can be read as "the probability that the parameter value for the response *first* in the condition *weil* is larger than in the condition *denn* is 0.97, based on the posterior distribution", or "97 % of the values of the posterior distribution for the parameter value estimated for the response *first* in the condition *weil* are larger than in the condition *denn*". For the categorical models used for the propositional reference data, we use hypothesis tests on the posterior distributions after exponential transformation (see the scripts in the repository for details). For the binomial models, we use *emmeans* (Lenth, 2023) to translate results from the log–odds scale to the probability scale. All visualizations were created with *ggplot2* (Wickham, 2016).

2.4. Experimental procedure

The experimental procedure was largely the same for all experiments. Participation took place online. Participants followed a link to the experiment platform (*PCIbex*, Zehr and Schwarz, 2018) for Experiment 1, *Qualtrics* for Experiments 2–6) and were randomly assigned to one of the three lists of the experiment. At the beginning of the experiment, participants were informed about their rights and asked to give their consent for participation. All participants whose data we used in the six experiments gave their informed written consent for us to anonymously use their experiment data for scientific purposes. The experiments were approved by the Ethics Board of the German Linguistic Society (#2016–09E2_200213).

They received a short introduction to the experiment and (except in Experiment 1) two training items, and could then proceed to the experiment proper once they were ready. Items were presented in random order. For each item, participants were presented with the corresponding mini-discourse on their screen. Below the discourse on the screen, participants were asked for the referent of the pronominal subject of the nonce verb clause (in the individual reference) or about what the demonstrative anaphor *das* in the continuation referred to (in the propositional reference). They had to select between the two subject referents by clicking on their names (individual reference, Exps 1, 3, 5) or between the three clausal choices by clicking on the option where what they thought *das* referred to was underlined (propositional reference, Exps. 2, 4, 6). In both types of experiments, since reference of the anaphor was otherwise ambiguous, we expected our experimental conditions to influence participants' choices in the experimental items. This was different for the catch fillers, which we therefore intended to detect inattentive participants. Once participants had made their choice, they were presented with the next item. There was no time limit, but participants were instructed to make a quick selection based on their intuitions.

3. Experiments 1 + 2: backward causal relations

In the first pair of experiments, the discourse relation holding between the two propositions denoted by the two clauses in the items was a backward causal relation, which is discourse-structurally subordinating (*explanation* in Asher and Lascarides, 2003). This means that the second clause was always the causal antecedent for the first clause. In designing the items, we took care that even when realized as two sentences with a full stop in between and without a connective, the meaning of the two clauses in sequence would make a causal relation at the content level (Sweetser, 1990, Frey, 2016) always the most likely interpretation.

3.1. Conditions

In Experiments 1 + 2, the three conditions (subordinating, comma-coordinating, full stop-coordinating) were implemented via the subordinating connective *weil* 'because', the coordinating connective *denn* 'because' and without any connective, respectively. (10) gives an example item with the biclausal construction in the three conditions (10a-c), and the continuation with the ambiguous anaphor and the question posed to the participants in the individual reference-experiment (Experiment 1, 10d and 10f) and in the propositional reference-experiment (Experiment 2, 10e and 10g).

(10)

comma* + *subordination **"weil"**	a) Nadja hat vegane Burger gekauft, weil Sabine kein Fleisch isst.	
	Nadja has vegan burgers bought, because Sabine no meat eats	
comma* + *coordination **"denn"**	b) Nadja hat vegane Burger gekauft, denn Sabine isst kein Fleisch.	
	Nadja has vegan burgers bought, because Sabine eats no meat	
full stop* + *coordination **"2-sentence"**	c) Nadja hat vegane Burger gekauft. Sabine isst kein Fleisch.	
	Nadja has vegan burgers bought. Sabine eats no meat	
	individual (Exp1)	***propositional (Exp2)***
Continuation	d) Sie *daup*te.	e) Das finde ich typisch.
	She dauped	*That find I typical*
Task question	f) Wer *daup*te?	g) Worauf bezieht sich *das* im letzten Satz?
	Who dauped?	*What does* das *refer to in the last sentence?*

3.2. Predictions

Our primary predictions are that both individual reference (Experiment 1) and propositional reference (Experiment 2) should be sensitive to our manipulations in the expected direction. That means that reference to the first clause subject referent (Ref1, in Experiment 1) and reference to *first* (in Experiment 2) should decrease from the subordinating condition (with *weil*) to the coordinating comma-condition (with *denn*), and from there to the coordinating full stop condition (without a connective).

3.3. Participants

We recruited 106 German native speaking students for Experiment 1 (individual reference) and 156 students for Experiment 2 (propositional reference) as participants, all from the University of Cologne. They participated for course credit.

In Experiment 1 (individual reference), we excluded data from participants who gave at least one wrong answer to a catch filler item from the statistical analysis. This left data from 74 participants (65 female, 9 male; mean 21.7 years, age range 18–46 years) for the final analysis.

In Experiment 2 (propositional reference), we excluded data from all participants who were not German native speakers, whose data was incomplete, who took an overly long time to complete the experiment, or who gave at least one wrong answer to a catch filler item. This left data from 78 participants (67 female, 11 male; mean age 22.07 years, age range 18–38 years) for the final analysis.

3.4. Results

Fixed-effects results (in log-odds) of the binomial model for Experiment 1 (individual reference) together with translation to probabilities and results of relevant one-sided hypothesis tests are given in Table 2. For the categorical model for Experiment 2 (propositional reference), Table 3 gives only the translated probabilities and the results of relevant one-sided hypothesis tests, since the model coefficients on their own are not very informative and take up a lot of space. See the scripts in the repository (https://doi.org/10.17605/OSF.IO/ENCU4) for details. Figs. 2 and 3 provide a visualization of the model results for Experiment 1 and 2, respectively.

Table 2
Fixed-effects results of the Bayesian mixed-effects model for Experiment 1.

Condition	Estimate (Error)	95 %-CrI	MPPV [HPD region]	Hypothesis tests
Intercept (=weil) *comma + subordination*	0.56 (0.25)	[0.08; 1.06]	0.635 [0.517; 0.74]	
denn *comma + coordination*	−0.4 (0.16)	[−0.71; −0.09]	0.539 [0.416; 0.661]	p (*denn* < 0) = 0.99
2-sentence *full stop + coordination*	−2.28 (0.27)	[−2.83; −1.77]	0.153 [0.079; 0.23]	p (*2-sentence* < *denn*) = 1

Values for Estimate, Error and 95 % Credible Interval (CrI) are given on the logit scale. Median posterior predictive values (MPPV) and Highest Posterior Density (HPD, 95 %) region values are given in probabilities.

Table 3
Fixed-effects results of the Bayesian mixed-effects model for Experiment 2.

condition	Response	Estimate (error)	95 %-CrI	Hypothesis tests
weil *comma + subordination*	First	0.344 (0.045)	[0.258; 0.435]	
denn *comma + coordination*	First	0.275 (0.045)	[0.193; 0.372]	p (*first* in *weil* > *first* in *denn*) = 0.97
2-sentence *full stop + coordination*	First	0.131 (0.027)	[0.085; 0.19]	p (*first* in *denn* > *first* in *2-sentence*) = 1
weil *comma + subordination*	Second	0.285 (0.064)	[0.171; 0.43]	
denn *comma + coordination*	Second	0.433 (0.079)	[0.28; 0.596]	p (*second* in *weil* < *second* in *denn*) = 1
2-sentence *full stop + coordination*	Second	0.489 (0.084)	[0.324; 0.655]	p (*second* in *denn* < *second* in *2-sentence*) = 0.81
weil *comma + subordination*	Both	0.365 (0.061)	[0.251; 0.493]	
denn *comma + coordination*	Both	0.286 (0.063)	[0.174; 0.419]	p (*both* in *weil* > *both* in *denn*) = 0.97
2-sentence *full stop + coordination*	Both	0.375 (0.077)	[0.236; 0.536]	p (*both* in *denn* < *both* in *2-sentence*) = 0.94

Values are given in probabilities.

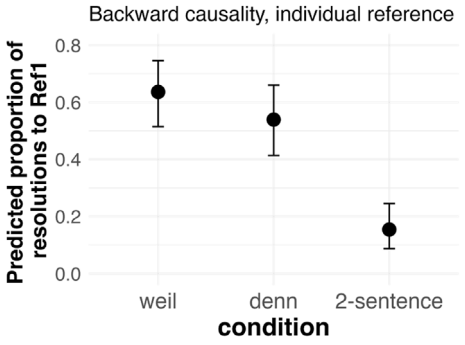

Fig. 2. Estimated marginal means plus HPD regions (error bars) for the three conditions of Experiment 1 (individual reference) based on the Bayesian model results. Values given are on the response scale and reflect the probability of the first-clause subject referent (Ref1) being chosen. Data from 74 participants.

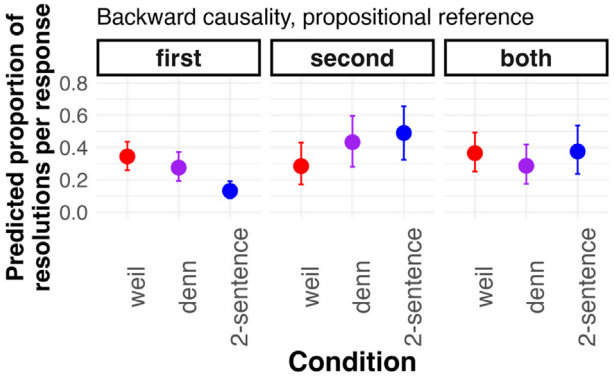

Fig. 3. Predicted values from conditional effects per condition and response for Experiment 2 (propositional reference). Values given are on the response scale and reflect the probability that a given response is chosen per condition. Data from 78 participants.

The hypothesis tests based on the model results confirm our predictions for both experiments: based on the model and the data, for individual reference (Experiment 1), resolution to the first clause subject referent reliably decreases from the subordinated *weil*-condition to the comma-coordinated *denn*-condition (from on average 64 %–54 % resolution, reliably negative change with p = 0.99) and from *denn* to the coordinated *2-sentence*-condition (54 %–15 %, p = 1). For propositional reference (Experiment 2), again based on the model and the data, resolution to the first clause also reliably decreases from *weil* to *denn* (from on average 34 %–28 % resolution, reliably negative change with p = 0.97) and from *denn* to *2-sentence* (28 %–13 %, p = 1), as predicted.

Resolution to *second* reliably increases from *weil* to *denn* (29 %–43 % resolution increase on average, reliably positive with p = 1), but the increase from *denn* to the coordinated full stop condition is less reliable (43 %–49 % increase on average, but probability that this change is positive is only at p = 0.81). Unlike the other two response choices, *both* does not show a trend in a single direction across the conditions: it shows a small decrease from *weil* to *denn* (37 %–29 %, p that this change is negative = 0.97), but an increase of similar size from *denn* to *2-sentence* (29 %–38 %, p that this change is positive = 0.94).

3.5. Discussion

The results show that the difference between the subordinated (*weil*) and the comma-coordinated (*denn*) conditions is smaller than that between the two coordinated conditions differentiated by typography (*denn* vs. *2-sentence*). This holds true both for individual reference measured in terms of resolution to the first clause subject referent in Experiment 1 and for propositional reference measured as resolution to *first* in Experiment 2. However, the absence of a connective in the *2-sentence* condition is a confound here, and we know that it affects at least individual reference independently from typography (Buchholz, Hoek and von Heusinger, under review). Therefore, at this point we should not automatically take this to mean that both a stronger typographic boundary (full stop) and the absence of a connective independently impact the prominence of the first clause; it could be that what we are seeing here is the effect of only one of these, although the relative size of the effect might suggest differently. The clear similarity in relative differences between the conditions as measured via the prominence of *first* or the first clause subject referent lends support to the Prominence Inheritance Hypothesis. It should not be too surprising that overall resolution to the first clause in Experiment 2 is clearly less than resolution to the first clause subject referent in Experiment 1, since there are 3 instead of 2 answer options in the propositional experiment.

In sum, the results from both experiments have confirmed the predictions regarding our hypothesis that manipulating how two clauses are combined syntactically and typographically affects the prominence of the first clause (Experiment 2) and that of its subject referent (Experiment 1) in a similar way. At this point, this correspondence might be particular to sentences with *backward causality*. In the next pair of experiments, we therefore test whether we also find it in another discourse relation that is the inverse of *backward causality*. Compared to *backward causality*, we expect the second clause to be more prominent there relative to the first clause, which predicts that if the Prominence Inheritance Hypothesis holds, the coreference pattern for both types of anaphora should shift accordingly.

4. Experiments 3 & 4: forward causal relations

For experiments 3 & 4, the discourse relation between the two clauses is a forward causal relation (*consequence*/*result*). In this relation, the order of the cause and the consequence is sequentially reversed compared to the backward causal relations (*explanations*) in experiments 1 & 2 (cf. Sanders et al., 1992, Asher and Lascarides, 2003, Volodina, 2014). We have the same three conditions as in experiments 1 & 2: syntactically subordinated, comma-coordinated, and full stop-coordinated. If the Prominence Inheritance Hypothesis is correct, the differing degree of structural integration should create the same pattern of similar resolution preferences between conditions for individual and propositional reference, independent of whether the direction of causality is backward or forward.

However, differences in overall resolution between the two sets of experiments are to be expected: while *backward* and *forward causality* are commonly considered semantically just inverses of each other, in SDRT, *forward causality* (*result*) is a coordinating discourse relation, while *backward causality* (*explanation*) is subordinating (cf. Reese et al., 2007, p.8), with the discourse unit corresponding to the second clause the (discourse-)subordinated one. This would mean that for the forward causal relations in experiments 3 & 4, at the point the continuation is processed, only the second clause is still accessible at the RF. This would predict almost categorical resolution to the second clause and its subject. However, such a prediction might be too strong, due to a theory-internal mechanism: In SDRT, a discourse-subordinate unit can never completely precede the main unit it belongs to.[11] Rhetorical Structure Theory (RST) does not impose the same restriction on its related principle of Nuclearity: a satellite (the subordinate) unit there can also precede the Nucleus it belongs to (cf. Mann and Thompson, 1988). Both frameworks, however, would predict that in forward causal relations the second clause (the consequence) is the more prominent one. In somewhat different terms, Volodina (2014), also makes a similar argument. According to her, German

[11] One reviewer points out that there are cases where a discourse-subordinate unit may be embedded inside a superordinate unit and thus chronologically precede parts of it, as with medially positioned appositives under the analysis by Hunter & Asher (Hunter and Asher, 2016):

i) [While she was filming Fresh Prince,]π4 [her mother, [who then worked as a librarian,]π5 would call her with Black history stories.]π6

In i) ((4) in (Hunter and Asher, 2016), p.1031), the discourse unit corresponding to the medial appositive *who then worked as a librarian* is related to the discourse unit corresponding to the main clause *her mother would call her with Black history stories* by a *Background* relation, which is subordinating, but the appositive is embedded inside the main clause and thus ends before all of the main clause has ended. However, we assume that such an analysis does not apply to our study, since in our examples the main clause is always complete, also in chronological terms, before the subordinate clause begins.

consequence-marked clauses are communicatively more restricted than cause-marked clauses: they are always used to introduce the consequence into the discourse as a new state of affairs to be discussed, with the cause treated as already established in the discourse.

4.1. Conditions

(11) gives example items in all conditions for Experiments 3 & 4. The subordinated condition uses the connective *so dass*, the coordinated comma-condition *also*. Items were again designed so that in all three conditions, a forward causal relation at the content level (Sweetser, 1990, Frey, 2016) would be the most plausible interpretation.

(11)	***comma* + *subordination*** **"so dass"**	a) Norbert hatte die Hände voll, so dass Christian die Tür aufgeschlossen hat. *Norbert had the hands full, so Christian the door opened has*	
	comma* + *coordination **"also"**	b) Norbert hatte die Hände voll, also hat Christian die Tür aufgeschlossen. *Norbert had the hands full, so has Christian the door opened*	
	full stop* + *coordination **"2-sentence"**	c) Norbert hatte die Hände voll. Christian hat die Tür aufgeschlossen. *Norbert had the hands full. Christian has the door opened*	
		individual (Exp3)	***propositional (Exp4)***
	Continuation	d) Er *wöff*te. *He* wöffed	e) Das finde ich überraschend. *That find I surprising*
	Task question	f) Wer *wöff*te? *Who* wöffed?	g) Worauf bezieht sich *das* im letzten Satz? *What does* das *refer to in the last sentence?*

4.2. Predictions

Our primary predictions are the same as in the previous experiments: individual reference (Experiment 3) and propositional reference (Experiment 4) should be sensitive to our manipulations in the expected direction, with reference to the first-clause subject referent (Ref1) (in Experiment 3) and reference to *first* (in Experiment 4) decreasing from the subordinating condition to the coordinating comma-condition, and from there to the coordinating full stop condition. Compared to the results from Experiments 1 & 2 with *backward causality*, we should expect an overall lower resolution to the first clause and its referent.

4.3. Participants

We recruited 75 German native speaking participants for Experiment 3 (individual reference) and Experiment 4 (propositional reference) each via the platform Prolific[12] and paid them for their participation. Participants in Experiment 3 were excluded from participation in Experiments 4 and 5 and vice versa. Participants in Experiment 4 were excluded from participation in Experiments 3 and 6 and vice versa.

In Experiment 3 (individual reference), we excluded data from participants who gave at least one wrong answer to a catch filler item from the statistical analysis. This left 67 participants (30 female, 36 male, 1 non-binary; mean age 35.1 years, age range 20–67 years) for the final analysis.

In Experiment 4 (propositional reference), we excluded data from participants who gave at least one wrong answer to a catch filler item. This left data from 53 participants (16 female, 34 male, 2 non-binary, 1 diverse; mean age 35.1 years, age range 19–64 years) for the final analysis.

4.4. Results

Fixed-effects results for Experiment 3 (individual reference) and Experiment 4 (propositional reference), are given in Tables 4 and 5, respectively. Figs. 4 and 5 provide a visualization of the results for Experiment 3 and 4, respectively.

[12] Our criteria for participant selection on Prolific for all experiments were that (according to themselves) they had to be located in Germany and have lived there at least 5 years, have German as their first and primary language, be fluent in it, have no language related disorders, and have at least a completed high school education. We estimated that participants would take 8 (individual reference) or 11 (propositional reference) minutes on average for completion and paid 9 GBP per hour.

Table 4
Fixed-effects results of the Bayesian mixed-effects model for Experiment 3.

Condition	Estimate (Error)	95 %-CrI	MPPV [HPD region]	Hypothesis tests
Intercept (= so dass) *comma + subordination*	0.08 (0.29)	[−0.49; 0.65]	0.521 [0.378; 0.655]	
also *comma + coordination*	−0.84 (0.22)	[−1.29; −0.42]	0.321 [0.185; 0.471]	p (*also* < 0) = 1
2-sentence *full stop + coordination*	−1.29 (0.23)	[−1.77; −0.86]	0.174 [0.127; 0.354]	p (*2-sentence* < *also*) = 0.94

Values for Estimate, Error and 95 % Credible Interval (CrI) are given on the logit scale. Median posterior predictive values (MPPV) and Highest Posterior Density (HPD, 95 %) region values are given in probabilities.

Table 5
Fixed-effects results of the Bayesian mixed-effects model for Experiment 4.

Condition	Response	Estimate (error)	95 %-CrI	Hypothesis tests
so dass *comma + subordination*	First	0.372 (0.06)	[0.258; 0.491]	
also *comma + coordination*	First	0.266 (0.057)	[0.162; 0.39]	p (*first* in *so dass* > *first* in *also*) = 0.99
2-sentence *full stop + coordination*	First	0.198 (0.049)	[0.115; 0.308]	p (*first* in *also* > *first* in *2-sentence*) = 0.95
so dass *comma + subordination*	Second	0.358 (0.087)	[0.204; 0.547]	
also *comma + coordination*	Second	0.519 (0.096)	[0.329; 0.704]	p (*second* in *so dass* < *second* in *also*) = 1
2-sentence *full stop + coordination*	Second	0.58 (0.097)	[0.382; 0.757]	p (*second* in *also* < *second* in *2-sentence*) = 0.84
so dass *comma + subordination*	Both	0.261 (0.062)	[0.152; 0.397]	
also *comma + coordination*	Both	0.209 (0.061)	[0.107; 0.346]	p (*both* in *so dass* > *both* in *also*) = 0.89
2-sentence *full stop + coordination*	Both	0.215 (0.067)	[0.105; 0.37]	p (*both* in *also* < *both* in *2-sentence*) = 0.56

Values are given in probabilities.

According to the results and the hypothesis tests, in Experiment 3 (individual reference), based on the model and the data, resolution to the first-clause subject referent (Ref1) decreases reliably from the subordinated *so dass*-to the comma-coordinated *also*-condition (52 %–32 % resolution on average, p that this change is negative = 1). It also likely decreases from *also* to the full stop-coordinated *2-sentence*-condition, (32 %–17 % on average), with the probability that this is indeed a negative change given the model and the data being at p = 0.94 and thus marginally reliable.

For propositional reference in Experiment 4, resolution to *first* reliably decreases from the subordinated *so dass*-condition to the comma-coordinated *also*-condition (37 %–27 % on average, p that this change is negative = 0.99) and from *also* to *2-sentence* (27 %–20 %, p that this change is negative = 0.95). Resolution to *second* increases reliably from *so dass* to *also* (36 %–52 % on average, p = 1) but then seems to remain there; resolution to *both* is between 21 % and 26 % on average and not reliably affected by the conditions.

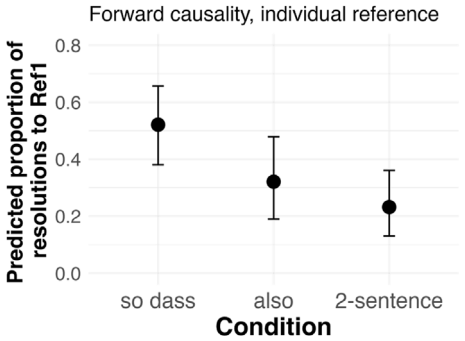

Fig. 4. Estimated marginal means plus HPD regions (error bars) for the three conditions of Experiment 3 (individual reference) based on the Bayesian model results. Values given are on the response scale and reflect the probability of the first-clause subject referent being chosen. Data from 67 participants.

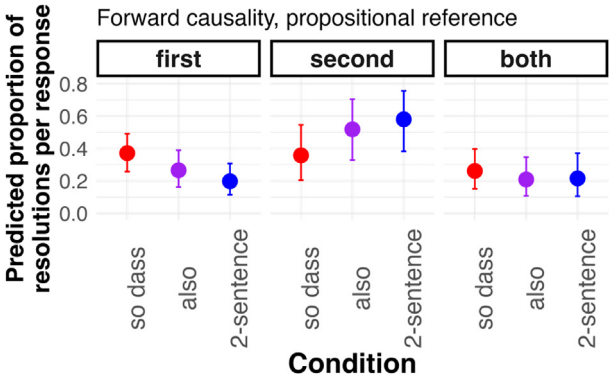

Fig. 5. Predicted values from conditional effects per condition and response for Experiment 4 (propositional reference). Values given are on the response scale and reflect the probability that a given response is chosen per condition. Data from 53 participants.

4.5. Discussion

The results confirm our primary predictions again: reference to the first clause subject referent in Experiment 3 decreases from the subordinated to the comma-coordinated to the full stop-coordinated condition to a similar extent as reference to the first clause does in Experiment 4.

These data are therefore also in line with the Prominence Inheritance Hypothesis.

Regarding our additional prediction that resolution to the first clause and its referent should be lower here than in the experiments using backward causal relations, we can state that indeed, resolution to the first clause subject referent in Experiment 3 is notably lower than in Experiment 1 in the conditions that use a comma (52 % and 32 % in *sodass* and *also* compared to 64 % and 54 % in *weil* and *denn*). Comparing propositional reference, resolution to the first clause is at the same level in Experiment 4 (37 %, 27 %, 20 % per condition) as in Experiment 2 (34 %, 28 % and 13 %), but we do see a difference in resolutions to the second clause (the consequence clause itself): this is overall higher in the forward causal relations (36 %, 52 %, 58 %) than in the backward causal relations (29 %, 43 %, 49 %). Resolution to *both* is lower in the forward causal relations than in the backward causal relations (21–26 % vs. 29–38 %). Notably, this is an *overall* difference between the *forward* and *backward causality* that affects all conditions equally. It does not seem to be the case that any one of our conditions is affected more than the others by this difference in discourse relations.

The comparatively lower resolution to *both* and higher resolution to *second* seems to be what gets translated to a lower resolution to the first clause subject referent in Experiment 3 (compared to Experiment 1). This could be interpreted as the two clauses in the forward causal relations in Experiments 3 & 4 being seen as less semantically integrated than the two clauses in the backward causal relations. This is on the one hand compatible with the idea that the forward causal relations would be discourse-structurally coordinating and the backward causal relations subordinating. On the other hand, the coreference patterns are not entirely compatible with an account where these forward causal relations are discourse-structurally coordinating and therefore only make the second clause accessible by virtue of being at the Right Frontier. Instead, our results seem more in line with RST's analysis of *result* relations, where the consequence is deemed more central to the discourse than (and thus discourse-structurally superordinate to) the cause.

We have now seen that our Prominence Inheritance Hypothesis is supported across two different discourse relations: backward and forward causal relations. In both pairs of experiments, the degrees of syntactic and typographic integration that our conditions manipulate affect propositional and individual reference to a very similar degree, and the difference in discourse relations between the two experiment pairs largely does so too. This is strong support for the idea that prominence as a structural principle is inherited downwards from the larger units to the smaller ones contained within them, affecting both types of reference. However, that does not mean that necessarily all kinds of manipulation at the clausal level should affect propositional and individual reference in the same way. With the last pair of experiments, we test how prominence inheritance interacts with another discourse relation, *violation of expectation*.

5. Experiments 5 & 6: violation of expectation

In Experiments 5 & 6, we intended the discourse relation between the two clauses to always be *Violation of expectation* (cf. Asher and Lascarides, 2003), a stronger version of the more general notion of *Contrast* (cf. Repp, 2016, Sanders et al., 2021, Prasad et al., 2008). Thus, in (12) the second clause in a-c) always creates an expectation or background assumption that is at odds with the content of the first clause. Unlike the causal relations in Experiments 1–4, *violation of expectation* relations tend to be overtly marked (Asr and Demberg 2012, Hoek et al., 2017). We therefore also used a connective in the coordinated full stop condition, but inserted it after the second-clause verb in an adverbial position in the middle field in order to minimize potential integrating effects. In the syntactically subordinated condition we used *obwohl* ('in spite of', 'although'); in the two syntactically coordinated conditions we used *aber* ('but'). Both connectives are compatible with and commonly used in

violation of expectation relations (DiMLex, 2002), and in constructing the items we made sure that the most likely interpretation of the relation was the same between conditions. However, while *obwohl* is quite restrictive in signaling a *violation of expectation*, *aber* is more flexible and can be interpreted in a number of ways (Breindl, 2014a, 2014b). While we thus aimed to make the conditions in this pair of experiments as similar as possible to those in the previous experiments in terms of syntax and typography, both the presence of the connective in the full stop-condition and the difference in semantic flexibility between *obwohl* and *aber* introduce additional factors. Our design was thus not as controlled as in Experiments 1–4. Since we used the same content in all three conditions, we think that we were as close to a uniform discourse relation across conditions as possible. However, we will see that the additional factors interact with the prominence relations in very interesting ways. (12) gives an example set of experimental items for Experiments 5 & 6.

(12)

comma* + *subordination **"obwohl"**	a) Pia hat Scrabble mitgebracht, obwohl Sophia keine Spiele mag. *Pia has Scrabble brought.with, even though Sophia no games likes*	
comma* + *coordination **"aber"**	b) Pia hat Scrabble mitgebracht, aber Sophia mag keine Spiele. *Pia has Scrabble brought.with, but Sophia likes no games*	
full stop* + *coordination **"2-sentence"**	c) Pia hat Scrabble mitgebracht. Sophia mag aber keine Spiele. *Pia has Scrabble brought.with. Sophia likes but no games*	
	Individual (Exp3)	***Propositional (Exp4)***
Continuation	d) Sie *trehm*te. *She* trehm*ed*	e) Das finde ich typisch. *That find I typical*
Task question	f) Wer *trehm*te? *Who* trehm*ed?*	g) Worauf bezieht sich *das* im letzten Satz? *What does* das *refer to in the last sentence?*

5.1. Items

In addition to the new set of experimental items, we created a new set of filler items, since many of the previous fillers had included *obwohl* and *aber* (see the list of items in the supplementary materials on *OSF*, at https://doi.org/10.17605/OSF.IO/ENCU4). Apart from that, everything was the same as in previous experiments.

5.2. Predictions

Our baseline predictions are the same as in the previous experiments: both individual reference (Experiment 5) and propositional reference (Experiment 6) should be sensitive to our manipulations in the expected direction, with reference to the first subject referent (Ref1) (in Experiment 5) and reference to *first* (in Experiment 6) decreasing from the subordinating condition (with *obwohl*) to the coordinating comma-condition (with *aber*), and from there to the coordinating full stop condition (with full stop and postverbal, adverbial *aber*).

However, both the presence of the connective in the full stop-condition and the difference in semantic flexibility between *obwohl* and *aber* are additional changes that probably do not affect all of our conditions in the same way. We might therefore expect different resolution ratios between the conditions than in the previous experiments. Potentially, these additional factors might also affect individual and propositional reference differently. We did not make any specific predictions in this regard.

5.3. Participants

We again recruited 75 German native speakers each for the two experiments via Prolific and paid them for their participation. Participants in Experiment 5 were excluded from participation in Experiments 6 and 3 and vice versa. Participants in Experiment 6 were excluded from participation in Experiments 5 and 4 and vice versa. We used the same catch filler exclusion criteria as before.

For Experiment 5 (individual reference), this left data from 49 participants (32 female, 16 male, 1 non-binary; mean age 38.4 years, age range 21–63 years) for the final analysis.

For Experiment 6 (propositional reference), this left data from 58 participants (31 female, 25 male, 1 non-binary, 1 no gender information; mean 33.9 years, age range 20–60 years) for the final analysis.

5.4. Results

Fixed-effects results for Experiment 5 (individual reference) and Experiment 6 (propositional reference), are given in Tables 6 and 7, respectively. Figs. 6 and 7 provide a visualization of the results for Experiment 5 and 6, respectively.

Table 6
Fixed-effects results of the Bayesian mixed-effects model for Experiment 5.

Condition	Estimate (Error)	95 %-CrI	MPPV [HPD region]	Hypothesis tests
Intercept (=obwohl) *comma + subordination*	0.14 (0.27)	[−0.4; 0.68]	0.534 [0.404; 0.665]	
aber *comma + coordination*	−0.71 (0.24)	[−1.18; −0.24]	0.36 [0.236; 0.501]	p (*aber* < 0) = 1
2-sentence *full stop + coordination*	−1.7 (0.31)	[−2.33; −1.11]	0.174 [0.091; 0.274]	p (*2-sentence* < *aber*) = 1

Values are given in probabilities. Values for Estimate, Error and 95 % Credible Interval (CrI) are given on the logit scale. Median posterior predictive values (MPPV) and Highest Posterior Density (HPD, 95 %) region

Table 7
Fixed-effects results of the Bayesian mixed-effects model for Experiment 6.

Condition	Response	Estimate (error)	95 %-CrI	Hypothesis tests
obwohl *comma + subordination*	First	0.673 (0.069)	[0.523; 0.796]	
aber *comma + coordination*	First	0.3 (0.059)	[0.189; 0.425]	p (*first* in *obwohl* > *first* in *aber*) = 1
2-sentence *full stop + coordination*	First	0.302 (0.061)	[0.188; 0.432]	p (*first* in *aber* > *first* in *2-sentence*) = 0.47
obwohl *comma + subordination*	Second	0.025 (0.012)	[0.009; 0.06]	
aber *comma + coordination*	Second	0.449 (0.1)	[0.258; 0.654]	p (*second* in *obwohl* < *second* in *aber*) = 1
2-sentence *full stop + coordination*	Second	0.461 (0.102)	[0.268; 0.661]	p (*second* in *aber* < *second* in *2-sentence*) = 0.58
obwohl *comma + subordination*	Both	0.299 (0.071)	[0.174; 0.453]	
aber *comma + coordination*	Both	0.243 (0.063)	[0.133; 0.383]	p (*both* in *obwohl* > *both* in *aber*) = 0.76
2-sentence *full stop + coordination*	Both	0.228 (0.063)	[0.121; 0.37]	p (*both* in *aber* > *both* in *2-sentence*) = 0.61

Values are given in probabilities.

As the results show, there are again reliable differences between the three conditions for Experiment 5 (individual reference), based on the model and the data: from the subordinated *obwohl*-condition to the comma-coordinated *aber*-condition, resolution to the first clause subject referent decreased from on average 53 %–36 %, from the comma-coordinated *aber*-condition to the full stop-coordinated *2-sentence* condition from 36 % to 17 % (both negative changes with p = 1). For Experiment 6 (propositional reference), again given the model and the data, resolution to the first clause also reliably decreased from *obwohl* to *aber* (67 %–30 %, negative change with p = 1), but it did not from *aber* to *2-sentence* (remaining at 30 %, negative change with p = 0.47). Resolution to the second clause also reliably increased only from *obwohl* to *aber* (3 %–45 %, p = 1), but not from *aber* to *2-sentence* (from 45 % to 46 %, p = 0.58). Resolution to *both* did not reliably change between the conditions (varying between 23 % and 30 %).

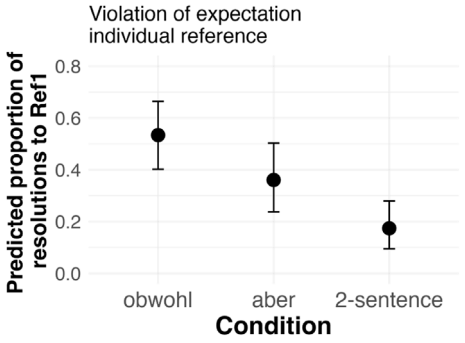

Fig. 6. Estimated marginal means plus HPD regions (error bars) for the three conditions of Experiment 5 (individual reference) based on the Bayesian model results. Values given are on the response scale and reflect the probability of the first-clause subject referent being chosen. Data from 49 participants.

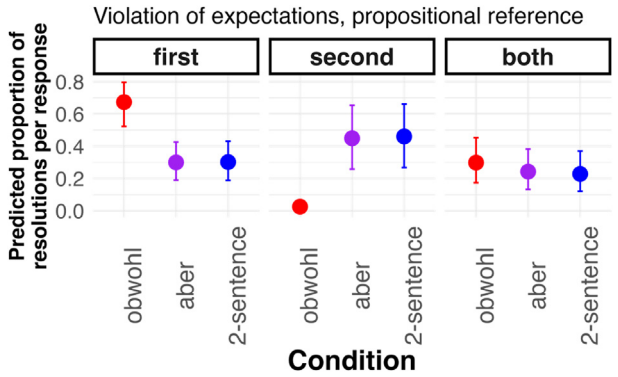

Fig. 7. Predicted values from conditional effects per condition and response for Experiment 6 (propositional reference). Values given are on the response scale and reflect the probability that a given response is chosen per condition. Data from 58 participants.

5.5. Discussion

With this last pair of experiments using *violation of expectation* as the discourse relation, results show a reliable three-way differentiation according to our conditions for individual reference (Experiment 5), but only a two-way differentiation between the subordinated to the coordinated conditions for propositional reference (Experiment 6). Compared to the previous experiment pairs, especially the one on *backward causality* (Experiments 1 & 2), the difference between the two coordinated conditions (comma vs. full stop) seems to have had no effect on the resolution to the first clause in Experiment 6. In addition, resolution to the second clause is effectively at zero in the *obwohl*-condition of Experiment 6 here, while resolution to the second-clause subject in Experiment 5 in the same condition is at around 47 %.

We thus observe two points of divergence of the results of the propositional anaphors in the discourse relation of *violation of expectation* (Experiment 6) with respect to the individual anaphors in the same discourse relation (Experiment 5) as well as to the propositional anaphors in the two other discourse relations (Experiments 2 and 4). These raise the question whether the results in experiment 6 truly reflect the prominence relations between the propositions. It should be kept in mind that we use propositional anaphors only as a proxy for the prominence of a proposition, and that additional factors can influence the resolution preferences of anaphors beside the prominence of their referents. If our results do reflect the prominence relations between propositions, then the Prominence Inheritance Hypothesis would have to be revised for this discourse relation. In the following we will lay out the reasons why we believe that this is not the case and that instead the two points of divergence here are indeed caused by some of the additional factors we introduced in this final experiment pair.

The first point is related to the *obwohl*-condition in propositional reference (Experiment 6) vs in individual reference (Experiment 5). Our results in Experiment 6 at first seem to suggest that the second clause in the *obwohl*-condition is entirely inaccessible to propositional anaphora. It has been argued that the proposition denoted by an *obwohl*-clause is not asserted: it cannot be targeted by a direct denial like *no that's not true* (Breindl, 2014b, p. 914). So rather than first being put up for discussion like asserted content (Farkas and Bruce, 2010), the content of an *obwohl*-clause is presumably directly imposed on the common ground (as a conventional implicature Anderbois et al., 2015, Potts, 2015, Fliessbach, 2023). However, if this is indeed the case, the continuations we used in the propositional reference experiments might simply be infelicitous for attaching to this type of content for semantic and pragmatic reasons, rather than because such a proposition has such low prominence that it is inaccessible. Recall that the continuations were always either *das finde ich typisch* or *das finde ich überraschend* 'I find that typical/surprising'. Assuming the speaker just imposed the content of the *obwohl*-clause on the common ground and therefore treats it as being taken for granted (uncontroversially true), it would be redundant for the same speaker/writer to follow this up by saying that it is typical (to be expected from the common ground), and blatantly contradictory to say that it is surprising (unexpected from the common ground). It would thus not be the case that conventionally implicated content is inaccessible for propositional reference on principle, but just in the specific context of

these two continuations. Consequently it should be possible to attach to only the content of an *obwohl*-clause via *das* with a continuation that is not pragmatically restricted in this way. And this is indeed the case, at least for some German speakers:[13]

(13) Benjamin hat den Ofen ausgemacht, obwohl Erik einen Kuchen backen wollte.
Benjamin has the oven turned.off, even though Erik a cake bake wanted
Das war ja eigentlich sein Plan für heute gewesen.
That was JA actually his plan for today been
Benjamin turned off the oven, even though Erik wanted to bake a cake. As we know, that had actually been his plan for today.

(14) Nadja hat Rinderbouletten gekauft, obwohl Sabine kein Fleisch isst.
Nadja has beef.burgers bought, even though Sabine no meat eats
Das ist ja schon seit drei Jahren so.
That is JA already since three years so
Nadja bought beef burgers, even though Sabine doesn't eat meat. As we know, that's been the case for the last three years.

(15) Pia hat Scrabble mitgebracht, obwohl Sophia keine Spiele mag.
Pia has Scrabble brought.with, even though Sophia no games likes
Das ist ja eigentlich bekannt.
That is JA actually known
Pia brought Scrabble, even though Sophia doesn't like boardgames. Actually everyone knows that.

If this account is correct, it can explain the difference in resolution between propositional and individual reference for *obwohl* (Experiments. 6 vs. 5) without affecting the Prominence Inheritance Hypothesis: in our individual reference experiments, the nonce-verb continuations avoid these kinds of context/infelicity effects (note that context effects are well-documented also for individual reference in other cases, see e.g Koornneef and Sanders, 2013, Bott and Solstad, 2014, Simovic and Chambers, 2024, and for propositional reference, see Meijer and Repp, 2016), and they might thus actually better reflect the prominence of the *obwohl*-clause. In order for this explanation to really hold, our account of the specific effects of continuation on the accessibility of non-asserted content needs to be properly empirically investigated. We leave this to future research for the moment.

The second point is related to different patterns in the resolution rates in the two *aber*-conditions, which firstly behave differently from the *obwohl*-condition and secondly behave very similar to each other, unlike in experiments 2 and 4. Even when both signal the same relation, we do not expect the second clause to be as inaccessible with *aber* as in the *obwohl*-condition, since an *aber*-clause, unlike an *obwohl*-clause, has been argued to be independently asserted, (Breindl, 2014a, 2014b, cf. Charnavel, 2017 who argues for a similar difference between *because* and *since*). Indeed, we found that the propositions denoted by the *aber*-clauses are as accessible as the individual referents in the *aber-comma*-condition of the individual anaphor experiment (Exp. 5). In addition, we pointed out that *obwohl*-clauses are likely much more restrictive than *aber*-clauses in how they can be interpreted: in addition to signaling a violation of expectation, *aber* can also be interpreted as signaling contrast in other and much broader senses (see Repp, 2016, Sanders et al., 2021) for an overview). While we took care in designing each item to be as equivalent as possible between conditions, participants saw each item in only one condition – when seeing an item in just one of the conditions that used *aber*, participants likely often interpreted the relations as contrast in a broader sense, e.g. merely juxtaposing two propositions that are parallel in some way. While in a *violation of expectation* relation, the two propositions are semantically very integrated, with the first clause conveying the more important proposition, they are much more independent if they are just juxtaposed with each other. The assumption that participants interpret the two *aber*-conditions as contrast relations likely also contributes to why there are more resolutions to *second* than in *obwohl*. Yet there is also the unexpectedly good accessibility of the first clause in the full stop-coordinated *2-sentence* condition. This differs from the propositional anaphors in the other discourse relations (Experiments 2 and 4) and crucially also from the individual anaphors in the same relation in Experiment 5, and is so far unexplained.

We think this may reflect a genuine difference between individual and propositional reference. In Centering Theory (Grosz et al., 1995, Grosz et al., 1995), topics (individual referents) are assumed to be updated across sentences, not clauses.

[13] All the examples here use the discourse particle *ja* in the continuation, because in our intuition this strengthens reference to the *obwohl*-clause. The particle *ja* has been analyzed as a reminder that a proposition is already in the common ground and has been found to be often used in a discourse segment that stands in a *background* relation to another, i.e. a segment that serves to facilitate understanding of the information in the other segment or in an *evidence* relation, providing evidence for the information in the other segment (cf. (Döring and Repp, 2019)). These observations about *ja* can serve as pointers for future investigations regarding which conditions must hold for a continuation to be able to attach to the content of an *obwohl*-clause like ours. Potentially, a proposition *q* that is itself in the common ground (which *ja* reminds the interlocutors of) could be better suited to attach to another proposition *p* that is also in the common ground (the content of the *obwohl*-clause), although surely other factors will also play a role. Some of them might be that a specific relation like *background* should plausibly hold between *p* and *q*. It seems to us that neither *das finde ich typisch* nor *das finde ich überraschend* suit these conditions particularly well.

Based purely on our intuition, we would thus not expect that if we just added *ja* to our original continuations, the *obwohl*-clauses would suddenly become perfectly accessible (or as accessible as in the individual reference experiments). Presumably, the content of the continuation *q* has to by itself be somewhat compatible with an interpretation as *background* only to the content *p* of the *obwohl*-clause (if that is indeed what makes attachment to it possible). In our intuition, *ja* facilitates or contributes to such an interpretation, but does not on its own enforce it. In a perhaps somewhat comparable case, the modal particle *ook* 'also' in Dutch was found to make a contribution to the preferred reference of a propositional anaphor whose effect size covaried with tense (cf. Meijer and repp, 2016). The tentative takeaway is that propositional anaphor resolution can be affected by the presence of particles, but in interaction with other factors.

In any case, we stress that these suggestions need to be experimentally tested in future work.

Miltsakaki (2011) and Buchholz, Hoek and von Heusinger (under review) present experimental evidence in favour of this idea (cf. also Just and Carpenter, 1980 and Bredel, 2008 for sentence wrap-up effects signaled by a full stop, also in German). Thus, the unit of a sentence seems to play an important role for individual reference. However, for propositional reference, this seems less plausible: it is uncontroversial that a propositional anaphor can take as its antecedent a complex combined proposition built from several independent sentences (our own results show that resolution to *both* is not negatively affected by the full stop-conditions). This seems less possible with individual reference, when the referential expression is in the singular.[14] We therefore suggest that our necessary addition of a connective to the full stop-condition here uncovered a hidden difference between individual and propositional reference: the prominence of propositional referents in a complex configuration is affected by the discourse relation between the propositions and whether and how it is signaled by connectives, but seemingly not by whether these propositions are realized as clauses or sentences. Discourse relations and connectives also affect individual reference (via Prominence Inheritance in our conception). But in addition, there seems to be a sentence-based recency effect for individual referents: everything else being equal, individuals in the most recent sentence are more prominent than individuals further away, with sentence boundaries conventionally signaled via the typographic full stop. The prominence of singular individual, but not of propositional, referents thus incurs a recency penalty when there is a sentence boundary between antecedent and pronoun. We leave a further exploration of our suggestion that the full stop does not matter (as much) for propositional reference as it does to (singular) individual reference to future research.

There is one additional observation to be made here: in SDRT, Contrast is considered a discourse-structurally coordinating relation (Asher and Lascarides, 2003, Reese et al., 2007), which again would predict that the first clause in our prompts is inaccessible by virtue of not being at the Right Frontier. However, SDRT's subsuming of all negative rhetorical relations under the single label of Contrast is controversial, and, as already pointed out above, other analyses of discourse relations make a more fine-grained differentiation (see Repp, 2016, Sanders et al., 2021) for an overview). RST, for instance, would consider the first clause in the relations we use to be the nucleus, and thus more prominent discourse segment. Our results here do support the latter more fine-grained approaches, since we clearly do not see an almost categorical resolution to only the second clause.

6. General discussion

Our study set out to test for the first time whether propositional and individual anaphora respond in a similar way to formal changes in the discourse, like syntactic subordination/coordination, typographic boundaries and the presence of connectives, as well as to the type of discourse relation. Our parallel experiments overwhelmingly show that they do: syntactic subordination/coordination, typographic boundaries and the presence/absence of connectives affect similar changes (in the same direction) in propositional and individual reference *within* the experiment pairs, while the type of discourse relation affects overall changes for both types of reference in a similar way *between* the experiment pairs. These results lend support to the Prominence Inheritance Hypothesis we laid out at the beginning: the prominence of clauses gets inherited by the referents contained within them. They also clearly support a model of discourse prominence as an overarching structural principle for a number of important linguistic phenomena and across different kinds of linguistic units (cf. von Heusinger and Schumacher, 2019).

Apart from this main overall result, our experiments have also shed light on the question of where the factors that impact individual and propositional anaphora diverge. As we pointed out in the introduction, it is unlikely that these factors overlap to 100 %, and our knowledge of propositional anaphora in general as well as how they differ from individual anaphora is still quite limited.

This came out most clearly in the experiments with *violation of expectation* as the discourse relation (Experiments 5 & 6), where the second clause with *obwohl* was almost never resolved to in propositional reference, but the second-clause subject was chosen much more often in individual reference. We have argued that this is because the two continuations we used in the propositional reference experiments (*das finde ich typisch/überraschend* 'I find that typical/surprising') both cannot refer to the *obwohl*-clause, whose content is directly introduced into the common ground without discussion, because that would result in pragmatic incoherence/infelicity, which is separate from inaccessibility. In contrast, the nonce verb-continuation in the individual reference experiment is not affected by this and shows the *obwohl*-clause to be relatively prominent and accessible. For the case of the *obwohl*-clauses, we would therefore say that the individual

[14] Reviewer Todd Snider points out that personal pronouns can also regularly create complex referents from antecedents that are potentially several sentences away, as in (i), when they are in the plural:

(i) Alex went to the park. Billie was there reading a book. They greeted one another and chatted for a bit.We agree that *they* here clearly refers to the complex referent composed of *Alex* together with *Billie*, even though *Alex* is more than one sentence away. But with a singular pronoun such a complex referent is obviously not possible. Anaphoric propositional reference thus seems to behave more like plural than singular individual reference in this respect (but note that in our results, majority resolution still goes to an individual proposition rather than *both*, and at least in English and German, anaphoric reference to propositions usually happens via singular forms (*das*, *es*/*that, this*) even when the referent is really composed of several propositions, so in other regards anaphoric propositional reference actually more resembles singular individual reference). It then seems that the sensitivity to sentence boundaries is actually specific to reference that is both singular and individual. But this might simply be because while a singular personal pronoun looks for the single most prominent individual as an antecedent, a plural pronoun looks for more than a single individual, and thus also takes less prominent (but still accessible) individuals into account. This is clearly an intriguing avenue to explore in the future.

reference (Experiment 5) perhaps gives us a better indication of their relative prominence. That is not to say that individual reference cannot also be affected by constraints on contextual compatibility that override structural prominence. But since we used nonce-verb continuations in our individual reference experiments, they are less affected here. We think that there is a rich field for future research to investigate how anaphoric context/continuation interacts with other factors.

The comparison between Experiments 5 & 6 revealed another potential point of divergence between individual and propositional anaphors. We had necessarily included a (postverbal) connective also in the full stop-coordinated condition in the experiments on *violation of expectation*. In Experiment 6 on propositional reference, the full stop-condition (with connective) was not different from the comma-coordinated condition, while in Experiment 5 on individual reference it was, as well as in the previous experiments where the full stop condition did not contain a connective. Given that we know that sentencehood and connectives both independently affect individual reference (Buchholz, Hoek and von Heusinger, under review, Miltsakaki, 2011, cf. Grosz et al., 1995), we suggest that propositional reference, unlike individual reference, might not be strongly affected by typographical sentence boundaries.

It is probably not surprising that the parallels between individual and propositional reference do not extend to full correspondence in coreference patterns, since both the anaphoric forms used and the referential objects themselves are different. However, we believe to have shown that there is a clear common core that can be theoretically captured using the model of discourse prominence and our Prominence Inheritance Hypothesis. We want to point out some questions that remain open for future research in this regard.

Firstly, we only manipulated the prominence of clauses, but it remains an open question how individual referent-level and clause-level manipulations interact. Is e.g. a main-clause object more prominent than a subordinate-clause subject?

And secondly, we have formulated Prominence Inheritance as working in one direction, from higher to lower-level units. But what about the other way round? Does a clause/proposition become more prominent if one of its referents is made more prominent, e.g. via prosody or topichood?

As a last point we would like to discuss how our results might be relevant to other fields of investigation. It has been suggested that *that* (or demonstratives in general) has a tendency to "bundle", i.e. to maximize reference (Wittenberg et al., 2021), or that propositional reference prefers to remain underspecified, if possible (Recasens, 2008). Our results speak to this insofar as resolution to *both* is concerned. Effectively, resolution to *both* did not change much, neither due to our conditions nor between the experiments, but it always stayed between 20 % and 40 %. This does not suggest that participants chose *both* overwhelmingly as an "easy", because undecided, option, or because propositional reference has a strong tendency to create maximal reference. Two questions that remain here are what factors can strongly affect the prominence of *both* and how exactly the prominence of *both* (or more generally, the maximally available propositional referent) affects individual reference.

Our investigation also touched upon differences between theoretical accounts of discourse relations and the right frontier of discourse. For both *forward causality* (Experiments 3 & 4) and *violation of expectation* (Experiments 5 & 6), we pointed out that SDRT makes predictions about where the right frontier would be that are not fully compatible with our results, mainly because of theory-internal constraints like the impossibility to have a subordinate discourse segment completely preceding its main segment, which for instance RST does not have. We can now also say something about likely conceptualisations of the discourse structure of our items. That resolution to *both* is relatively unaffected by our condition - in particular, that it does not dramatically decrease in the full stop-coordinated condition - suggests that the complex discourse unit corresponding to the whole biclausal construction is also accessible when there is a full sentence boundary between the two clauses. But the fact that *both* is resolved to in only about a third of all cases (i.e. at chance) also is an argument against assuming that this CDU is most recent in the structure, since then it would be alone at the right frontier and the discourse units corresponding to the two individual clauses should not be accessible anymore. Similarly, our results speak against the scenario in which the discourse unit corresponding to the first clause is only complete once the whole construction is processed so that then the first clause would be alone at the right frontier. We do not see an overall resolution to *first* that would warrant this conclusion. Overall, we think that our results probably should not be taken as evidence for or against the right frontier itself, but rather call into question some of these assumptions from SDRT. Elementary evidence for the Right Frontier Constraint being valid or not should therefore probably come from more clear-cut, uncontroversial discourse structures.

However, our results do clearly show that discourse relations are relevant for anaphoric availability (as demonstrated by the overall differences in results between backward (Experiments 1 & 2) and forward (Experiments 3 & 4) causal relations), an assumption that the Right Frontier Constraint generally captures. However, our results also show that anaphoric reference is impacted by syntax in a way that SDRT does not describe. As mentioned earlier, RST's nuclearity principle also captures the relative importance of discourse segments within discourse relations, and as our results show, also seems to bear on anaphora resolution (and at times even make more accurate predictions than SDRT, as pointed out at relevant points above). Some research has linked nuclearity to syntactic patterns (e.g. Matthiessen and Thompson, 1988), but, as in SDRT, nothing in RST predicts the impact that the syntactic and typographic manipulations within each set of our experiments have on anaphoric reference.

Our results also speak to the literature on (the different kinds of) at-issueness and its relation to propositional accessibility. To look at one particular case, as far as we are aware no account of at-issueness predicts that *obwohl*-clauses, if their content is conventionally implicated (and thus at least p-not-at-issue), cannot be felicitously attached to via some continuations, while other continuations do not result in infelicity (cf. (13), (14), (15)). While the exact differences

between the felicitous and infelicitous continuations are still to be determined, it seems that p-and-q-at-issueness cannot account for this because, oversimplifying somewhat, they equate being marked as belonging to the common ground with inaccessibility and leave no real room for differences in continuations.[15] C-at-issueness does predict differences due to continuation. But at least in Hunter & Asher's version (Hunter and Asher, 2016) it does not allow for the possibility that common ground status might actually interact with continuation, which is what we think happens in our Experiment 6. We hope that our findings can also serve as a starting point for more empirical research using different kinds of tests on the question of how concepts of at-issueness really affect propositional reference, especially when different continuing contexts are considered.

In conclusion, we have conducted experiments testing the influence of clause-level manipulations on propositional and individual anaphor resolution in German, in parallel for the first time. Our results are compatible with the idea of discourse prominence as an overarching structural principle and the proposal that it gets inherited by smaller units (individual referents) from the larger units (propositions) they are contained in. We have also discussed aspects of our results that indicate where individual and propositional reference might differ and pointed out avenues how these differences can be explored in future research.

CRediT authorship contribution statement

Timo Buchholz: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Jet Hoek:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Conceptualization. **Klaus von Heusinger:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Funding acquisition, Conceptualization.

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Declaration of competing interest

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Data availability

The accompanying OSF repository with all data and all scripts can be found at: https://doi.org/10.17605/OSF.IO/ENCU4.

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[15] Broadly speaking, this seems to be the established view in the literature, cf. Koev (2018, p.6). However, for q-at-issueness (Snider, 2017), puts this into question, suggesting that what the direct assent/dissent-test (Tonhauser, 2012) tests is the accessibility of a propositional discourse referent separate from at-issueness. For P-at-issueness, Murray (2014) also already separates the two, saying that while at-issue-content always creates a propositional discourse referent, not-at-issue content does not necessarily do so. Her treatment does not focus on multiclausal structures, but she specifically mentions them as potential cases where not-at-issue content can also create a propositional discourse referent, which would make it in principle accessible. However, neither of these works discuss different continuations systematically.

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