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Freezing: Between grammar and processing

Abstract: We argue in this paper that ‘freezing’ phenomena do not reflect grammatical constraints, but rather processing complexity. We extend this result to the radical hypothesis that in general, judgments of unacceptability that have been taken in the literature as evidence for grammatical constraints on otherwise well-formed configurations are in fact the consequence of processing complexity and context effects. After briefly reviewing the notion of freezing, we look at the kind of evidence that has been used to argue for freezing constraints. Then we review experimental evidence that suggests that the unacceptability of certain freezing configurations is actually due to the processing effects of interacting extraction chains, and we argue that certain freezing effects are due to discourse processing factors such as information structure. We conclude with a summary and a statement of our radical hypothesis as a basis for future research.

1 Introduction

1.1 Freezing: a brief history

The idea of freezing in syntactic theory is that the reordering of syntactic material may under certain circumstances render parts of a structure closed to extraction. It has a venerable history, going back to Ross (1967, 1974); see Corver (2006, 2017) for a review.

Ross (1967) proposed the Immediate Self-Domination Principle (ISP), which said that in a structure of the form \([A A B]\), nothing can be extracted from B. In the Standard Theory of the time, such structures arose through movement and adjunction; hence the consequence of the ISP is that nothing can be extracted from a derived adjoined constituent.

Ross (1967: 305) also observed that extraction from a PP that has been extraposed is reduced in acceptability, as shown by (1b).

\[(1) \quad \begin{align*}
\text{a.} & \quad \text{You saw [a picture] yesterday [PP of Thomas Jefferson].} \\
\text{b.} & \quad \text{*Who did you see [a picture} tj]\text{ yesterday [PP of } tj]\text{?}
\end{align*}\]

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Ross’s (1967) formulation of the Frozen Structure Constraint in (2) deals specifically with such examples.¹

(2) a. The Frozen Structure Constraint: If a clause has been extraposed from a noun phrase whose head noun is lexical, this noun phrase may not be moved, nor may any element of the clause be moved out of that clause. (Ross 1967: 295)

   b. If a prepositional phrase has been extraposed out of a noun phrase, neither that noun phrase nor any element of the extraposed prepositional phrase can be moved. (Ross 1967: 303)

Later, Wexler & Culicover (1980) proposed the Raising Principle (3) and the Freezing Principle (4), based on considerations of language learnability.

(3) Raising Principle (Wexler & Culicover 1980: 143)
   If a node A is raised, then no node that A dominates may be used to fit a transformation.

(4) Freezing Principle (Wexler & Culicover 1980: 119)
   a. If the immediate structure of a node in a phrase-marker is nonbase, that node is FROZEN.
   b. If a node A of a phrase-marker is frozen, no node dominated by A may be analyzed by a transformation.²

Principle (3) can be interpreted as blocking subextraction from an extraposed PP, as in (1).³ There is in fact evidence that subextraction from raised constituents is unacceptable, as seen in (5).

(5) a. *Who did you say that [friends of t₁], you dislike t₁? [subextraction from embedded topicalization]
   b. *Who did you say that [friends of t₁] t₁ dislike you? [subextraction from subject]

¹ Ross’s formulation of the constraint reflects the fact that it is not possible to extract from an extraposed relative clause, even though it is not in a configuration that would fall under the Complex NP Constraint. Thus we see right at the start the treatment of freezing as a special type of island phenomenon.
² The expressions “analyzed by” in (4) and “used to fit” in (3) mean “undergo”.
³ In the original learnability proof, raising is understood to be movement from an embedded S into the S that immediately contains it. The cases discussed here do not fall under the Raising Principle as originally formulated.
In (5a) a constituent is extracted from a topicalized constituent. Attribution of the unacceptability in (5b) to the Raising Principle of course depends on an analysis in which the subject is raised from a lower position.

Turning to the Freezing Principle (4), it stipulates that freezing arises from a non-structure-preserving adjunction, in the sense of Emonds (1970, 1976). What condition (4b) means in practical terms is that adjunction of a constituent B to some phrase A should make it impossible to subsequently extract from anything dominated by A, including B.

We give a simple illustration. In cases such as (6c), the heavy NP *a picture of who* has arguably moved from the position adjacent to the verb to the end of the VP. In (6d), extraction is from the PP over which the heavy NP moves. (*t_j* indicates the gap corresponding to the canonical position of the direct object.)

(6)  

a. You put [a picture of FDR]_j on the table.  
b. You put *t_j* on the table [a picture of FDR]_j.  
c. *Who* did you put *t_j* on the table [a picture of *t_j]*?  
d. *Which* did you put *t_j* on *t_i* [a picture of FDR]_j?

By hypothesis, the configuration [VP V PP NP] is not a base configuration in English; hence it is frozen. It should not be possible to extract from any constituent of the VP, according to (4). The judgments in (6) appear to confirm this prediction.

More recently, Müller (2010, 2014) has proposed a contemporary version of the Wexler and Culicover Freezing Principle to explain the fact that extraction is not possible in German from a specifier if it is last-merged in its projection (e.g. subjects). However, extraction is possible when some other phrase scrambles over the last-merged specifier and becomes the last-merged specifier itself within the same phrase, which Müller refers to as melting.

Müller gives the data in (7) and (8) as instances of freezing and melting in German, respectively.

(7)  

*Was* haben [DP *t_i* für Bücher] [DP den Fritz] beeindruckt?  
What have [DP *t* for books.NOM] [DP the Fritz.ACC] impressed  
‘What kind of books impressed Fritz?’

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4 The same result follows from Ross’s ISP, cited above.  
5 Adjunction in this sense is daughter adjunction, where B becomes a daughter of A, and not so-called Chomsky-adjunction where a new node of category A is created above sisters A and B. (cf. Ross 1967)
On Müller’s account, *was für Bücher* in (7) is frozen, because it is last-merged in the specifier-position of vP. However, it is not frozen in (8), because the movement of *den Fritz* over it by scrambling removes the offending configuration that froze it – this is melting.

Contemporary syntactic theories, whether they are derivational or monostatal, do not permit the kinds of derivations in Ross (1967) and Wexler & Culicover (1980). For both, extraposition and heavy NP shift require rightward movement, which has been ruled out in more recent versions of syntactic theory (see the papers in Beermann et al. 1997 for discussion). Moreover, since at least Chomsky (1981), all operations in derivational theories have been stipulated to be structure-preserving, and the issue of structure-preservingness simply does not arise in a theory without movement. Hence it is impossible in contemporary approaches to syntax to derive the frozen structures that (4) is intended to rule out.6

Although the idea of freezing as envisioned by Ross and Wexler and Culicover may not be viable in contemporary theories, the idea of freezing as a grammatical phenomenon has persisted. For example, Rizzi (2006) (see also Rizzi & Shlonsky 2006, 2007, this volume) has proposed a notion of ‘criterial freezing’, which freezes any constituent that has moved in order to satisfy the formal checking requirements (i.e., criterion) of a head. The crucial cases of criterial freezing involve extraction of a wh-phrase to a position higher than its scope position, as in (9) (Rizzi 2007: 147, from Lasnik & Saito 1992).

(9) a. Bill wonders [[which book], Q [ John published t, this year ]

b. *(Which book), does Bill wonder [ t, Q [ John published t, this year ]]

Similarly, Gallego & Uriagereka (2007) propose that constituents on the left edge of phrases are frozen with respect to further analysis.

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6 Gereon Müller (p.c.) raises the question of whether some version could not be formulated in more contemporary terms. The key idea in the learnability proof is error detection on simple input. That is, the learner must be able to determine that s/he has hypothesized the wrong grammar on the basis of examples with limited embedding of structure. It is not clear whether it is possible to recreate error detection; an offending feature would have to be put on a node and only become visible after movement to a higher position in the structure.
1.2 Chain interactions

Let us step back and consider the characteristics of derivations that produce freezing effects. These derivations involve subex Extractions from constituents that have themselves been extracted. We refer to these types of chain interactions as Right Surfing and Left Surfing. The patterns are schematized in (10).

(10) a. Right surfing
   ?the person who I think that he gave a picture to Mary of t

b. Left surfing
   *the person who I think that he gave a book t

These patterns have been ruled out as ungrammatical because they violate freezing constraints in the grammar.

But it has been recognized since Chomsky & Miller (1963) and Chomsky (1965) that not all cases of unacceptability have to do with grammatical well-formedness per se. The classic examples involve multiple chains and center-embedding. The configuration of (11b) is the same as that of (11a).

(11) a. The cat the dog chased ate the cheese.
   b. *The rat the cat the dog chased killed ate the cheese.

(11b), unlike (11a), has multiple chains in a ‘nesting’ relationship.

The unacceptability of such cases suggests that it may be the complexity of the chain interaction that is responsible for unacceptability in the freezing cases, not a grammatical constraint. This idea is made more plausible by the fact that there are other non-surfing chain interactions that can yield unacceptability. We illustrate Nesting and Crossing in (12).

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7 The term ‘surfing’ to refer to extractions from extracted constituents originates with Sauerland (1999). The idea of a chain interaction typology that we discuss here was developed in collaboration with Jutta Hartmann.

8 We do not intend to suggest that Nesting and Crossing will automatically yield precisely the same kinds of judgments in every instance. The psycholinguistic mechanisms of chain processing are far from being well understood, and there are well-known lexical effects that can...
To take another case, Chomsky (1973) discusses examples that show that nested chains are not fully acceptable, and crossing chains are even less acceptable. Consider his examples in (13) – the judgments are ours.

(13) a. ?[Which violins]$_i$ are [these sonatas]$_j$ easy to play $t_j$ on $t_i$?
   b. ??[Which sonatas]$_i$ are [these violins]$_j$ easy to play $t_j$ on $t_i$?

There have in fact been proposals in the literature attributing a variety of island phenomena to extra-grammatical factors. A particularly well-studied case has been extraction from subject. The following examples showing the variability of judgments are due to Kluender (2005).

(14) a. Who$_i$ does [being able to bake ginger cookies for $t_i$] give her great pleasure?
   b. ??What$_i$ does [being able to bake $t_i$ for her children] give her great pleasure?

Kluender argues that the distance of the gap from the right edge of the constituent that contains it plays a role in determining acceptability, perhaps reflecting different demands on memory in the course of processing. Other work demonstrates the role of such factors as the relatedness between the extracted constituent and the head of the subject DP, the relatedness between the extracted constituent and the main verb, and the thematic structure of the main verb (Clausen 2010; Chaves 2013; Polinsky et al. 2013). Other studies that argue for the proposition that extra-grammatical factors play a role in judgments of unacceptability of various island violations are: Arnon, Hofmeister, Jaeger, Sag & Snider (2005); Gieselman, Kluender & Caponigro (2011); Hawkins (1994, 2004); ameliorate judgments in otherwise complex sentences. For discussion, see Lewis, Vasishth & Van Dyke (2006) and references cited there.
Hofmeister, Jaeger, Sag, Arnon & Snider (2007); Hofmeister & Sag (2010); Hofmeister, Staum Casasanto & Sag (2013); Kluender (1991, 1992, 1998); Kluender & Kutas (1993a,b); Sag, Hofmeister & Snider (2007). Taken together, these studies suggest the following hypothesis, which forms the backdrop to this paper.

(15) *No Freezing Hypothesis*: the unacceptability of freezing configurations, and perhaps all islands, is due to processing complexity.

In order to adequately evaluate this hypothesis, we first have to consider what the sources of unacceptability are, and on what basis it is reasonable to attribute unacceptability judgments to grammatical or extra-grammatical factors. This question is taken up in the next section.

2 What constitutes evidence for freezing?

We argue in this section that unacceptability in itself is not evidence for ungrammaticality. It is premature to attribute the unacceptability of configurationally well-formed expressions to grammatical principles without entertaining the possibility of alternative explanations.

The classical view of grammaticality is that a string of words is grammatical if it is licensed by the grammar. Licensing by the grammar involves assigning a proper structural description to the string. If the grammar does not assign a proper structural description to a given string, then the string is ungrammatical.

If there is no clear evidence that unacceptability is due to semantic anomaly or processing complexity, the default assumption in the field has been that an unacceptability judgment reflects ungrammaticality. That is, the grammar rules out the unacceptable string. However, a string of words may be well-formed except for the violation of one particular grammatical condition. For instance, in the following sentence the only problem is that there is an inflection error on the last verb.

(16) *Everyone said that they thought that Sandy would wins the race.

Compare this example with one that has the words of a grammatical sentence in reverse order.

(17) a. Sandy wants to climb Mount Everest.
   b. *Everest Mount climb to wants Sandy.
It is clear that (16) is much better than (17b), although strictly speaking both are ungrammatical. Such observations give rise to the notion of relative grammaticality, a phenomenon that has been characterized in various ways in the literature. This was a concern early on in generative grammar (cf. Katz 1964, Chomsky 1975: Chapter V and Ross 1972), and has been taken up more recently by, for example, Featherston 2005; Sorace & Keller 2005; Staum Casasanto et al. 2010.

In considering whether there is evidence for a grammatical constraint per se, then, it is not sufficient to show that a given sentence or configuration is acceptable or unacceptable to some degree. Clear evidence for a grammatical constraint is that there is a component of the unacceptability judgment that simply cannot be accounted for in terms of extra-grammatical factors (Phillips 2013). At the same time, it must be demonstrated that this component of the unacceptability judgment does not occur when the particular configuration at issue is absent – it must be uniquely associated with the configuration.

Our reasoning here follows Occam’s Razor. Given that processing and pragmatic factors have demonstrable effects on judgments of acceptability, we must do our best to rule out such factors before we conclude that certain unacceptability judgments are due to a grammatical constraint. For example, if extractions in sentences that do not satisfy the definition of freezing are nevertheless unacceptable, and in the same way as in freezing configurations, it would be reasonable to conclude that the unacceptability is due to the extraction itself, and not to a freezing configuration.

Our goal is to demonstrate that at least for the prominent cases of putative freezing introduced above, the unique association of configuration and unacceptability judgment does not hold. There are two types of evidence that we bring to bear.

Additivity: We show that the unacceptability encountered in these cases of freezing can be accounted for entirely in terms of the individual extractions. That is, there is no portion of the unacceptability that adheres specifically to freezing.

Context: We show that the judgments can be manipulated by context, so that the unacceptability cannot be attributed to the configuration but rather to discourse processing factors, such as information structure.

Section 3 shows that the unacceptability judgments in the classic Ross case of extraction from extraposition are additive, leaving no part of the judgment to be explained by a grammatical principle. This section also addresses the classic Wexler and Culicover case of extraction from heavy NP shift, with similar results. In section 4 we show that the case of freezing due to Müller (2010) (cited above) can be explained by appealing to the computation of topic and focus with and without plausible context.
3 Processing complexity

3.1 Extraction from extraposition: distance matters

In this section we cite evidence that suggests that an extraposed PP is not actually frozen. The unacceptability of extraction appears to depend on how far to the right the PP has been extraposed; cf. (18).

(18) a. Who\textsubscript{i} did you show [a picture \textsubscript{t\scriptscriptstyle j}] yesterday \textsubscript{[of t\scriptscriptstyle i]} to Martha at the party?
   b. Who\textsubscript{i} did you show [a picture \textsubscript{t\scriptscriptstyle j}] yesterday to Martha \textsubscript{[of t\scriptscriptstyle i]} at the party?
   c. Who\textsubscript{i} did you show [a picture \textsubscript{t\scriptscriptstyle j}] yesterday to Martha at the party \textsubscript{[of t\scriptscriptstyle i]}?

Our intuition is that (18a) is least unacceptable while (18c) is most unacceptable.

Our intuition agrees with the observation that increasing the distance between syntactically related linguistic units slows reading times at the point where they are integrated (cf. Gibson 1998, 2000; Grodner & Gibson 2005; Bartek et al. 2011). To confirm this intuition, we ran an experiment with English native speakers to test the hypothesis that extraposition by itself (without extraction) lowers judgments, and that as extraposition distance increases, acceptability decreases. The experiment was carried out in collaboration with Philip Hofmeister. In this experiment, as well as in the other experiments described in this paper, we collected acceptability judgments via Amazon.com’s Mechanical Turk marketplace on a five or seven point scale with higher values indicating higher acceptability. 60 participants took part in the present experiment. All of them identified their location as the US and indicated that they were native English speakers. Participants received between $1.50 and $3 for their participation. As the present experiment is not published elsewhere, it will be described in some detail.

We constructed 24 items and manipulated the distance between an NP and the PP extraposed from it in terms of the number of phrases intervening between them within items as illustrated in (19). The head noun of the NP was separated from the syntactically and semantically related PP by zero, one, or two phrases. The three levels of the predictor distance are labelled SHORT, as in (19a), where the PP about that actor follows the noun phrase a story immediately; MEDIUM, as in (19b), where the PP occurs to the right of the adverb anxiously and is separated from the head noun by one phrase; LONG, as in (19c), where the PP is extraposed to the end of the clause over two phrases.

(19) a. My friend read a story [about that actor] anxiously while having breakfast. [= SHORT]
b. My friend read a story anxiously [about that actor] while having breakfast. [= MEDIUM]

c. My friend read a story anxiously while having breakfast [about that actor]. [= LONG]

The three different variants of an item (cf. 19) were assigned to three different lists according to a Latin square design such that each list contained eight experimental items in each of the three conditions. 72 distractor items accompanied the experimental items. Participants were randomly assigned to one of the three lists. The instructions preceding the experiment asked participants to judge the subsequent sentences in terms of naturalness on a 5 point scale. Following each sentence, we included a comprehension question to ensure that participants read the items carefully. All participants performed better than 75% correct and were included in the analysis.

The acceptability data were subjected to a linear mixed model (LME) analysis in R with the single fixed factor distance and random intercepts and slopes for participants and items. We were interested in the course of the decrease in acceptability with increasing distance. Therefore, we used a polynomial contrast for the single three-level predictor distance (SHORT, MEDIUM, LONG), which checks for a linear and a quadratic component of the decrease (contr.poly in R). This contrast supposes that the predictor distance is taken to be an interval scaled variable with equidistant spaces from SHORT to MEDIUM and from MEDIUM to LONG (zero vs. one and one vs. two intervening phrases). Mean acceptability judgments are shown in Figure 1.

![Figure 1: Mean acceptability judgments for extraposition distance. Error bars show +/- standard error.](image-url)
The analysis corroborates significant linear and quadratic components in the decrease of acceptability as a function of the increasing distance between NP and PP (cf. Table 1). In particular, the quadratic component confirms that the decrease from SHORT to MEDIUM distance is larger than the further decrease from MEDIUM to LONG distance. In other words, the effect of interposing a second phrase was weaker than the effect of interposing the first one.

Extraction from PP in a subject produces similar results (Huck & Na 1990). While extraction from the non-extraposed PP in subject position is slightly degraded (20b), extraction from the extraposed PP is much worse (21b). (The judgments are Huck and Na’s.)

(20) a. A picture [of that actor] was for sale at the market yesterday.
   b. A picture $t_j$ was for sale at the market yesterday [of that actor]$_j$.

(21) a. *Which actor$_i$ do you suppose that [a picture [of $t_j$]] was for sale at the market yesterday?
   b. *Which actor$_i$ do you suppose that [a picture $t_j$] was for sale at the market yesterday [of $t_j$]??

Furthermore, Huck & Na (1990) (see also Bolinger 1992) showed that contrastively stressing the preposition and contextualizing the contrast conveyed by the accent facilitates stranding of the preposition.

(22) Okay, you saw a picture yesterday, but just who(m) did you see a picture yesterday OF?

(23) a. Here’s an article in the Tribune by Trevor, of all people; he’s someone I’d expect to read a story in the paper ABOUT.
   b. I know Alger found letters in the file TO Chambers, certainly, but I’m not sure I can remember whom he found letters in the files FROM.
   c. I think Bill said we saw a film yesterday by Napoleon, but of course Napoleon was the fellow who(m) we saw a film yesterday ABOUT.
   d. I heard Mary took some photographs in Peoria for the director, but one has to wonder what she could find there to take photographs for the director OF. (Huck & Na 1990: 66)
Huck and Na propose that what is going on in the extraposition cases is not a matter of grammar, but of accent and contrastive focus, which are linked to discourse context.

### 3.2 Chain processing

If Huck and Na are on the right track, a question that arises is, Why does context make extraction from extraposition more acceptable? The beginning of an answer to this question takes note of the fact that it is not just any context that helps, but context that increases the expectation that there is an extraposed PP. In (22) the first clause contains *a picture* with no complement, and the second clause supplies the complement. In (23) the first clause sets up a contrast between the extraposed PP with one preposition, e.g. *to* (*Chambers*), and the second clause has the same extraposed structure with a contrasting preposition, e.g. *from*.

So we must ask why the appropriate contrastive context improves acceptability. Our answer appeals to the idea that the sentence processor is a probabilistic parallel processor (Hale 2001, 2003; Levy 2005, 2008, 2013; Levy et al. 2012; van Schijndel et al. 2013). On this view, the total “probability mass” of the parse of a sentence is allocated over the possible alternative parse trajectories at any point in the processing. If the actual parse follows the most probable trajectory, there is minimal “surprisal”. But if the actual parse trajectory takes a course that is of low probability, there is high surprisal, and the subjective experience of difficulty, which leads to a lower ranking of the sentence.

This story raises a couple of obvious questions. One is, why does context facilitate processing? The other is, why do some parse trajectories have lower probability than others?

The answer to the first question, we suggest, is that context changes the probabilities in favor of the structure that is exemplified. This is, in effect, a form of priming. Along related lines, Levy, Fedorenko, Breen & Gibson (2012) show that surprisal, as measured by reading times and corpus frequency, is lower for an extraposed relative clause when there are cues for it in the antecedent NP. We suggest that anything that raises the expectation of a particular parse trajectory will have the effect of lowering surprisal and raising acceptability.

The answer to the second question is that surprisal is a function of frequency, and frequency is a function of complexity. It has been shown by Hawkins (2014) that more complex structures are less frequent in corpora and less likely to be licensed by the grammars of languages. Hawkins’ central assertion is that the
complexity of a dependency correlates with the length of the dependency: the longer the dependency, the more complex the dependency, and the lower the frequency.\(^9\)

Given the foregoing, our No Freezing Hypothesis in (15) above suggests an experimental approach to judgments of unacceptability that have been attributed to freezing. Sections 3.3 and 3.4 summarize results of experiments on chain interactions in extraction from extraposition and HNPS, respectively. The results suggest that unacceptability in these cases is due entirely to processing complexity. Section 4 reviews an experiment that shows that manipulation of context can alleviate or induce unacceptability of putatively frozen structures. In all cases, it appears that there is no need to appeal to a grammatical principle of freezing.

### 3.3 Experiment: Extraction from extraposition

Focusing now on extraction from extraposition, we see that there are two types of dependency that are relevant. One is the wh-chain of the extraction, and one is the extraposition dependency. In the case of a simple extraction without extraposition, or a simple extraposition without extraction, there is one chain that must be constructed. When there is extraction from extraposition, there are two chains.

We reason, therefore, that the unacceptability of examples such as (18) is due simply to the complexity of the two chains. On this view, there is no interaction in the processing of the chains. In the simplest case, we would expect that the processing complexity of sentences with extraction from extraposition, thus the frequency and hence the rankings, would be determined by the sum of the complexity of the two dependencies.

We ran an experiment, reported on in Hofmeister, Culicover & Winkler (2015), to confirm our initial intuitions that such chain interaction causes processing complexity. The experiment determines if the acceptability judgments due to extraposition and extraction are in some way dependent on the two factors occurring together in the same examples, that is, if there is a freezing effect. A sample of the examples used in this experiment is given in (24).

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\(^9\) An anonymous reviewer points out that Hawkins has also argued for an influence of processing on grammar. Hawkins argues that frequency effects due to processing considerations (mainly minimizing dependency length) may become grammaticalized in the limit. Thus a particular configuration that is more or less acceptable due to processing complexity in one language may be completely impossible, hence ungrammatical, in another. If Hawkins is right, it will be useful to bring to bear experimental evidence of the kind provided in this paper in order to adjudicate between grammatical and extragrammatical accounts of certain phenomena.
(24) a. You told me your friend read a story [about an actor] twice while having breakfast. [No extraction, no extraposition]
b. You told me your friend read a story twice [about an actor] while having breakfast. [No extraction, extraposition]
c. Tell me which actor your friend read [a story about t] twice while having breakfast. [Extraction, no extraposition]
d. Tell me which actor your friend read [a story t] twice [about t] while having breakfast. [Extraction, extraposition]

Example (24a) has neither extraposition nor extraction. Example (24b) shows extraposition without extraction, while (24c) shows extraction from the unextraposed PP. Example (24d) shows extraction from the extraposed PP. This design allows us to determine how much extraposition and extraction independently lower judgments, and whether combining the two lowers judgments beyond what is expected on the basis of each independent source of unacceptability.

Our results, as reported in Hofmeister, Culicover & Winkler (2015), showed that when combined, extraction and extraposition are additive (mean acceptability judgments are shown in Figure 2). There is no interaction: extraction is no worse in contexts with extraposition, (24d), than in contexts without, (24c).

![Figure 2: Mean acceptability judgments from experiment on extraction/extraposition interaction. Error bars show +/- standard error.](image-url)
The freezing violations (24d) have an average rating that is predictable on the basis of the independent average penalties for extrapolation and extraction. This fact, taken together with the observation in section 3.1 that chain distance plays a role in the acceptability judgments suggests that it is processing that is responsible for the judgments, and not a grammatical freezing constraint.

### 3.4 Experiment: Heavy NP shift

Another classic case of freezing is Heavy NP shift (HNPS). If freezing is not due to a grammatical principle, as the preceding sections suggest, we expect to find similar additivity in the case of extraction from a shifted heavy NP. This is precisely what we found, in an experiment that we summarize briefly in this section.\(^\text{10}\) We collected acceptability judgments via Amazon.com’s Mechanical Turk marketplace. 96 individuals completed the survey on Mechanical Turk in the two experiments, respectively. Participants were instructed to judge the sentences in terms of naturalness on a 7-point scale, 1 being extremely unnatural and 7 being extremely natural.

For reasons discussed in the preceding sections, extraction is expected to cause some reduction in acceptability, because of the chain processing. In the case of HNPS without extraction in (6a,b), repeated below, a chain processing account is plausible. Staub, Clifton & Frazier (2006) found evidence of a processing slowdown at this point, regardless of the subcategorization properties of the verb.

\[(6)\]
\[\begin{align*}
\text{a. You put \{a picture of FDR\}_j \text{ on the table.}} \\
\text{b. You put } t_j \text{ on the table \{a picture of FDR\}_j.}
\end{align*}\]

With this in mind, we presented subjects with experimental materials varied with respect to whether or not there is extraction, as well as whether the heavy NP is shifted or not. Combining these factors yields example items like (6c), repeated here.

\[(6)\]
\[\text{c. *Who}_i \text{ did you put } t_j \text{ on the table \{a picture of } t_i\}_j?\]

In addition, we varied the material to the right of the NP. In our materials, the intervening phrases consisted of adverbial PPs, adverbs and PP arguments of the

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\(^{10}\) See Konietzko, Winkler & Culicover (2018) for experimental details.
verb. (25)–(27) show the various conditions. In (25) for example, (25a) is the base order where the heavy NP immediately precedes the PP adverbial (non-extr. (base)). In (25b) the heavy NP follows the PP adverbial (non-extr.(shift)), and (25c) shows extraction from the heavy NP in its base position (extr.(base)). Example (25d) illustrates extraction from the shifted heavy NP (extr.(shift)). The examples in (26)–(27) show the same alternatives for a heavy NP and an adverb and a PP argument, respectively.

(25) Adverbial PPs (PP-ADV)
   a. The professor praised a detailed review of the new book in his article.  
      [Base order]
   b. The professor praised in his article a detailed review of the new book.  
      [HNPS]
   c. What did the professor praise a detailed review of in his article?  
      [Extraction from base order]
   d. What did the professor praise in his article a detailed review of?  
      [Extraction from HNPS]

(26) Adverbs (ADV)
   a. The professor praised a detailed review of the new book passionately.  
      [Base order]
   b. The professor praised passionately a detailed review of the new book.  
      [HNPS]
   c. What did the professor praise a detailed review of passionately?  
      [Extraction from base order]
   d. What did the professor praise passionately a detailed review of?  
      [Extraction from HNPS]

(27) PP arguments of the verb (DITR)
   a. The professor gave a detailed review of the new book to his colleague.  
      [Base order]
   b. The professor gave to his colleague a detailed review of the new book.  
      [HNPS]]
   c. What did the professor give a detailed review of to his colleague?  
      [Extraction from base order]
   d. What did the professor give to his colleague a detailed review of?  
      [Extraction from HNPS]

As Figures 3–5 show, HNPS lowers acceptability for all of the conditions. The differences are all significant – see Konietzko et al. (2018). Examples
Figure 3: Mean acceptability judgments for shift over PP-adverbials, with and without extraction from heavy NP.

Figure 4: Mean acceptability judgments for shift over adverbs, with and without extraction from heavy NP.

Figure 5: Mean acceptability judgments for shift over PP-arguments, with and without extraction from heavy NP.
like (25a,c), (26a,c) and (27a,c) are judged to be worse than examples like (25b, d), (26b,d) and (27b,d). Extraction lowers judgments in all conditions. Examples like (25c,d),(26c,d) and (27c,d) receive lower ratings than examples like (25a,b), (26a,b) and (27a,b). However, HNPS is no worse in contexts with extraction than in contexts without.

We do see differences in the effect of HNPS in what is shifted over. Sentences with final adverbs are judged to be not as good as sentences with final adverbial PPs. (We speculate that this is due to the fact that the preferred position for the adverbs is preverbal.) HNPS has a significantly larger negative affect on the judgment of the PP adverbials than the adverbs.

Similarly, sentences with final PP arguments are judged to be not as good as sentences with final PP adverbials. Again, HNPS has a larger negative effect on the judgment of the PP adverbials than the PP arguments.

In all conditions, the effect of extraction is independent of the effect of HNPS; there is no significant interaction. The judgments in each condition are additive. The mean acceptability judgments for extraction from the shifted heavy NP in the individual conditions are not significantly different from the sum of the acceptability conditions for HNPS and extraction alone. In fact, while the interaction is slightly superadditive in the PP adverbial condition, it is underadditive in the adverb and PP argument conditions.

Thus, the current results support the prima facie case against a grammatical account of freezing. The more plausible explanation, it seems, is that the judgments are due to the processing of multiple chains.

There are, of course, alternative explanations depending on the analysis of HNPS, but these do not bolster the case for a grammatical freezing principle. For example, it might be that HNPS is a base order. This would make the question of freezing moot, since without movement it would not be frozen in the conventional sense.11

3.5 Discussion

Summarizing to this point, we see that for two classical cases of freezing, the experimental evidence does not provide support for a grammatical constraint.

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11 Alternatively, we might suppose that the heavy NP is in a Spec position and the rest of the VP moves over it to the left, as in Larson (1988) (but see Jackendoff 1990). In this case the NP would also be in situ, and a freezing account would not explain the reduced acceptability of extraction from the NP. The Larsonian account does not result in freezing of the larger VP that contains the heavy NP, the V and other material, since it assumes a local structure-preserving movement.
The case of extraction from extraposition purports to be freezing due to ‘raising’ – it is subextraction from a raised constituent. The evidence thus suggests that the Raising Principle is not descriptively adequate. Rizzi (2006, 2007, 2014) arrives at similar conclusions in his formulation of criterial freezing – the raised constituent cannot be moved beyond the criterial position, but subextraction can apply to the raised constituent.

In the case of Heavy NP Shift we have evidence that data that had been explained by the Freezing Principle itself must have an alternative account. As noted above, the non-structure-preserving movement of the heavy NP is not licensed in contemporary syntactic theories. Furthermore, the experimental results suggest, again, that the unacceptability of extraction from the heavy NP is a function of the chain dependencies, and not the configuration of the VP.

4 Context

4.1 Müller 2010: was-für split

We turn now to another case of freezing, was-für split, which we introduced briefly in section 1.1. We provide evidence that in this case the lack of appropriate context is responsible for the unacceptability of the frozen examples, not the syntactic configuration.

The was-für ‘what for’ construction in German consists of was-für plus N(oun) and is usually translated as ‘what kind of DP’ as in (28).

(28) was-für

\[
\text{Was für Bücher} \quad \text{hat er} \quad \text{t kritisiert?}
\]

‘What kind of books did he criticize?’

One specific feature which is central to the present discussion is that the wh-element was ‘what’ can be subextracted out of the DP-constituent, as in (29).

(29) was-für split

\[
\text{Was für Bücher} \quad \text{hat er} \quad \text{t kritisiert?}
\]

‘What kind of books did he criticize?’

This phenomenon, called was-für split, was first observed by Bennis (1983) and den Besten (1985).
The puzzle that we focus on is described by Müller (2010). Müller’s freezing account represents the classical syntactic view that a certain grammatical configuration causes freezing. He updates the original freezing principle by Wexler & Culicover (1980: 119) by formulating a general constraint in terms of configuration, rather than extraction.

Müller (2010:61) gives the data in (30) and (31) as instances of freezing and ‘melting’ in German, respectively.

(30) *Was haben [DP \(t\) für Bücher] [DP den Fritz] beeindruckt?
    What have [DP \(t\) for books. NOM] [DP the Fritz.ACC] impressed
‘What kind of books impressed Fritz?’

(31) Was haben [DP den Fritz] \([DP \(t\) für Bücher]\) \(t\) beeindruckt?
    what have [DP the Fritz.ACC] [DP \(t\) for books. NOM] \(t\) impressed
‘What kind of books impressed Fritz?’

According to Müller, (30) is marked – and in his view ungrammatical – since was-für extraction takes place from a frozen configuration, here the last-merged subject in vP, was für Bücher. However, (31), where the freezing configuration has been removed by subsequent merging of the direct object above the subject, is deemed grammatical. Müller calls this process melting, defined as in (32).

(32) Melting
Local scrambling in front of what would otherwise qualify as a last-merged specifier renders the specifier transparent for extraction. (Müller 2010: 35)

(31) is an instance of melting, here brought about by a local scrambling operation, which moves den Fritz to a position higher in the structure than was für Bücher.

Müller further suggests (2010: 61, fn. 35) that freezing effects occur not only with psych-verb subject extractions like beeindrucken (‘impress’), but also with regular transitive verbs, such as kritisieren (‘criticize’) in (33).

(33) Freezing
*Was haben [DP \(t\) für Ärzte] [DP den Minister] kritisiert?
    What have [DP \(t\) for doctors. NOM] [DP the secretary.ACC] criticized
‘What kind of doctors criticized the secretary?’

Müller’s proposal also predicts that if the definite DP den Minister is scrambled over the subject and adjoined to the highest vP, grammaticality is restored; cf. (34).
(34) Melting
Was haben \[DP \text{den Minister}]_i [DP \text{t für Ärzte}]_j t_k kritisiert?

‘What kind of doctors criticized the secretary?’

Our intuition about this data, and specifically about the putative ill-formedness of example (33), is that it is not a matter of a grammatical constraint. Rather, there is an interaction between the constituent order, the default assignment of sentence accent, and extraction. The key to the interaction is that in the absence of context, the default accent in German falls on the immediate preverbal constituent. This constituent is interpreted by default as the focus. Extraction from focus is well-formed, while extraction from a non-focus is not.

Context can be used to manipulate the placement of focus on different constituents of a sentence. Our hypothesis is that contrastive focus on Ärzte and backgrounding den Minister raises the expectation of a particular parse trajectory (see section 3.2). It thereby lowers surprisal and increases the judgment. Hence extraction, given the same constituent order and constituent structure, may receive different judgments in the absence of context and in the presence of context that shifts the position of focus reliably onto the subject. The consequence of this interaction is that in the absence of context, was-für split from a subject is understood as extraction from a non-focus constituent, which produces an information structure conflict, and hence ill-formedness.

4.2 Information structure constraints in German

In order to give substance to the intuition noted at the end of the previous section, we summarize here three constraints that govern the interpretation of accent in German. They are summarized in (35).

(35) DEFFOC: Assign default focus to immediate preverbal position.
DESTRESS: Destress Given
EXTRACT: A’ extract only from a focused constituent.

The first constraint, DEFFOC, was first formulated by Höhle (1982) for declarative sentences. It has subsequently been used as a diagnostic criterion for wide focus readings (cf. Haider & Rosengren 2003; Reis 1993; Selkirk 2011; Truckenbrodt 1995, among others). A schematic representation of the default intonational pattern in German declaratives is given in (36), where we distinguish the different fields according to their information-structural contribution. The H*+L accent is
the default accent realized on the immediate preverbal DP. The particle *denn* is a diagnostic for the left edge of vP and plays a central role in locating the precise position of the focal accent in the structure.

\[(36) \quad H^*L \quad [CP... [TP...<topic \text{field}>... [vP (denn) [vP ...<focus \text{field}>... ] V_{\text{fin}}]]]]\]

In (37), we show that DEFFOC applies to regular V-final patterns in German. The same constraint accounts for the default intonation of the embedded *was-für* split construction in (38a), as it does for the V2 *was-für* split construction in (38b). In each of these examples the DP *Bücher* (‘books’) receives the default focus, indicated by full capitalization.

\[(37) \quad \text{warum er (denn) BÜCHER gelesen hat} \quad \text{‘why he then read books’}\]

\[(38) \quad \text{a. Ich wollte wissen, was er (denn) für BÜCHER gelesen hat} \quad \text{‘I wanted to know what books he read’}\]

\[\text{b. Was hat er (denn) für BÜCHER gelesen} \quad \text{what has he PRT for books read}\]

The second constraint, DESTRESS, requires the deaccentuation of old information in discourse. Such a constraint has been explicitly proposed by Féry & Samek-Lodovici (2006), but observed before by Chomsky (1971); Culicover & Rochemont (1983); Ladd (1980), Rochemont (2013a), Rochemont (2013b); Rochemont (2016), Schwarzschild (1999), among many others.

The third constraint, EXTRACT, is a reformulation of Bayer’s (2004) generalization in (39); see also Erteschik-Shir (2007).

\[(39) \quad \text{In a topic/focus structure} \quad [[\text{TOP} X] [\text{FOC} Y]], A^\prime\text{-movement is not allowed to affect} \quad X.\]

Bayer investigates subject/object asymmetries in long extractions and observes that the opposition is not one of grammatical function (subject vs. object), but a difference in information structure (IS) status. He distinguishes the topic domain and the focus domain and argues that elements cannot be extracted from the topic domain (cf. Bayer 2004: 238).
In section 4.3 we summarize the results of a rating study that suggest that these constraints are in fact responsible for acceptability judgments of the word order patterns in was-für construction.

4.3 Experiment: Extraction from was-für

The experiment that we summarize in this section is discussed at greater length in Winkler, Radó & Gutscher (2016). The goals of the experiment were (i) to demonstrate that judgments on examples such as (33) are graded, and (ii) to demonstrate that the IS-based constraints discussed in section 4.2 can explain the gradient character of the freezing-melting phenomenon.

The core cases of freezing, melting and extraction from a moved subject are provided in (40). They are based on some of Müller’s (2010) examples. However, in contrast to the examples we discussed earlier in (31) and (33), they involve the particle denn, which clearly identifies the boundary between the topic and the focus field (cf. Bayer 2012; Bayer & Obenauer 2011; Grosz 2016). Through the position of denn we can exactly identify the position of the subject remnant; otherwise the freezing case (40a) and the subject movement case (40c) would be indistinguishable.

(40) a. No movement [NM]
   *Was$_i$ haben denn [DP t$_i$ für Ärzte] [DP den Minister] kritisiert?
   ‘What kind of doctors criticized the secretary?’

   b. Object movement [OM]
   Was$_i$ haben [DP den Minister] denn [DP t$_i$ für Ärzte] t$_j$
   kritisiert?
   ‘What have doctors criticized the secretary?’

   c. Subject movement [SM]
   *Was$_i$ haben [DP t$_i$ für Ärzte] denn [DP den Minister]
   kritisiert?
   ‘What have doctors criticized the secretary?’

The three different was-für patterns are given schematically in (41). Since all three patterns involve wh-extraction from the subject position, we represent the word
order patterns prior to this operation for simplicity. We refer back to (41) in our analysis below.

(41) \[\text{a. No Movement (NM)} \Rightarrow \text{Müller's Freezing} \]
\[*[\text{CP} \ [\text{TP} \ (\text{denn}) \ [\text{VP Subj Obj }] \text{V}]]\]

\[\text{b. Object Movement (OM)} \Rightarrow \text{Melting} \]
\[\text{[CP} \ [\text{TP Obj}_1 \ (\text{denn}) \ [\text{VP Subj } t_1 ] \text{V}]]\]

\[\text{c. Subject Movement (SM)} \Rightarrow \text{Control Condition; Freezing} \]
\[*[\text{CP} \ [\text{TP Subj}_1 \ (\text{denn}) \ [\text{VP } t_1 \text{ Obj }] \text{V}]]\]

In Müller’s terms, wh-extraction from Subj in (41a) is from the last merged subject. We refer to it as the ‘no movement’ (NM) case since both the subject and object are in their base position in vP. This is the configuration Müller defines as freezing. Wh-extraction from Subj in (41b) is again from the subject in vP. The difference here is that the object is scrambled to a position to the left of the modal particle denn. We refer to this instance as the “object movement” (OM) case. Note that the subject is the only argument left in the vP. From a linear perspective, it occurs immediately preverbally. This is the so-called “melting” configuration.

In (41c), extraction is from a moved subject. The subject moves out of the focus field into the topic field prior to wh-extraction. This case is called “subject movement” (SM). For our experiment, this configuration serves as a control. It is a structure that is characterized as extraction from a moved subject. In contrast with the NM-case of (41a), (41c) constitutes a prototypical case of freezing of the Ross/Wexler and Culicover variety.

Following this perspective, the NM-structure (41a) is not frozen, but victim to processing difficulties and therefore marked relative to the OM-case (Müller’s melting, 41b). Constraint satisfaction accounts of sentence processing assume that all possible analyses of a sentence structure are activated at the same time (cf. MacDonald 1994). However, the level of activation depends on the support that the different analyses receive from the constraints relevant to processing the sentence, here the constraints in (35). The core challenge is that information structural, prosodic and syntactic constraints lend support to different possible ways of analyzing the sentence structure at different points of analysis. Only in the OM-case (41b) do the constraints in (35) point to the same processing alternative throughout the sentence. The scrambled object is given, default focus is assigned to the subject, extraction occurs from the focused subject. In the no movement (41a) and the subject movement (41c) cases, competing analyses receive similar amounts of expectation and leave the parser with a greater processing burden (see Winkler et al. 2016).
One major argument against the configurational view of freezing is that the acceptability judgments may change if context is provided. More specifically, our account predicts that the degraded status of Müller’s freezing case should be improved by a suitable context.

The essential idea is that a DP in immediate preverbal position in German is by default accented and focus, as discussed in section 4.2. In the absence of context, a sentence such as (40a) with this implicit intonation is interpreted with focus on the immediate preverbal constituent. Extraction from was für Ärzte is thus from a constituent not in focus, in violation of the constraint EXTRACT. However, if context forces the implicit accent and the focus interpretation onto was für ÄRZTE, extraction will not violate this constraint and thus should be acceptable.

With this in mind, we designed an experiment in which we manipulated word order (NM vs. OM vs. SM) and default focus (DF) vs. contrastive focus (CF) on the subject, induced by a preceding context, yielding a total of six conditions, as illustrated in (42a)–(43c).

(42) DF
Sag mal (‘Say,’):
  a. Was haben denn für Ärzte [den Minister]_{DF} kritisiert?
  b. Was haben den Minister denn [für Ärzte]_{DF} kritisiert?
  c. Was haben für Ärzte denn [den Minister]_{DF} kritisiert?
   ‘what have for doctors.NOM then the minister.ACC criticized’

(43) CF
Dass den Minister Journalisten kritisiert haben, weiß ich schon, aber
(‘I know already that journalists criticized the minister, but ’)
  a. Was haben denn [für Ärzte]_{CF} den Minister kritisiert?
  b. Was haben den Minister denn [für Ärzte]_{CF} kritisiert?
  c. Was haben [für Ärzte]_{CF} denn den Minister kritisiert?
   ‘what have for doctors.NOM then the minister.ACC criticized’

We constructed 18 experimental items like those in (42)–(43). The particle denn was used to mark the boundary between the topic and the focus field. We selected simple transitive verbs to avoid potential problems with establishing the base position of the direct object. The was-für phrase was always the subject DP. In the CF context conditions, the target sentences were preceded by a subordinate clause that introduced the direct object of the matrix clause, as well as an alternative to the matrix subject (e.g., ‘journalists’ in the example in (43)). This manipulation forced contrastive focus on the matrix subject, while
making the direct object “given”. In the no-context conditions, the sentences were introduced by the phrase *Sag mal*, (‘Say,’), since complex sentences such as those used in our experiment may sound less natural without any lead in at all, especially in comparison to the contrastive context versions.

We expected object movement in the absence of context to be rated best, because the wh-extraction is from the immediate preverbal constituent, which is the focus, as we discussed in section 4.2. Subject movement should be the worst, because it involves extraction from a topic, in violation of EXTRACT; moreover, this case is an instance of Left Surfing; there are two chains. And the no movement condition should be intermediate, since the only conflict is that the gap is not in the default focus constituent.

With context establishing the object as given and the subject as contrastively focused, however, no change is expected in the OM-condition, since context supports the analysis that was the most highly activated in the first place. In contrast, the NM- and SM-conditions should improve significantly. The SM-condition is still expected to be more degraded, since although it does not involve an information structure conflict, it does have a chain interaction, similar to that discussed above in connection with extraction from extraposition.

The results of our experiment are summarized in Figure 6; see Winkler et al. (2016) for discussion of the methodology and statistical analysis.

![Figure 6](image.png)

**Figure 6**: Mean normalized ratings per condition. Error bars show the 95% confidence interval.
We see that the results come out as predicted, and are very robust. In the absence of context, the construction with the direct object outside the VP and the split subject remaining in the focus field (42b) was significantly better than the condition where both subject and object were inside the VP (42a). Focus assignment in the latter case was ambiguous because of conflicting IS constraints. The worst configuration, however, was the one where the subject phrase containing the trace of the *was-für* element appeared outside the VP in the topic field (42c). Here, in addition to conflicts between the IS constraints, the occurrence of *denn* to the right of the subject phrase signals that the subject has been displaced into the topic field. Here, extraction occurred out of a topic which has been moved from its base position and therefore further complicated processing.

As predicted, context that places contrastive focus on the subject guided the interpretation in (42a). Context also improved subject movement (42c), but the construction was still clearly suboptimal, since parsing the structure involves two IS constraint violations in any case. Note that the best case, object movement (42b), did not benefit from the contrastive context at all. This is predicted by our account since the construction can already be parsed unambiguously without guiding context. Even in the absence of context, the analysis in which focus is assigned to the preverbal subject remnant is clearly the most probable one. The lack of improvement cannot be explained by a ceiling effect: the OM-conditions were still rated considerably worse than the highest rated fillers.

Interestingly, the context that placed contrastive focus on the subject was not sufficient to make the NM-condition (42a) as good as the OM-condition (42b). Although the context clearly supported the analysis where the subject remnant is focused and increased probability, the competing analyses were apparently still available. This is because the contrastive context is just one of the relevant factors that jointly determine the probability of a given analysis. We hypothesize that the high probability that analysis (42a) received made the alternative analyses dispreferred, yet their (lower) probability still resulted in a certain additional processing load, which led to the perception of markedness. Processing the OM-sentence in (42b) did not face these problems.

Our evidence supports an alternative approach to Müller’s (2010) freezing vs. melting opposition in *was-für* extractions. More specifically, it suggests that a purely syntactic account cannot describe the phenomenon properly. Rather, the results support the information structural hypothesis that context dependent contrastive focus on the subject facilitates extraction. The reason is that context can correct violations of the information structural constraints;
it enhances interpretability and increases processing ease. As we have demonstrated, the degraded status of the freezing structure in (42a) relative to its melting counterpart (42b) reduces when presented to the reader in a suitable context. The rating of the melting case does not change in context since it fulfills all the IS constraints. A purely syntactic explanation does not predict this.

5 Conclusion and a radical hypothesis

More generally, we have found that the freezing phenomena that we have been able thus far to study experimentally appear to be artifacts of processing complexity, construed generally. In the case of extraction from extraposition and HNPS, the effect seems to arise from processing multiple chains, plausibly placing demands on gap identification, memory and integration across chains. Among the relevant factors appear to be dependencies and dependency length, and chain interactions. The types of chain interactions that lead to processing complexity involve surfing, as in the freezing cases, but also nesting, as in self-embedding, and crossing.

In the case of was-für split, the freezing/melting effects appear to arise from the requirement that the processor correctly predicts the gap, given discourse conditions. And when there is a true chain interaction, stronger unacceptability follows.

No doubt there are other factors that contribute to unacceptability. But, crucially, we have encountered no evidence yet that suggests that there needs to be a grammatical definition of freezing (or melting) configurations per se or a grammatical constraint that specifically blocks extraction from such configurations.

This leads us to strengthen our original No Freezing Hypothesis, as follows.12

(44) Radical Unacceptability Hypothesis: All judgments of reduced acceptability in cases of otherwise locally well-formed extractions are due to processing complexity, not grammatical constraints.

There is, interestingly, a precedent for seriously entertaining such a possibility: “... one might propose that once process models are developed we will find that

12 For speculation along the same lines, see Chaves (2012).
all relevant facts are explained without any abstraction to a rule system that articulates the speaker-hearer’s knowledge of his language. This thesis might prove correct ... ” (Chomsky 1976).

Of course, as Chomsky took pains to note, in order to evaluate such a proposal seriously, it must be made explicit and it must be based on independently motivated theories of processing. There has been progress along these lines, e.g. Gibson (1990, 1991, 1998, 2000); Kluender (2005); Kluender & Kutas (1993b); Lewis (1993, 1996); Lewis & Vasishth (2005); Lewis, Vasishth & Van Dyke (2006) among others. But we are not yet at the point where we can predict with accuracy the judgments of native speakers on arbitrary sentences simply on the basis of a processing model. We take the development of such a model as a long-term goal, one that is informed by the types of data addressed in this paper.

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