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ARTICLE

Processing Factors Constrain Word-Order Variation in German: The Trouble with Third Constructions

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A subset of German control verbs allows for the discontinuous linearization of their infinitival complements, a word-order pattern known as the "third construction" pattern. Compared to alternative word-order options (notably, extraposition), third constructions are very rare in present-day German. Here we ask whether the third construction pattern's low occurrence frequency can be accounted for by processing factors. We report the results from a self-paced reading task and a production priming task investigating whether third constructions are difficult to comprehend, difficult to produce, or both. Our results show that the third construction pattern's local structural ambiguity impedes comprehension, and that the pattern is also resistant to priming. We conclude that this word-order pattern is an example of a "latent" construction that is grammatically licensed but strongly dispreferred in language use because easier-to-process word-order variants are available.

Keywords: German; control verbs; third construction; self-paced reading; production priming

1. Introduction

In German, infinitival complements of control verbs can appear in three different linearization patterns, as illustrated in (1a–c).

(1) a. EXTRAPOSITION

Johanna	sagt,	dass	Max	beschlossen	hat
Johanna	says	that	Max	decided	has
[den	Plan	zu	ändern].		
the	plan	to	change		

b. INTRAPOSITION

Johanna	sagt,	dass	Max	[den	Plan	zu	ändern]
Johanna	says	that	Max	the	plan	to	change
beschlossen	hat.						
. decided	has						

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c. THIRD CONSTRUCTION

Johanna	sagt,	dass	Max	[den	Plan]	beschlossen	hat
Johanna	says	that	Max	the	plan	decided	has
[zu	ändern].						
to	change						

ALL: 'Johanna says that Max decided to change the plan.'

All three variants are semantically equivalent, with *den Plan zu ändern* ('to change the plan') understood as the theme argument of the lexical matrix verb *beschliessen* ('decide'). In the extraposition variant (1a), the entire infinitival complement has been placed at the right clausal periphery. In (1b), the infinitival complement appears between the matrix subject *Max* and the matrix verbal complex (*beschlossen hat* 'decided has'), which is the canonical position for direct objects in German. The present study focuses on the third variant, the so-called third construction (3rd C) pattern in (1c), in which the infinitival complement is linearized discontinuously (den Besten & Rutten 1989, Wöllstein-Leisten 2001).[1]

Corpus analyses have shown that the 3rd C pattern is extremely rare in present-day German and more likely to be attested in spoken than in written corpora (Bosch et al. 2022). Its use is assumed to be restricted to a subset of control verbs, so-called optionally coherent verbs (Haider 1994).[2] An analysis of De Cesare's (2021) synchronous corpus data focusing on nine subject control verbs revealed that only 1.65% of infinitival complements appeared in the third construction pattern, whilst extraposition accounted for 81.31% and intraposition for 17.04% of all tokens.

Examining the 3rd C pattern in depth, Wöllstein-Leisten (2001) shows that third construction infinitives pattern with coherent infinitives—such as the complements of raising verbs—in that they form a monoclausal structure with the matrix predicate. The 3rd C pattern's monoclausal structure results from argument structure merger or unification, but without verb-cluster formation as is characteristic of other types of coherent infinitive. According to Wöllstein-Leisten (2001), the part or parts of the infinitive that appear to the right of the matrix verb result from verb phrase (VP) rather than complementizer phrase (CP) extraposition, along the lines indicated in (2) (compare also Haider 2010).

(2)

dass	[$_{VP}$	Max	den	Plan	beschlossen	hat	[$_{VP}$	zu	ändern]]
that		Max	the	plan	decided	has		to	change

The lack of verb-cluster formation, in the absence of a CP boundary between matrix verb and infinitive, allows for the matrix verb to be placed relatively freely among the extraposed infinitival verb's arguments. For unified complex predicates

[1] Third constructions are also available in Dutch (for instance, den Besten & Rutten 1989), a language we are not examining in the present study.

[2] The notion of coherence dates back to Bech (1955) and relates to how tightly connected an infinitival complement is with its matrix clause or predicate. Sentences containing extraposed infinitives always form a biclausal incoherent structure, while intraposed infinitives are ambiguous between a coherent (monoclausal) and incoherent (biclausal) construal (Haider 2010). Optionally coherent verbs allow for both construals.

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that involve ditransitive verbs, the following base-generated word-order options (3a,b) are available (adapted from Wöllstein-Leisten 2001:217).[3]

(3) a. $\text{argument}_2^{\ 2}\ \text{V}_{\text{matrix}}^{\ 1}\ \text{argument}_1^{\ 2}\ \text{V}_{\text{infinitive}}^{\ 2}$

b. $\text{argument}_2^{\ 2}\ \text{argument}_1^{\ 2}\ \text{V}_{\text{matrix}}^{\ 1}\ \text{V}_{\text{infinitive}}^{\ 2}$

According to Wöllstein-Leisten, third constructions and other coherently construed *zu*-infinitives do not involve a control relationship. Instead, the infinitival marker *zu* is argued to allow for the infinitival verb's external argument to be unified with that of the matrix verb, as a result of which the complex predicate has a single external argument only (for example, the proper noun *Max* in (2)). We assume Wöllstein-Leisten's analysis to be essentially correct, while remaining agnostic as to some of its theory-specific formal details.

Our study examines the hypothesis that third constructions are rare because they are difficult to process. Considering the distribution of different word-order patterns from a processing perspective can help elucidate the relationship between processing difficulty and occurrence frequency, and can also inform theories of language change (for instance, Hawkins 2004, Temperley 2007, Fedzechkina et al. 2018). Here we report the results from two experiments examining the online comprehension and production of third constructions in German in comparison to other word-order variants. We specifically ask whether third constructions are difficult to comprehend, difficult to produce, or both.

The remainder of this article is organized as follows: Section 2 provides information about the theoretical background and previous findings. In section 3 we report the results from an online reading-time task that allows us to tap into the step-by-step processing of third constructions. Section 4 reports the results from a spoken production task examining whether third constructions can be primed. Our results are discussed in section 5, which is followed by a brief conclusion in section 6.

2. Background

2.1. Relating Processing Difficulty and Word-Order Preferences

Processing-related constraints are often invoked as possible explanations for word-order preferences in the typological literature (for instance, Hawkins 1994, 2004, 2014, Jaeger & Tily 2011, Gibson et al. 2019, Futrell et al. 2020). The hypothesis that structural variants that are difficult to process should be less frequently attested compared to easy-to-process variants seems highly plausible. What is less obvious is whether the frequency distributions of different word-order variants should be determined by constraints on language production, comprehension difficulty, or both. At the level of theorizing, the answer to this question depends in part on the extent to which the production and comprehension systems are assumed to overlap (see Gambi & Pickering 2017 for a review of recent models).

[3] Superscripts indicate which verb an argument belongs to and subscripts indicate an argument's relative ranking. Alternative word-order options are available that involve scrambling, a discussion of which is beyond the present study's scope, however.

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One processing-related economy constraint that features fairly prominently in recent research on word-order preferences is *dependency length minimization* (DLM) (see Liu et al. 2017, Temperley & Gildea 2018, Futrell et al. 2020 for review and discussion). The DLM constraint is a preference principle which holds that the linear distance between elements entering into a syntactic dependency should be kept as short as possible. This helps minimize the processing cost associated with maintaining incomplete dependencies in memory during the processing of subsequent sentence material, the difficulty of memory retrieval at the point at which a dependency can be completed, and the likelihood of intervening constituents interfering with dependency formation. The hypothesis that word-order preferences and distributions are constrained by the DLM is supported by evidence from both corpus studies and language processing experiments. Language comprehension studies have shown that sentences containing longer grammatical dependencies are more difficult to process than those containing shorter dependencies, for example (for instance, Grodner & Gibson 2005). This finding appears to be mirrored in sentence production, such that sentences containing longer dependencies are harder to produce than those containing shorter ones (Scontras et al. 2015). The DLM constraint has also been linked to the crosslinguistic rarity of structural patterns that involve crossing dependencies (Ferrer-i-Cancho 2006).

Dependency length minimization is not the only constraint influencing speakers' word-order choices, of course, and may be overridden by other factors (Liu 2020). Sentences may be difficult to produce for multiple reasons. One is the avoidance of ambiguity as a potential obstacle to efficient comprehension and communication (Grice 1975). There is little experimental evidence of speakers selecting specific word-order variants so as to facilitate comprehension, however (see Wasow 2015 for review and discussion). Ferreira & Dell (2000), for example, provide evidence from sentence recall experiments indicating that English speakers do not avoid producing locally ambiguous sentences even if this option is available to them. One likely reason for this is that the message to be conveyed is never ambiguous for the speaker himself or herself.[4] MacDonald (2013) puts forward the alternative proposal that speakers' word-order choices are determined by constraints on sentence planning and production, which in turn determine the distribution frequencies of different word-order variants. An "Easy First" bias in language production, for example, accounts for the tendency to place short before long constituents in languages like English (Hawkins 1994) as it helps minimize planning load and maximize fluency. There is also evidence that elements which are more accessible in memory, and thus easier to retrieve, tend to be produced earlier than less accessible ones (for instance, Bock & Irwin 1980, Bock & Warren 1985).

While MacDonald (2013) argues that word-order distribution frequencies also determine sentence comprehension difficulty, other findings suggest that pattern frequency is not necessarily a good predictor of comprehension difficulty (for instance,

[4] The results from some experimental (for instance, Haywood et al. 2005) and corpus-based (for instance, Temperley 2003, Norcliffe & Jaeger 2016, Hörberg 2018) studies do provide evidence for ambiguity avoidance, however.

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Gibson et al. 1996). A growing body of research on real-time language comprehension has shown instead that the processing cost or "surprisal" associated with newly incoming words or phrases is affected by their conditional probability, that is, by the likelihood of a given word or phrase appearing in a specific context (for instance, Demberg & Keller 2008, Boston et al. 2011, Frank et al. 2015, Hörberg & Jaeger 2021; see Levy 2008 for a review).

In the following section we consider the 3rd C pattern with regard to its ambiguity, from a sentence planning and production perspective, and from the perspective of the DLM constraint, taking into account previous experimental findings.

2.2 A Processing View on Third Constructions

Most previous experimental studies on German infinitival complementation focused on intraposition versus extraposition and disregarded the 3rd C pattern (for instance, Bader & Schmid 2009, Bayer et al. 2005). Considering all three possible linearization patterns in (1a–c), Bosch et al. (2022) carried out a whole-sentence reading-time experiment to compare the overall comprehension difficulty of extraposition, intraposition, and 3rd C patterns. Sentences containing third constructions took significantly longer to comprehend compared to sentences containing either extraposed or intraposed infinitives. The authors speculated that this might have been due to this word-order pattern's local ambiguity, which can be illustrated using the 3rd C example in (4) below.

(4) dass Max [den Plan] beschlossen hat [zu ändern].
that Max the plan decided has to change
'. . . that Max decided to change the plan.'

The 3rd C pattern's ambiguity is linked to the fact that it involves a crossing dependency, such that the subject–verb dependency in the matrix clause (*Max . . . beschlossen hat*) intersects with the dependency between the embedded verb and its object (*den Plan . . . zu ändern*). Crossing dependencies have been identified as a potential source of processing difficulty (Levy et al. 2012).

Note that even if we assume Wöllstein-Leisten's (2001) argument structure unification analysis to be correct, this analysis will not be immediately apparent to the parser. During real-time sentence processing the parser tries to integrate each new incoming word or phrase as soon as possible into the emerging structural representation, even in verb-final languages (for instance, Bader & Lasser 1994). Parsing is guided by economy constraints such that the simplest analysis consistent with the current input will normally be assumed and grammatical dependencies will be sought to be completed as soon as possible (Frazier 1987). For our 3rd C example (4), this means that the accusative-marked noun phrase (NP_{obj}) preceding the participial matrix verb *beschlossen* ('decided') should initially be analyzed as this verb's direct object. With all preceding argument phrases being assigned grammatical and thematic roles in accordance with the verb's argument structure, the sentence could in fact terminate at this point (compare *Johanna sagt, dass Max den Plan beschlossen hat* 'Johanna says that Max has decided on the plan').

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In example (4), subsequent sentence material reveals that the initial direct object analysis was in fact incorrect. The arrival of the infinitive *zu ändern* ('to change') signals the presence of a discontinuously realized, nonfinite clausal complement of *beschlossen*, and the NP *der Plan* ('the plan') turns out to be an argument of the infinitival verb *ändern*. Recognizing and revising errors of this kind typically triggers a measurable processing disruption known as a "garden-path" (GP) effect (Frazier & Rayner 1982). To investigate whether this hypothesized scenario is indeed borne out, we carried out a self-paced reading experiment that allows us to tap into the step-by-step incremental processing of 3rd C versus extraposition patterns (Experiment 1). The word-by-word reading-time data thus obtained should allow us to identify the sources of processing difficulty more precisely than was possible in Bosch et al.'s (2022) study.

Note that local ambiguities of the kind that gives rise to GP effects should mainly present problems for comprehenders, as speakers or writers normally have a clear idea of what message they wish to convey. Even if speakers' syntactic choices were influenced by ambiguity avoidance, given that ambiguity is ubiquitous in human languages (Piantadosi et al. 2012), the presence of a local ambiguity does not by itself explain why a given word-order pattern is also rarely attested in corpora.

A processing constraint that is likely to be relevant to both comprehension and production is the DLM constraint, with "distance" usually operationalized in terms of the number of words separating a head and its dependents (for example, Gildea & Temperley 2010). In the 3rd C pattern (4), the matrix verb interrupts the dependency between the infinitival verb *ändern* ('change') and its internal argument *den Plan* ('the plan'), potentially giving rise to GP effects in comprehension. Material belonging to the infinitival complement (that is, the accusative-marked NP *den Plan*) moreover interrupts the dependency between the matrix subject *Max* and the lexical matrix verb *beschlossen* ('decided'). The formal legitimacy of the 3rd C pattern notwithstanding, two clauses thus intertwined violate the DLM constraint, in the sense that the 3rd C pattern does not have the shortest dependency length within the set of alternative orders.[5] In the corresponding extraposition pattern in (5), in contrast, the distances between the lexical matrix verb and its subject, and between the infinitival verb and its theme argument, are both minimized.

(5)	dass	Max	beschlossen	hat	[den	Plan	zu	ändern].
	that	Max	decided	has	the	plan	to	change

Language production research has shown that parts of utterances are planned in advance, that is, prior to speech onset. Sentence planning is assumed to start with the generation of a conceptual (preverbal) message prior to linguistic encoding (Levelt 1989). Although planning scope in sentence production may vary (for example, Ferreira & Swets 2002), there is evidence that constituents as large as a clause can be planning units (Holmes 1988, Meyer 1996) and that syntactically dependent elements are planned together (Lee et al. 2013, Momma 2021). Sentence production is thought to be incremental, but models of sentence production differ, among other things, with

[5] Note that the intraposition pattern (1b) also violates the DLM constraint by breaking up the dependency between the matrix subject and matrix verb.

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regard to the question of how closely linear word order corresponds to lexical planning order. Experimental evidence shows that verbs are planned in advance of their objects even in verb-final languages (Momma et al. 2016), which indicates that planning order and surface word order are not necessarily in strict correspondence. However, keeping planned syntactic constituents in working memory for delayed production may increase processing cost relative to word orders that mirror planning order more closely (compare, for example, Christiansen & Chater 2016).

Consider now the two word-order options in (4) and (5) from the perspective of sentence planning. If the lexical matrix verb *beschliessen* is planned before its infinitival complement, then extraposing the latter as in (5) will not only correspond to planning order but will also allow for the infinitival complement to be planned as a separate clausal constituent. For our 3rd C example in (4), on the other hand, the infinitival verb *ändern* ('change') will need to be planned earlier than, or concurrently with, the matrix verb *beschliessen* for the infinitival verb's theme argument *den Plan* to be produced ahead of the matrix verb. In other words, if third constructions are coherent structures in the sense of forming a single clausal unit with the matrix verb phrase, then their production would seem to require a comparatively large clausal planning scope. Experimental results reported by Gómez Gallo et al. (2008) suggest that there is a limit as to how much information can be included in a clausal unit during sentence planning, and that this can affect whether speakers choose to plan an intended message as a monoclausal or biclausal utterance. Considering these findings, the discontinuous linearization of clausal infinitives that defines the 3rd C pattern may indeed be suboptimal from the perspective of language production.

To compare the likelihood of each of the three possible word-order patterns being produced, Bosch et al. (2022) carried out an unprimed spoken production task. Participants were asked to describe an action shown in pictures in a single sentence and making use of both a subject control and a content verb that were shown next to the picture. Participants overwhelmingly produced the extraposition pattern, whereas 3rd C and intraposition patterns were rarely produced. The observed pattern of productions closely mirrored the different word-order patterns' corpus frequencies. It remains unclear whether the low likelihood of participants' producing third constructions reflects the low statistical distribution of this word-order pattern, or its hypothesized processing complexity, however.

To maximize the likelihood of speakers producing 3rd C patterns, we used a structural priming task (Experiment 2). Structural priming refers to the observation that speakers or writers tend to reuse structural patterns they were recently exposed to (Bock 1986, Mahowald et al. 2016), and previous research indicates that less frequent syntactic patterns may show stronger priming effects than frequent patterns, a phenomenon known as the "inverse frequency effect" (compare, for example, Hartsuiker & Westenberg 2000, Ferreira 2003, Scheepers 2003, Kaschak et al. 2011, Jaeger & Snider 2013).

If speakers' production choices reflect statistical occurrence frequencies, then repeated exposure to this pattern should increase the likelihood of this pattern being used subsequently, relative to a control condition. If, on the other hand, third constructions are rarely produced because they are effortful to plan and produce, they may turn out to be resistant to priming, given that easier-to-produce variants are available. A reviewer points out an alternative possibility, however: Structural variants that are difficult to produce might show comparatively large priming effects as repeated

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exposure to corresponding primes might provide some form of training for the hard-to-produce structure.[6] The link between structural priming and production difficulty has rarely been examined directly, however. There is some evidence that individuals with aphasia who have difficulty producing certain structural patterns (such as passives) may increase their production of these patterns through priming (for instance, Saffran & Martin 1997, Hartsuiker & Kolk 1998), but little is known about how production difficulty affects the size of priming effects in language-unimpaired speakers.

Taken together, the results from our two experiments should help us determine whether third constructions are rare in present-day German because they are (i) difficult to comprehend but not difficult to produce, or (ii) difficult to produce and comprehend.

3. Experiment 1: Self-Paced Reading

We used an online self-paced reading task to tap into the implicit incremental processing of infinitival complements in the third construction in comparison to extraposed infinitives. In this kind of task, sentence regions which give rise to processing difficulty are expected to elicit longer reading times compared to the same regions in a control condition. This should allow us to identify the sources of processing difficulty associated with the 3rd C pattern more directly than is possible by measuring global comprehension time. Given that the 3rd C pattern (but not extraposition) gives rise to a local argument ambiguity, we might expect third constructions to show garden-path effects at or shortly after the point of disambiguation.

3.1. Method

Participants

We recruited 51 German adult native speakers (34 female, 17 male; mean age: 24.63 years, range: 18–40 years) from the Potsdam and Berlin area via the University's participant database and social contact. All participants reported to have grown up with only German being spoken at home and none were speakers of any nonstandard German dialects. All participants had normal or corrected-to-normal vision and did not report any language-related or other behavioral or neurological disorders. All participants gave their voluntary written consent and received a small monetary compensation for their participation.

Materials. Our experimental sentences were constructed around seven subject-control verbs that admit infinitival complements as well as nominal direct objects: *anfangen* ('begin'), *ankündigen* ('announce'), *bedauern* ('regret'), *beschliessen* ('decide'), *planen* ('plan'), *versuchen* ('try'), and *vorschlagen* ('propose').[7] All of these verbs had

[6] The reviewer also raises the possibility that the inverse frequency effect may be linked to production difficulty, on the assumption that rare structural variants may also be difficult to produce (compare MacDonald 2013).

[7] Five of these verbs are usually considered to be optionally coherent, whilst the verbs *ankündigen* ('announce') and *bedauern* ('regret') are thought to require a biclausal incoherent construal. Note, however, that according to survey results reported by Wöllstein-Leisten (2001), *bedauern* was accepted in the third construction pattern a high proportion of the time both in active (2001:290) and passive environments (2001:311). The verb *ankündigen* was not included in her survey.

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Table 1. Word-order patterns (percentages) attested in written and/or spoken corpora (De Cesare 2021)

	Word-order pattern		
Control verb	Extraposition	Intraposition	3rd C
anfangen	89	0.9	11
ankündigen	100	0	0
bedauern	97.5	2.5	0
beschliessen	97.9	2.1	0
planen	100	0	0
versuchen	76.2	12	12
vorschlagen	100	0	0

previously been attested in De Cesare's (2021) synchronous corpus analysis. The corresponding relative frequencies for the different word-order variants are displayed as percentages in table 1.

We created 28 experimental item sets in four conditions, as shown in (6a–d), with each control verb used in four different item sets.

(6) a. EXTRAPOSITION, PLAUSIBLE

Lena	sagt,	dass	der	Sohn	geplant	hat	die	Hochzeit
Lena	says	that	the	son	planned	has	the	wedding
lieber	persönlich	zu	besuchen.					
rather	in person	to	visit					

b. EXTRAPOSITION, IMPLAUSIBLE

Lena	sagt,	dass	der	Sohn	geplant	hat	die	Grossmutter
Lena	says	that	the	son	planned	has	the	grandmother
lieber	persönlich	zu	besuchen.					
rather	in person	to	visit					

c. THIRD CONSTRUCTION, PLAUSIBLE

Lena	sagt,	dass	der	Sohn	die	Hochzeit	geplant	hat
Lena	says	that	the	son	the	wedding	planned	has
lieber	persönlich	zu	besuchen.					
rather	in person	to	visit					

d. THIRD CONSTRUCTION, IMPLAUSIBLE

Lena	sagt,	dass	der	Sohn	die	Grossmutter	geplant	hat
Lena	says	that	the	son	the	grandmother	planned	has
lieber	persönlich	zu	besuchen.					
rather	in person	to	visit					

ALL: 'Lena says that the son planned to visit the {wedding/grandmother} in person instead.'

All experimental sentences started with a main clause containing a finite declarative complement clause (for example, *Lena sagt, dass* … 'Lena says that …')

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whose main verb was a subject control verb taking an infinitival complement. We manipulated both the way the infinitival complement was linearized, such that it was either extraposed to the right sentence periphery (6a,b) or appeared in the 3rd C pattern (6c,d), and the plausibility of the infinitival verb's object (for example, *die Hochzeit* 'the wedding') as a direct object of the lexical matrix verb (for example, *planen* 'to plan'). In our 'plausible' conditions (6a,c) NP_{obj} was semantically plausible as a direct object of the matrix verb (for example, *die Hochzeit planen* 'to plan the wedding'). In the 'implausible' conditions (6b,d) this was not the case (for example, *#die Grossmutter planen* 'to plan the grandmother'). Note that all our experimental sentences were globally plausible as NP_{obj} was always a semantically plausible direct object of the infinitival verb (for example, *die Hochzeit/Grossmutter besuchen* 'to visit the wedding/grandmother'). A full list of our experimental sentences is available at the Center for Open Science Framework (OSF) website (https://osf.io/b5m3y/).

Recall that from the perspective of left-to-right incremental processing, NP_{obj} is temporarily ambiguous in the 3rd C conditions (6c,d) because it appears directly left-adjacent to the matrix verb and so might initially be misanalyzed as the matrix verb's direct object. This error only becomes obvious to comprehenders once subsequent sentence material is received (here, the adverbial phrase *lieber persönlich* 'rather in person') which signals the presence of an infinitival complement and should trigger reanalysis. Our plausibility manipulation serves as a diagnostic for an initial misanalysis here: If participants try to analyze NP_{obj} as the object of the matrix verb, they should find this analysis easier if it is semantically plausible (6c) compared to when it is not (6d). Correcting this error when disambiguating information is received, on the other hand, should be easier if the misanalysis was implausible in the first place. The extraposition conditions (6a,b), in contrast, are not expected to yield any plausibility effects as NP_{obj} should not be mistaken for an object of the control verb preceding it.

The minimal pairs of (im)plausible nouns were matched for length, that is, the number of letters (mean plausible: 9.3; mean implausible: 8.7), for morphological complexity, that is, number of morphemes (mean plausible: 1.7; mean implausible: 1.9), and for lemma frequency (plausible: 1,342; implausible: 1,204) on the basis of the log-transformed normalized frequency data of the dLEX corpus (Heister et al. 2011). None of these measures yielded any statistically significant differences between the "plausible" and "implausible" nouns. Summaries of statistical analyses on these length and frequency measures are available on OSF (https://osf.io/b5m3y/).

In addition, all combinations of noun phrases and matrix verbs were pretested in a binary choice (*yes/no*) plausibility rating task to make sure that plausible and implausible combinations were indeed perceived as such. For this purpose, minimal pairs of sentences containing finite complement clauses without infinitives were created, as shown in (7).

(7) Lena sagt, dass der Sohn {die Hochzeit/#die Grossmutter} geplant hat.
Lena says that the son the wedding/the grandmother planned has
'Lena said that the son had planned {the wedding/the grandmother}.'

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Forty-six adult native speakers of German who did not participate in the main experiment were recruited from among the student communities of the University of Potsdam and provided with a link to an online questionnaire via Google Forms. Sentences were presented individually on the computer screen, and participants were asked to indicate whether they considered a given sentence plausible or not by clicking on a *yes* or *no* button. Binary plausibility ratings were coded as 1 (*yes*) and 0 (*no*) and mean plausibility scores were calculated for each item. Any combination which elicited less than 75 percent expected answers (that is, *yes* for plausible and *no* for implausible sentences) was adapted for the main experiment by replacing the noun itself so as to make noun–verb combinations more (im)plausible. This was the case for two plausible and seven implausible NP_{obj}-verb combinations.

In addition to the critical stimulus sentences, our main experiment included 42 filler sentences which did not contain any infinitival complements and differed from our experimental items both in their lexical material and syntactic structure. In eight of our filler sentences, analyzing NP_{obj} as the direct object of the finite verb following it proved to be correct (for example, *Lars weiss, dass der Koch das Restaurant empfohlen hat* 'Lars knows that the chef recommended the restaurant'). These items served to prevent participants from developing the expectation that a preverbal NP_{obj} would always turn out to be part of an infinitival complement.

Half of all sentences were followed by a *yes/no* comprehension question targeting the main clause (for example, *Lena sagt*), the subject of the subordinate clause (for example, *der Sohn*), or the adverbial phrase (for example, *lieber persönlich*). Together with a set of four "sanity check" items asking participants to press a specific button on the keyboard, this allowed us to verify whether participants read the stimulus sentences attentively. The 28 experimental sentences were distributed across four presentation lists in a Latin-square design, and mixed with the 42 filler sentences, resulting in 70 sentences per list. All presentation lists were uniquely randomized for each participant, with not more than three critical items appearing in a row.

Procedure

The experiment was designed as a web-based study using the experimental platform Ibex Farm (Drummond 2013), and participants received a link to access the experiment. We used a word-by-word, noncumulative self-paced reading paradigm (Just et al. 1982), which allows readers to determine the presentation duration of each word using button presses. The presentation of each item began with a blank line. Pressing the spacebar triggered the presentation of a stimulus sentence's first word. Each word was presented in the middle of the computer screen and was replaced by the next word when participants pressed the space bar. The final word in each sentence was presented together with a full stop, and pressing the spacebar again brought up either the next stimulus item or a comprehension question. Participants were asked to answer each question by clicking on either the *yes* or *no* button shown on the computer screen. Participants' word-by-word reading times (RTs), their responses to the comprehension questions, and their response times were recorded.

The main experiment was preceded by a set of biographical questions and the presentation of three practice trials to allow participants to familiarize themselves with the experimental task. All sentences were presented in black letters (font: Lucida

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Grande; size: 30pt) against a light grey background and there were four preprogrammed breaks during the experiment. A progress bar shown above the stimulus sentences allowed participants to keep track of their progress during the experiment, which could be completed in about 30 minutes.

Data Cleaning and Analysis

The response data were coded as 1 ('correct') and 0 ('incorrect') to calculate mean comprehension accuracy scores. For the reading-time data, excessively long RTs above 2,000ms and extremely short RTs below 200ms were excluded from further analyses (affecting 1.23% of the data). The remaining RT data were log-transformed and analyzed for each of the six words of the infinitival complement and for the matrix predicate consisting of the participial control verb and finite auxiliary. In addition, full sentence reading times were compared so as to obtain a measure of relative global processing difficulty. Statistical analyses were conducted on logRTs making use of linear mixed-effects modeling (Bates et al. 2015), using sum-coded contrasts, with the *lme4* package in R (R Core Team 2017). The factorial structure of our experiment was reflected in the structure of our models, which were held constant across by-participant and by-item random effects. As categorial fixed-effect variables, the models included the factors Word Order (extraposition [coded as -1] versus 3rd C [coded as 1]) and Plausibility (plausible [coded as -1] versus implausible [coded as 1]) as well as their interaction. RT at the pre-interest region was added as a covariate to the model selection process of each region of interest to control for potential spillover effects from the preceding region (Bartek et al. 2011). In addition, word length of the critical regions was centered around its mean and included as a covariate in the analyses in order to control for the effect of word length. For determining the best-fit random slopes structure, we followed the recommendation of Matuschek et al. (2017) and included random slopes only if they resulted in models with greater goodness of fit as assessed by their Akaike Information Criterion (AIC) value, a measure that penalizes complexity and leads to predictors being kept only if they make a substantial contribution to explaining variance in the data (Venables & Ripley 2002). Lower AIC values indicated greater goodness of fit. We started with the maximal model including random slopes for factors and their interactions. The slope that provided the largest drop in AIC was first included and all other slopes were retested for inclusion, with this process being repeated for as long as a better model could be achieved. For models which failed to converge, we iteratively removed random slopes by participant or by item which explained the least variance (Barr et al. 2013) until the model did not improve any further according to its AIC value. The best-fit model for each analysis is reported in the results section. As suggested by Baayen et al. (2008), when p-values are not reported, we base our significance criterion on whether the absolute value of the relevant t-statistic exceeds 2.

Predictions

We expect our 3rd C conditions (6c,d) to take longer to process overall than the extraposition conditions (6a,b) (compare Bosch et al. 2022). Regarding word-by-word reading times, our main region of interest is the disambiguating adverbial phrase

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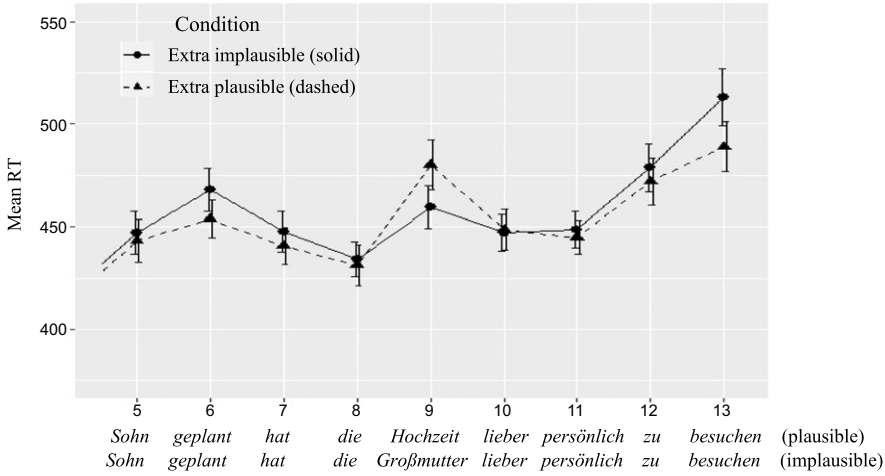

Figure 1a. Mean word-by-word reading times in milliseconds for the two EXTRAPOSED conditions from word 5 onwards (error bars indicate standard deviations).

(for example, *lieber persönlich* 'rather in person' in (6)). Here we expect to find an interaction pattern, with effects of our plausibility manipulation restricted to the 3rd C conditions (6c,d). The "plausible" condition (6c) should elicit higher reading times than the "implausible" one at this sentence region, reflecting the comparatively greater difficulty of revising an initially plausible misanalysis of NP_{obj} as the object of the matrix verb compared to an implausible one. For the two extraposition conditions (6a,b), in contrast, no processing differences are expected.

For our 3rd C conditions (6c,d), moreover, we expect to find plausibility effects during participants' reading of the matrix predicate (for example, *geplant hat* 'has planned'), our second region of main interest. Here the implausible condition (6d) should elicit higher reading times than the plausible one (6c), reflecting the perceived incompatibility of NP_{obj} and the control verb in the implausible condition. No plausibility effects are expected during participants' reading of the matrix predicate in the extraposition conditions.

3.2 Results

The end-of-trial responses to one experimental item had to be removed due to a coding error. Participants' overall response accuracy for the remaining comprehension questions was 92.45% (critical items: 91.5%), confirming that they read the stimulus sentences actively for meaning. Statistical analyses revealed that full reading times for sentences containing extraposed infinitival complements (6a,b) were significantly shorter (mean: 5,612ms) compared to sentences containing infinitives in the third construction (mean: 6,876ms; β=0.09, SE=0.01, t=17.49). Figures 1a and 1b show participants' mean raw word-by-word reading times for extraposed (figure 1a) and third construction (figure 1b) conditions respectively.

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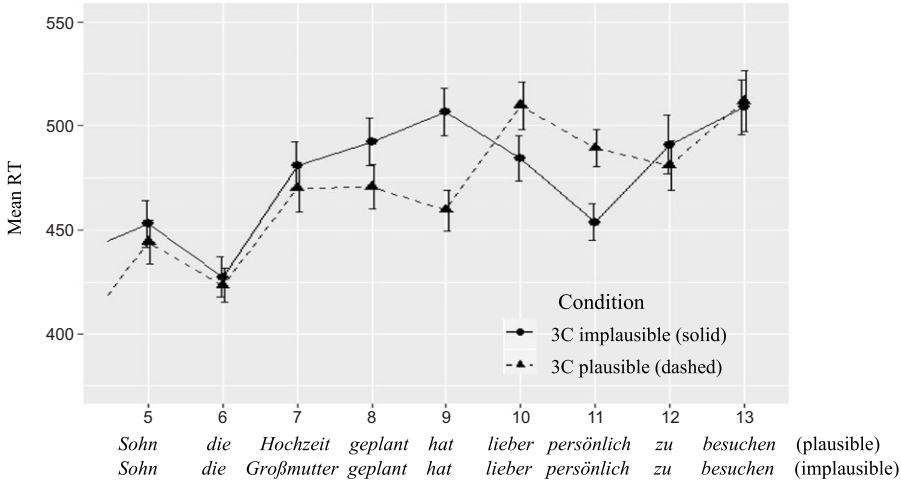

Figure 1b. Mean word-by-word reading times in milliseconds for the two THIRD CONSTRUCTION conditions from word 5 onwards (error bars indicate standard deviations).

Table 2. Summary of the statistical analysis of reading times at region 10 (asterisks indicating significant effects at $\alpha = 0.05$)

	Estimate	Std. error	*t*-value
(Intercept)	6.09	0.03	225.59*
ME Word Order (Extra vs. 3rd C)	0.05	0.01	6.33*
ME Plausibility (plaus. vs. impl.)	−0.01	0.01	−1.73
Word Length	−0.00	0.01	−0.59
Word Order x Plausibility	−0.02	0.01	−2.42*

*R formula: lmer(logRegion10 ~ WordOrder*Plausibility + c.(WordLengthR10) + (1|Participant) + (1|Item) + scale(Region9), data)*

Summaries of the overall statistical analyses on the critical adverbial region (words 10 and 11) are provided in tables 2 and 3. We obtained significant effects of Word Order at the disambiguating adverbial in both regions 10 and 11, indicating that extraposed infinitival complements were read significantly faster relative to third constructions there. In addition, statistical analyses revealed a significant effect of Plausibility at region 11, reflecting the fact that the "implausible" conditions elicited faster reading times than the "plausible" ones. However, at region 11, word length of the adverbial appeared to have influenced reading times as indicated by the significant effect of the factor Word Length here. Crucially though, we obtained significant interactions of the two factors Word Order and Plausibility at the critical region at both words 10 and 11, indicating that plausibility effects were significantly modulated by word order.

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Table 3. Summary of the statistical analysis of reading times at region 11 (asterisks indicating significant effects at $\alpha = 0.05$)

	Estimate	Std. error	*t*-value
(Intercept)	6.07	0.03	221.63*
ME Word Order (Extra vs. 3rd C)	0.02	0.01	2.44*
ME Plausibility (plaus. vs. impl.)	−0.02	0.01	−2.64*
Word Length	0.01	0.00	2.16*
Word Order x Plausibility	−0.02	0.01	−3.06*

*R formula: lmer(logRegion11 ~ WordOrder*Plausibility + c.(WordLengthR11) + (1|Participant) + (1|Item) + scale(Region10), data)*

In follow-up analyses, we investigated the effect of plausibility for both extraposed and 3rd C conditions separately. These analyses showed that plausibility effects were restricted to the 3rd C conditions, with the "plausible" condition (6c) yielding significantly longer reading times than the "implausible" condition (6d) at both word 10 ($\beta = -0.03$, $SE = 0.01$, $t = -2.79$) and word 11 ($\beta = -0.04$, $SE = 0.01$, $t = -3.77$). In contrast, no significant plausibility effects were found at the adverbial expression for the two extraposition conditions. There were no significant effects at all at the final *zu*-infinitive region.

As the extraposition and 3rd C conditions differed in their word order prior to the critical adverbial phrase, we analyzed the preceding words 6–9 separately for each condition pair. Summaries of statistical word-by-word analyses are available at the OSF website (https://osf.io/b5m3y/). Sentences containing extraposed infinitival complements (6a,b) did not yield any statistically significant differences in reading times between the two plausibility conditions at any analysis region.

For sentences containing third constructions (6c,d), we found significant plausibility effects at the matrix predicate, such that sentences containing implausible object NPs yielded significantly increased reading times compared to sentences containing plausible ones at word 9 ($\beta = 0.04$, $SE = 0.01$, $t = 3.85$). This finding suggests that integrating implausible object NPs (for example, *die Grossmutter* 'the grandmother') with the matrix verb (for example, *geplant*) was significantly more costly compared to the integration of plausible object NPs (for example, *die Hochzeit* 'the wedding'). There were no significant reading-time differences at the preceding NP_{obj} itself (words 6 and 7), suggesting that both plausible and implausible NPs were read equally fast.

3.3 Summary and Discussion

Our global reading-time analysis confirmed that sentences containing third constructions are more difficult to comprehend than sentences containing extraposed infinitives. Regarding the word-by-word incremental processing of third constructions, Experiment 1 yielded two main findings: Firstly, processing the disambiguating adverbial was more costly when the initial direct object analysis was plausible. Secondly, the matrix predicate was easier to process if the noun phrase

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immediately preceding it was a plausible direct object of the lexical matrix verb compared to when it was implausible. The observed reversal in the direction of plausibility effects during incremental processing shows that readers initially attempted to analyze the ambiguous NP_{obj} as an object of the matrix verb but were forced to revise this analysis when they came across subsequent sentence material that signalled the presence of an infinitival complement. The processing disruption caused by the arrival of disambiguating sentence material was greater in the "plausible" than in the "implausible" condition, as was predicted. The results from Experiment 1 thus demonstrate that third constructions trigger GP effects, a well-known source of comprehension difficulty.

Models of sentence comprehension account for GP effects in different ways, and our study was not designed to empirically evaluate these models. While the original "garden-path" model of sentence processing (Frazier 1987) attributes them to the application of structural economy constraints during incremental parsing, interactive or "constraint-based" models (McRae & Matsuki 2013) posit a range of other factors that may contribute to the occurrence and severity of garden-path effects. Processing difficulty results if newly incoming information is not in line with previously experienced language input. Expectation-based processing models (Levy 2008) also attribute garden-path effects to failed expectations or "surprisal" but differ from constraint-based models in terms of their formalization. For review and discussion, see, for example, Ferreira & Çokal (2015) and Traxler (2014).

Recall that the 3rd C pattern is also suboptimal from the perspective of the DLM constraint. The DLM constraint also affects sentence production, such that grammatically dependent constituents are preferentially placed close to each other. Assuming that the information-carrying capacity of clausal planning units is limited (Lee et al. 2013), planning and producing third constructions should be more challenging compared to producing extraposition structures. In Experiment 2, we used the structural priming technique to test whether German speakers can be enticed into using the 3rd C pattern despite the problems it may present for sentence production.

4. Experiment 2: Structural Priming

Our second experiment investigates whether and to what extent German speakers can be led to produce otherwise rare third constructions when this word-order pattern is used repeatedly as a prime. Repeated prior exposure to a given structural pattern has been shown to increase the likelihood of this pattern being reused, with low-frequency patterns showing stronger priming effects than high-frequency ones. Assuming that structural priming effects result from implicit learning, Jaeger & Snider (2013) account for the inverse frequency effect in terms of surprisal or prediction errors: Less expected syntactic patterns prime more because expectation violations trigger a stronger learning effect.[8] As we noted earlier, the relationship between production difficulty and priming is unclear: If third constructions are more

[8] Other theoretical or computational models of priming invoke the mechanism of spreading activation. Discussing or evaluating different models of priming is beyond the present study's scope, however; see Yang et al. (2021) for a review.

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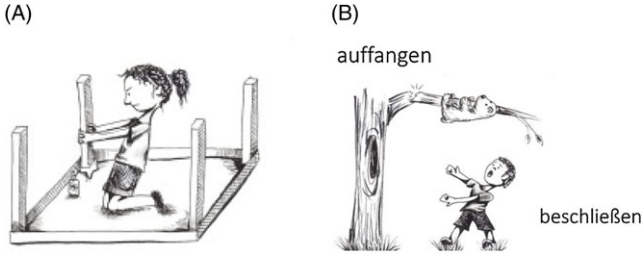

Figure 2. Matching prime picture card (A) and target picture (B) for the prime sentences in (8a–d).

difficult to produce than their structural alternatives (in particular, extraposition), we might find that the likelihood of this pattern being produced cannot be significantly increased by prior exposure. Conversely, if repeated exposure to 3rd C primes provides some form of production training, we might see third constructions benefiting comparatively strongly from priming.

4.1 Method

Participants

We recruited 24 adult native speakers of German (21 female, 3 male; mean age: 24.25 years; range: 18–35 years) from the Potsdam and Berlin area. All participants reported to have grown up with only German being spoken at home. All participants were recruited via the university's participant database and social media contact. They all held a high school diploma and were studying at university at the time of testing. They all had normal or corrected-to-normal vision and did not report any language-related and/or behavioral or neurological disorders. All participants gave their written consent to participate in our study, were naïve with respect to the ultimate purpose of the experiment, and received either course credit or were offered a small reimbursement after completing the experiment.

Materials

The stimulus materials were constructed around six subject control verbs (*ankündigen* 'to announce', *bedauern* 'regret', *beschliessen* 'decide', *planen* 'plan', *versuchen* 'try', and *vorschlagen* 'propose') that were also used in Experiment 1. Using each control verb twice, we created 12 prime sentences in four conditions as shown in (8a–d) below. Sentences of type (8a) contained no infinitival complement and served as a baseline. Sentences containing infinitival complements (8b–d) were structurally parallel to those used in Experiment 1, with the infinitive selected by the lexical verb of a finite declarative complement clause, but with another possible linearization pattern (intraposition) added. Condition (8b) contained an extraposed infinitive, condition (8c) an intraposed one, and condition (8d) contained an infinitival complement in the third construction.

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(8) a. Baseline
Ich glaube, dass die Frau den Tisch repariert.
I believe that the woman the table repairs
'I believe that the woman is repairing the table.'

b. Extraposition
Ich glaube, dass die Frau versucht den Tisch zu reparieren.
I believe that the woman tries the table to repair
'I believe that the woman is trying to repair the table.'

c. Intraposition
Ich glaube, dass die Frau den Tisch zu reparieren versucht.
I believe that the woman the table to repair tries
'I believe that the woman is trying to repair the table.'

d. Third Construction
Ich glaube, dass die Frau den Tisch versucht zu reparieren.
I believe that the woman the table tries to repair
'I believe that the woman is trying to repair the table.'

Intraposed infinitival primes were added because intraposition shares with the 3rd C pattern the fact that it breaks up the matrix clause by intervening between the matrix subject and predicate. This should make intraposed infinitives more difficult to plan and produce than extraposition structures as well, and therefore difficult to elicit in production tasks. While intraposed infinitival complements of control verbs are slightly more frequently attested than the 3rd C pattern, they are also much rarer than extraposed infinitives (for example, Bosch et al. 2022). A corpus search carried out by Bayer et al. (2005) that included 56 control verbs revealed that less than four percent of infinitival complements were intraposed.[9] If 3rd C and intraposition patterns are merely rare but are not any more difficult to produce than extraposition, we might expect larger priming effects for both of these linearization patterns compared to extraposition priming ("inverse frequency effect").

The prime sentences were prerecorded in a sound studio and were spoken with natural intonation by a female native speaker of standard German. They were digitized at a sampling rate of 48kHz, 16-bit stereo and were compiled into audio.wav files. For each prime sentence quadruplet, two different pictures were drawn that

[9] Intraposition of *zu*-infinitives being obligatory with raising verbs such as *scheinen* ('seem') increases the overall frequency of this linearization pattern, though.

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depicted an easily describable action. One of these pictures matched the action described in the prime sentences and the other one illustrated an unrelated action, as shown in figure 2. Both the control verb and the infinitival verb were provided together with the target picture in printed form, to help participants grasp the depicted action more easily.

The target pictures served to elicit responses in which participants made use of one of the three linearization options for infinitival complements (for example, *Ich glaube, dass der Junge beschliesst den Bären aufzufangen* 'I believe that the boy decides to catch the bear'). The experimental procedure is described in more detail in the Procedure section below.

Across the whole experiment, each of the 12 target pictures was preceded by one prime sentence per condition, which led to a total of 48 critical prime-target combinations. In addition to the experimental items, our materials included 48 filler trials. These did not contain any infinitival complements as part of the prime sentences, and the target pictures only showed a single content verb next to the picture. The filler items differed from our experimental prime-target combinations in their lexical material and depicted actions. In order to keep the experimental session reasonably short and not to exhaust participants, we distributed the experimental and filler items across two presentation lists in pseudo-randomized order, such that not more than two critical prime-target combinations appeared in a row. This procedure resulted in 48 trials per experimental list.

Procedure

The experiment involved a picture description task using PowerPoint as a presentation tool. Participants were tested in a quiet laboratory at our institute. Before the experiment began, participants were asked to answer a set of biographical questions and to provide their consent to participating in our study. After receiving written instructions for the experimental task, participants were sat in front of a 17-inch computer screen and were asked to wear headphones to listen to auditory input. They were given two minutes to familiarize themselves with a set of picture cards assembled on the table in front of them. One example trial was provided in the introductory text, and participants were presented with three practice trials in order to familiarize themselves with the experimental task before the actual experiment started.

The presentation of each trial began with the spoken prime sentence. Primes were followed by a pause during which participants were asked to select the matching picture card from a set of picture cards in front of them. This intermediate task helped ensure that participants listened attentively to the prime sentences. Afterwards, they were asked to describe a target picture that appeared on the computer screen by making use of both verbs that were presented along with the picture. Participants' sentence productions were recorded using a voice recorder and transcribed by a student assistant after each testing session. After a participant had responded, the next trial was started by the experimenter and began again with the presentation of another prime sentence. Participants could take as much time as they needed for each trial, and the experiment was completed in about 20 to 30 minutes depending on how

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Table 4. Produced word-order patterns (percentages) during target picture descriptions following the four different prime conditions, Experiment 2

	Produced word-order pattern			
Prime condition	Extraposition	Intraposition	3rd C	Finite
Baseline	79	10	5.5	5.5
Extraposition	94	3	0	3
Intraposition	83	11	4.2	1.4
3rd C	82	8	6	4

fast participants could find matching picture cards and how readily they produced picture descriptions.

Data Analysis

We analyzed participants' transcribed sentence productions to target pictures following the four different prime conditions. Trials in which a finite clause was produced were removed prior to analysis, affecting 13.9 percent of our data. Spoken productions were coded with 1 to 3 according to the type of infinitival complement (1 = extraposition, 2 = intraposition, 3 = third construction) and analyzed with generalized linear mixed-effects models (binomial family) using the lme4 package in R (R Core Team 2017). We ran three separate models for each of the three types of infinitival constructions, namely, extraposition, intraposition, and third construction, employing sum-coded contrasts, with random intercepts and slopes for Subject and Item (Baayen et al. 2008). Prime Condition was added as a fixed factor (four levels: baseline, extraposition, intraposition, 3rd C). In addition, the continuous predictor Trial Position (that is, the order of items in each presentation list), which was centered around its mean, was also included in the analyses, in order to control for task-related habituation effects. For determining the best-fit random slope structure, we started with the maximal model and iteratively removed random slopes by participant or by item which explained the least variance (Barr et al. 2013) until the model did not improve any further according to its AIC value (Venables & Ripley 2002). The best-fit model for each analysis is reported in the results section. For each of the three models, we employed treatment contrasts with the baseline condition as reference level for the factor Prime Condition.

4.2 Results

Overall, participants' spoken productions revealed a clear preference for extraposed infinitival complements irrespective of prime condition (see table 4). Intraposed infinitives and 3rd C patterns were produced considerably less often than extrapositions, with third constructions being the least frequently produced word-order option.

Table 5 shows that extraposition was strongly preferred across all six control verbs under investigation, with the verb *versuchen* showing a weaker preference for

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Table 5. Produced word-order patterns (percentages) for each of the six matrix verbs, Experiment 2

	Matrix verb					
WO pattern	*ankündigen*	*bedauern*	*beschliessen*	*planen*	*versuchen*	*vorschlagen*
Extraposition	91.67	97.87	92.50	89.58	62.50	93.75
Intraposition	4.17	2.13	2.5	10.42	27.08	2.08
3rd C	4.17	0	5	0	10.42	4.17

extraposition compared to the rest. The verb *versuchen* is also attested comparatively frequently with 3rd C and intraposition patterns in corpora (see table 1), indicating that this verb allows for coherent construals more readily that other subject control verbs. The likelihood of the 3rd C pattern being produced was either low or zero, and not systematically related to whether a given verb was considered obligatorily (*ankündigen* 'announce', *bedauern* 'regret') or optionally coherent (*beschliessen* 'decide', *planen* 'plan', *versuchen* 'try', *vorschlagen* 'propose').

The statistical results are summarized in table 6. The generalized linear mixed-effects model for extraposed infinitival complements revealed a significant effect of Prime Condition, such that the proportion of produced extrapositions after encountering an extraposed infinitival complement in the auditory prime presentation was significantly increased compared to when a baseline auditory prime was presented. In contrast, the proportions of extraposition productions following intraposition or 3rd C primes did not statistically differ from those following baseline prime sentences. Unlike extraposition productions, the likelihood of intraposition or third constructions being produced following corresponding intraposition or 3rd C primes did not significantly increase compared to productions following the baseline prime condition.

Trial Position did not yield any significant effects for any of the three word-order patterns, indicating that the choice of word-order variant was not influenced by the position of trials in the experimental session. That is, the likelihood of participants producing a 3rd C pattern (or either of the other two patterns) in response to a corresponding prime did not increase over the course of the experiment.

4.3 Summary and Discussion

Experiment 2 investigated whether and to what extent the production of comparatively rare word-order patterns can be artificially increased via directed input. We can report two main findings. Firstly, in line with previous findings from an unprimed spoken production task (Bosch et al. 2022), extraposed infinitival complements were preferably produced across all conditions and matrix verbs. Secondly, despite providing equal numbers of prime sentences in all three word-order variants (extraposition, intraposition and 3rd C), only the production of extrapositions increased following corresponding prime sentences. The production of intraposition and third constructions, in contrast, could not be primed.

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Table 6. Summaries of statistical analyses (asterisks indicating significant effects at a=0.05) for each produced word-order variant following the four different prime conditions

Production of extraposition	Estimate	Std. error	z-value	p-value
3rd C	0.04	0.56	0.07	0.947
Extraposition	2.07	0.74	2.81	0.005*
Intraposition	0.21	0.55	0.38	0.707
c.(Trial Position)	−0.01	0.03	−0.41	0.680
R formula: glmer(Production_Extra ~ Condition + c.(Trial) + (1 |Participant) + (1|Item))				
Production of intraposition	Estimate	Std. error	z-value	p-value
3rd C	0.28	0.88	0.32	0.747
Extraposition	−1.43	0.99	−1.45	0.148
Intraposition	0.43	0.76	0.56	0.576
c.(Trial Position)	0.03	0.05	0.55	0.586
R formula: glmer(Production_Intra ~ Condition + c.(Trial) + (1 |Participant) + (1|Item))				
Production of third construction	Estimate	Std. error	z-value	p-value
3rd C	0.10	0.84	0.12	0.901
Extraposition	−0.36	1.45	−0.03	0.980
Intraposition	−0.22	0.85	−0.26	0.795
c.(Trial Position)	0.01	0.05	0.19	0.853
R formula: glmer(Production_3rd C ~ Condition + c.(Trial) + (1 |Participant) + (1|Item))				

Our results are inconsistent with previous findings indicating that less frequent patterns (here, intraposition and 3rd C) show stronger priming effects than more frequent ones (extraposition). We did not find any evidence for the idea that repeated exposure to 3rd C primes might provide some form of production training, either, and the likelihood of speakers' producing the prime patterns did not measurably increase over the course of the experiment.

Since inverse frequency effects are well attested in the research literature, the absence of 3rd C and intraposition priming in our study indicates that any potential priming benefit due to these constructions' relatively low frequency was overridden by stronger constraint(s) that prevented our participants from increasing their production of these word-order variants. These may include the DLM constraint or the avoidance of creating word-order patterns with crossing dependencies (Yadav et al. 2021). Experimental evidence of the influence of syntactic complexity on the size of priming effects is hard to come by, but there is evidence from Hindi indicating that structural patterns with crossing dependencies are difficult to prime (Husain & Yadav 2020). As the 3rd C pattern we tested also involves a crossing dependency, our finding that this pattern is resistant to priming is in line with Husain & Yadav's finding.

Note that language production is a "winner-takes-all" process in which the word-order variant that best meets the selection criteria wins, while all other variants lose

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out. Although our prime sentences were matched for length and the three prime conditions did not differ dramatically in terms of the dependency lengths involved, even small disadvantages may prevent a given variant from being chosen. While both 3rd C and intraposition are deemed acceptable (Bosch et al. 2022) and German speakers are clearly able to produce these patterns, both patterns break up syntactic dependencies creating either nested (intraposition) or crossing dependencies (third constructions). We think that extraposition easily out-competes both 3rd C and intraposition in sentence production because it represents the optimal candidate from the perspective of sentence planning and execution: Extraposition allows for the main and embedded clauses to be planned separately and for each to be produced as an uninterrupted string, thereby also avoiding the creation of syntactic ambiguity.

5. General Discussion

We asked whether third constructions are rare in present-day German because they are difficult to comprehend, difficult to produce, or both. In Experiment 1 we investigated whether the increased sentence processing time observed by Bosch et al. (2022) for 3rd C versus extraposition patterns can be attributed to the third construction's local ambiguity, and Experiment 2 examined whether third constructions can be primed. Taken together, our results show that third constructions are both difficult to comprehend and resistant to priming.

The analysis of participants' word-by-word reading times in Experiment 1 revealed a GP effect likely due to comprehenders' initially trying to analyze the ambiguous noun phrase (NP_{obj}) as a direct object of the lexical matrix verb, an analysis that later needs to be revised. Revising this misanalysis upon encountering disambiguating information was more costly when the initial direct object analysis was plausible. The results from Experiment 2 showed that despite rare structural patterns usually eliciting stronger priming effects than more frequent patterns, neither third constructions nor intraposed infinitives could be primed.

As we noted in the Introduction, 3rd C patterns are monoclausal structures whereas extraposed infinitives constitute separate clausal constituents. Sentences containing intraposed infinitives are potentially ambiguous between a biclausal and a monoclausal construal but are preferentially analyzed as monoclausal coherent structures (Bayer et al. 2005). If the choice between planning a monoclausal or biclausal structure is influenced by a message's information load (Lee et al. 2013), then complex events as described by examples (1a–c) should preferably be realized as biclausal structures. Recall further that unlike extraposition, both the 3rd C pattern and intraposition break up syntactic dependencies and may thus require a comparatively large planning scope. If verbs are planned in advance of their internal arguments (for example, Momma et al. 2016), then the extraposition pattern also mirrors verb-complement planning order more closely than third constructions or intraposition do. In short, the extraposition pattern should be favored from an economy-of-production perspective, other things being equal.

As sentence production is a "winner-takes-all" process, the optimal candidate is selected for production while less optimal variants are suppressed, which would explain the lack of 3rd C and intraposition priming effects observed in Experiment 2. The results from Experiment 2 are consistent with the claim that constraints on

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sentence production determine the occurrence frequencies of different word-order variants (MacDonald 2013).

Word-order patterns that are difficult to produce are not necessarily difficult to comprehend, however. Bosch et al. (2022) found a difference in processing difficulty between 3rd C and intraposition structures such that third constructions took significantly longer to comprehend than sentences containing intraposed infinitives, which did not differ in global processing time from extraposition structures. Considering that intraposed control infinitives are similar to 3rd C infinitives in being much less frequently attested than extraposed ones, this finding cannot obviously be attributed to differences between intraposition and extraposition distribution frequencies. Instead, from the perspective of incremental comprehension, it is third constructions that differ from both intraposition and extraposition in that they may trigger an initial misanalysis that gives rise to GP effects. For illustration, compare (9a) and (9b).

(9) a. THIRD CONSTRUCTION

dass	der	Sohn	[die	Hochzeit]	geplant	hat
that	the	son	the	wedding	planned	has
[zu	besuchen].					
to	visit					

b. INTRAPOSITION

dass	der	Sohn	[die	Hochzeit	zu	besuchen]
that	the	son	the	wedding	to	visit
geplant	hat					
planned	has					

Only in the 3rd C structure (9a), but not in the intraposition structure (9b), can the postverbal NP *die Hochzeit* ('he wedding') be misanalyzed as a direct object of the lexical matrix verb *planen* ('to plan'). Recognizing and correcting this error will disrupt processing at later sentence regions. In contrast, in (9b), the NP_{obj} is followed by its subcategorizing verb *besuchen* ('visit'), so that a direct object analysis is actually correct and no GP effects are expected. From the perspective of incremental comprehension, the 3rd C pattern is thus predicted to be more difficult to process than intraposition, which is indeed what Bosch et al. (2022) found. Taken together, Bosch et al.'s and the current findings show that comprehension difficulty does not necessarily mirror a structural pattern's distribution frequency (*contra* MacDonald 2013) but can also be affected by the way the comprehension system analyzes the input.

Having established that the 3rd C pattern is both difficult to comprehend and disfavored in production, we might ask why this structural pattern is still available to speakers of German. From a representational perspective, perhaps the simplest answer to the question of why the 3rd C pattern is still a valid word-order option is because the grammatical mechanisms that allow for this pattern to be generated are available independently. Recall that according to Wöllstein-Leisten (2001), generating 3rd C patterns involves both extraposition (that is, the placement of constituents to the right of the finite verb or "postfield") and argument structure unification, as is illustrated in simplified form in (2), repeated in (10) below.

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(10) dass [$_{VP}$ Max den Plan beschlossen hat [$_{VP}$ zu ändern]]
that Max the plan decided has to change

German allows for both clausal and nonclausal constituents to be extraposed to the right of the matrix verb, whilst argument structure unification is also involved in other types of coherent structure, notably with raising verbs and their infinitival complements (compare, for instance, Haider 2010: chapters 5 and 7).

Given the low occurrence frequency of third constructions, Bosch et al. (2022) suggested that the 3rd C pattern may be a "latent" construction in the sense of Newmeyer (2003): a structural pattern that is grammatical but hardly used. Adli (2011) has linked latent constructions to language change, such that over time, a latent construction may either become the preferred variant or disappear from the grammar. If this line of reasoning is correct, then the 3rd C pattern's rarity in present-day German and speakers' resistance to using this pattern indicate that the 3rd C pattern may be in the process of becoming obsolete.

Although evidence for speakers planning their sentences so as to avoid ambiguity is mixed (Wasow 2015), it is nevertheless conceivable that ambiguity avoidance is one of the factors contributing to the 3rd C pattern's rarity. The assumption that writers are more likely to avoid producing ambiguous structures compared to speakers (Temperley 2003:482) fits with the observation that this pattern occurs more frequently in spoken than in written German. But more research is required to systematically examine the role of ambiguity avoidance in speakers' word-order choices in variation contexts.

Having shown that the production of third constructions cannot be primed, we may wonder what circumstances might actually trigger their use. Information-structural factors may provide one possible motivation for using third constructions. As Geilfuss (1991) notes, the 3rd C constituent to the left of the matrix verb in sentences such as (11) can be focused.

(11) dass Maria den Tisch versucht zu reparieren
that Maria the table tries to repair
'. . . that Maria is trying to repair the table.'

Note, however, that the argument preceding the matrix verb does not need to be focused, and infinitival material appearing after the matrix verb can also carry focus (12) (see Wöllstein-Leisten 2001:91–99 for further discussion).

(12) dass Maria den Tisch versucht einem Freund zu verkaufen
that Maria the table tries a friend to sell
'. . . that Maria is trying to sell the table to a friend.'

Besides information-structural considerations, it is conceivable that constraints on sentence production sometimes facilitate rather than disadvantage the 3rd C pattern. Recall that in spoken sentence production, linearization sequences are partly determined by the order in which words or phrases become available to the speaker. That is, words or phrases that are retrieved easily tend to be produced earlier than others. Assuming that the 3rd C pattern is monoclausal and involves the formation of a complex predicate that can be linearized in different ways, arguments of the infinitival verb that are particularly easy to retrieve, for example because they are conceptually or discourse-salient (for

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example, Bock & Warren 1985), may occasionally be produced earlier than the matrix verb. As the written language is less likely to reflect ease of memory retrieval compared to spoken language, this might help explain why the 3rd C pattern is more likely to be attested in spoken than in written German (compare Bosch et al. 2022). Future research might explore whether increasing the accessibility of an infinitival verb's object noun phrase can make third constructions more likely to be produced.

6. Conclusion

Formal linguistic theory can account for the availability of alternative word-order patterns but not for differences in their relative frequency of occurrence. Processing difficulty is often hypothesized to account for low usage frequency, but such hypotheses are rarely backed up by data from processing tasks. Our experimental results showed that third constructions, a comparatively rare, discontinuous infinitival complementation pattern available in languages such as German and Dutch, are both difficult to comprehend and resistant to priming. We argued that the German 3rd C pattern presents somewhat different problems for comprehension and production; however, even though these problems all ultimately result from the way the matrix verb and its infinitival complement are structurally intertwined. Regarding sentence comprehension, we found that the 3rd C pattern's temporary structural ambiguity disrupted real-time incremental processing. The lack of priming, on the other hand, can be accounted for by assuming that producing third constructions requires a larger planning scope compared to the alternative (and much more frequent) extraposition variant. Dependency-crossing and a potential mismatch of planning and linearization order are likely to contribute to the 3rd C pattern being strongly dispreferred in production.

We hope that our study not only contributes to a better understanding of the 3rd C pattern's low distribution frequency but also demonstrates the usefulness of using controlled experiments to verify claims about how processing factors might influence language use. Although we concluded that the third construction's resistance to priming most likely reflects the relative difficulty of producing this structural pattern (specifically, in comparison to extraposition), there is a surprising dearth of research relating production difficulty to the size of priming effects. This issue aside, our study's main limitations include the fact that we focused on a single language and tested a comparatively small set of subject control verbs only, and that we did not examine a wider range of possible 3rd C patterns including ditransitive patterns and 3rd C patterns derived via scrambling.

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