

# Retrievability and Gradience in Filler-Gap Dependencies

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## 1 Introduction

The defining characteristic, from a linguistic point of view, of certain kinds of unbounded dependencies is that they violate one of a set of putatively universal constraints on syntactic dependencies. These so-called "island" constraints obstruct or block filler-gap dependencies into (or out of) particular syntactic configurations (Ross 1967; Chomsky 1973; Chomsky 1977; Chomsky 1981; Chomsky 1986). Exemplified below are violations of two such constraints, known as the *Wh*-Island constraint (1a) and Superiority (1b):

- (1) a. What don't you remember who wrote?  
b. What did who read?

Ironically, non-syntactic choices can significantly improve the acceptability of many of these island violations, despite the definition of these violations being stated in strictly syntactic terms. For instance, varying the content of the extracted element or filler can noticeably change how good or bad the example sounds:

- (2) a. Which article don't you remember who wrote?  
b. What don't you remember who wrote?
- (3) a. Which article did who read?  
b. What did who read?

In each case, the variant with the more informative or descriptive *wh*-phrase, *which article*, improves upon the acceptability of the minimally different island violation. This observation goes back at least to Karttunen (1977), who notices the improvement in the context of Superiority violations, but many others have since made very similar claims regarding not just *wh*-phrases, but extracted elements of all sorts (Rizzi 1990; Cinque 1990; Chung 1994; Kroch 1998; Comorovski 1989; Pesetsky 1987; Pesetsky 2000; Szabolsci 1992; Kluender 1998). These accounts diverge from one another in how they label this property that produces the observed acceptability contrast.

Underlying all these observations is the question of why the content (or amount of content) in the extracted element should so significantly alter acceptability, especially given that this contrast appears most strikingly in the context of supposedly universal syntactic constraints. In other words, the relationship between the informational content of a filler-phrase and the ease with which it can be extracted is not immediately clear. In a discussion of this very problem, Chung (1994) essentially asks the same question:

“Why should long movement be legitimized in just those cases where the trace ranges over a sufficiently restricted set? To put the question differently, what is it about the ability to narrow down the domain of *wh*-quantification ‘enough’ that makes it possible for strict locality to be violated?” (p.39)

There is a range of answers to these questions in the relevant literature, from largely pragmatic explanations to deeply theoretical and framework-specific syntactic explanations. For instance, Pesetsky (1987) argues that certain *wh*-phrases, which he terms “D(iscourse)-linked” *wh*-phrases, are not subject to the normal rules on movement. Problematically, though, Pesetsky never formally defines what it means for a *wh*-phrase to be D-linked. Instead, Pesetsky merely indicates that “context sets previously mentioned in the discourse qualify a phrase as D-linked, but so do sets that are merely salient,” thus indicating that lexical items themselves are not inherently marked for this property, but merely acquire it via contextual licensing. Whether such a characterization is ultimately viable or not, it still leaves open the larger question of the relationship between discourse salience and conditions on phrasal movement. That is, why should being salient or not have any affect on the possibility of movement? Pesetsky himself admits that the connection is unclear: “The reason for this link between semantics and syntax is obscure, and will remain obscure even at the end of this book.”

As an additional example of efforts to explain the observed differences in extractability, Cinque (1990), building off the analysis of Rizzi (1990), divides Italian DP arguments into two separate categories, “referential” and “nonreferential.” He defines the former type of arguments as those which “refer to specific members of a set in the mind of the speaker or preestablished in discourse.” According to Cinque, this property obviates the requirement for traces of referential arguments to be antecedent governed, effectively removing some major theoretical obstacles for phrasal movement. Instead of antecedent government, the traces of referential arguments could be bound by a special “referential index,” alluding to the indexing mechanism for anaphora binding that is unconstrained by syntactic boundaries. On the other hand, non-referential arguments and adjuncts still require antecedent government of their traces, and hence these phrases can only move cyclically and are bound by far stronger locality requirements.

Unfortunately, as Chung (1994) points out, the indexing mechanism for referential arguments, as Cinque and Rizzi describe it, “introduces a nonuniformity into the treatment of DPs that has no obvious correlate in the theory of anaphora.” That is to say, the division of DPs into referential and non-referential ones, according to whether they bear an index, does not translate into the world of bound variable anaphora. DPs falling into Rizzi and Cinque’s non-referential class can clearly antecede a bound variable pronoun. Therefore, their hypothesis essentially requires a separate indexing system for phrasal movement, in a way that differs substantially from the traditional system devised for anaphora. This dissonance consequently breaks down the whole strength of the analogy to binding. In the end, Chung notes that “we are left wondering whether the use of indices in this theory amounts to more than a diacritic to distinguish the DPs that allow long movement from those that do not.”

Approaching the problem from a different angle, I suggest here that the connection between the informational content of the extracted element and its extractability concerns memory retrieval and issues of processing difficulty. The acceptability of syntactic structures depends at least partly upon the processing difficulty they involve—as demonstrated for the case of complex center-embeddings, strong garden path sentences, and numerous other constructions (Chomsky & Miller 1963; Bever 1970; Kluender & Kutas 1993; Fanselow & Frisch 2004). In particular, increasing processing difficulty typically leads to lower ratings of acceptability (although there are some exceptions), and especially in cases of serious processing difficulty, may be responsible for a perception of ungrammaticality.

Filler-gap dependencies, in general, are known to impose a relatively high level of processing difficulty, given the simultaneous requirements to store a filler, identify the appropriate gap site or subcategorizer, and process other intervening constituents along the filler-gap path.<sup>1</sup> Moreover, various factors contribute to the cumulative difficulty of processing a filler-gap dependency, such as the linear or structural distance of the dependency (Gibson 1998; Gibson 2000), interference effects (Gordon *et al.* 2004; Van Dyke & McElree 2006), as well as processing load imposed by other referential entities along the filler-gap path (Warren & Gibson 2002), among other factors. Here, I contend that the informativity of the extracted element plays an important role in determining the overall processing difficulty of a filler-gap dependency. As an explanation of this relationship, I present the *Memory Facilitation Hypothesis* (Hofmeister 2007):

(4) *Memory Facilitation Hypothesis*

Linguistic elements that encode more information (lexical, semantic, syntactic, etc.) facilitate their own memory retrieval later.

Intuitively, the idea behind this hypothesis is that non-distinctive or vague representations will be harder to recall than distinctive or specific representations, all else being equal. As an illustration, the *wh*-phrase *who* says relatively little about the sort of objects that it ranges over, contributing only a minimal amount of information about animacy, while a more informative *wh*-phrase like *which professional baseball player for the St. Louis Cardinals* specifies a number of additional features besides animacy, including number information and the type of individual. Thus, the facilitation hypothesis predicts that, given identical filler-gap contexts, the more informative *which-N'* phrase should lead to faster retrieval at the appropriate subcategorizer or gap site. Similarly, comparing two indefinites like *a poet* versus *a reclusive English poet*, the latter should result in faster retrieval and hence easier processing whenever that discourse entity needs to be re-accessed for comprehension.

Returning to the data that started this discussion, the memory facilitation hypothesis relates the acceptability contrasts to differences in retrievability. These

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<sup>1</sup>Although the term filler-gap dependency is used throughout this paper, there is no accompanying theoretical commitment to the view that memory retrieval and integration occurs at a gap site rather than at the subcategorizing head, or vice versa. The experiments in this paper furthermore offer no evidence in either direction, but purely for convenience, only the term 'subcategorizer' is used, instead of 'gap site.'

contrasts emerge most clearly in the context of island-violating filler-gap dependencies presumably because such constructions already impose numerous processing challenges: long filler-gap dependencies, numerous referential entities along the filler-gap path, etc. Kluender and Kutas (1993) suggest, along the same lines, that subadjacency essentially results from a processing bottleneck at clause boundaries. Ameliorating one significant processing difficulty, namely memory retrieval of the filler, may thus bring global processing difficulty below a certain threshold, such that the relevant extraction cases can be judged as acceptable.

Within this paper, I review the results of several self-paced reading experiments which test the predictions of the memory facilitation hypothesis. First, I evaluate whether manipulating the informativity of an extracted element has a significant effect on the processing of dependencies into *wh*-islands. Following upon this, I turn to *wh*-dependencies that do not involve island-violations to determine whether the observed pattern of results in the *wh*-island study reflects a general processing consideration or merely reflect artefacts of reading island-violations. Lastly, I describe the results of an experiment that evaluates how informativity affects the processing of clefted indefinites. This study complements the others by showing that the observed effects are not limited to *wh*-dependencies. In the final section of this paper, I discuss the implications of these results for the understanding of gradience in extractability.

## 2 Methodology

The experimental evidence discussed in this paper was obtained via a series of self-paced reading experiments. In these comprehension experiments, subjects read sentences at their own pace on a computer screen. Initially, they are presented with a screen of dashes separated by spaces, representing the words for that experimental item, so that they have some sense of the number of words in the sentence. With each press of a predefined key, a new word appears on the screen and the previous word disappears. The interval between key presses (how long it takes a subject to read the word or region) is automatically recorded, labeled, and stored. Longer reading-times at a particular word or region are interpreted as an indication of processing difficulty. Question-answer accuracy and reaction times to the questions were also recorded.

Residual reading-times were derived for each word on the basis of a linear regression equation that computes reading-time for each individual as a function of word length. This method effectively reduces variability due to individual differences in reading-times. Negative residual reading-times indicate that subjects read that word at a faster rate than their average for words of the same length.<sup>2</sup> For each experimental item, a comprehension question (sometimes the area of interest itself) ensured subjects followed the text and read for understanding. The results presented here consist only of reading-times from items which were correctly answered. Furthermore, the results for any subject scoring less than 67% on question-accuracy

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<sup>2</sup>In the first two experiments detailed here, the residual reading-times reflect relatively fast reading rates due to the fact that the relevant word regions belong to comprehension questions. Subjects consistently read comprehension questions at a much faster rate than the preceding text.

were entirely removed from all statistical analyses. Also, extreme outliers for each word region were removed by data trimming—removing an equal number of outliers from each condition at each word. This process affected less than 3% of the overall data. Where I report statistical comparisons, only the residual reading-times are considered, rather than the raw reading-times. The results from all experiments covered here were analyzed with repeated measures ANOVAs which take into account the random factors of subjects and items.

### 3 Experiment 1: Reading Wh-Islands

The first experiment investigates whether differences in the informativity of an extracted *wh*-phrase significantly affects subsequent processing in the context of island-violating filler-gap dependencies. The memory facilitation hypothesis predicts that memory retrieval should happen faster when the *wh*-phrase encodes more information. More precisely, this hypothesis predicts that the processing facilitation should be localized to the retrieval site, and thus should be observable at the point where information about the extracted element must be retrieved.

#### 3.1 Materials and Participants

The materials for this experiment consisted of 24 sets of *wh*-dependencies. Each experimental item had two conditions of interest, which differed in terms of the amount of information encoded within a *wh*-phrase extracted out of a *wh*-island. Subjects saw either a bare *wh*-item *who* or a more informative *which-N'* phrase. In addition, each experimental item also included a baseline against which to evaluate the reading-times from the island contexts. A sample item is shown in (5).

Twenty Stanford University undergraduates, all fluent in American English by the age of 5 or earlier, participated in this study for course credit in a cognitive science class. Subjects initially saw a declarative sentence describing some scene or event, followed by a comprehension question, presented in the same word by word fashion as the initial declarative. In this experiment and the next, the real stimuli were the comprehension questions themselves; the initial context sentences merely justified the presence of these questions which would be extremely unnatural without any background. Each subject saw only one condition per item (Latin-square design). Forty-eight fillers were also included in the experiment, twelve of which were also *wh*-islands in order to mask some of the more salient and consistent features of the actual stimuli. Across the entire item set, an equal number of questions began with *who*, *what*, and *which*-phrases to remove any experiment-internal bias for processing one type of interrogative faster than another.

- (5) Albert learned that the managers dismissed the employee with poor sales after the annual performance review.

BARE: Who did Albert learn whether they dismissed after the annual performance review?

WHICH: Which employee did Albert learn whether they dismissed after the annual performance review?

BASELINE: Who did Albert learn that they dismissed after the annual performance review?

After reading the question, subjects answered the question by selecting from multiple choices. Of the three possible answers presented to them, one was correct (*the employee with poor sales*), another was lexically and syntactically similar (*the employee with poor hygiene*), and the third option differed drastically (*the cashier who stole money*). Question-answer accuracies, however, did not vary significantly across conditions (BARE = 89.6%,  $SE = 2.21$ ; WHICH = 88.5%,  $SE = 2.31$ ; BASELINE = 90.6,  $SE = 2.99$ ).

### 3.2 Results

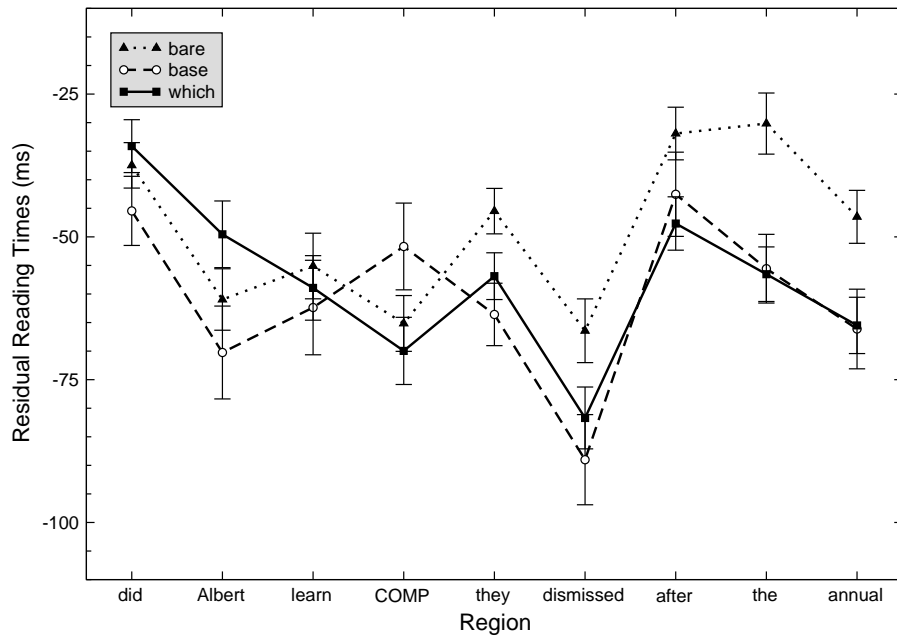
As per the predictions of the memory facilitation hypothesis, faster processing takes place at the retrieval site when the extracted *wh*-phrase encodes more information. At the subcategorizing verb (e.g. *dismissed* above), the WHICH condition led to faster reading, as compared to the BARE condition. This contrast was significant by subjects, but only marginally so by items ( $F(1,19) = 5.275$ ,  $p < .05$ ,  $F(1,23) = 3.179$ ,  $p < .1$ ); however, when reading-times at the subsequent word are taken into account, the difference between *which-N'* phrases and *who* is significant by both subjects and items ( $F(1,19) = 6.548$ ,  $p = .019$ ,  $F(1,23) = 7.725$ ,  $p = .01$ ). In fact, at the three words after the subcategorizer, where processing effort spills over, the processing advantage for the WHICH conditions persists and even intensifies. Considering the verb together with the three subsequent words, the effect of informativity is thus highly significant ( $F(1,19) = 15.255$ ,  $p < .001$ ,  $F(1,23) = 14.420$ ,  $p < .001$ ).

Two other important points stand out from the data: 1) prior to the subcategorizer, the more informative *which-N'* phrases do not result in faster reading-times, and 2) the processing advantage conferred by reading a more informative *wh*-phrase effectively eliminates any difference from the baseline non-island. With respect to the first point, the evidence actually indicates that immediately after processing the *wh*-phrase, subjects are slower after the more complex *which-N'* phrases, as shown in Figure 1. This effect likely stems from the additional processing necessary to build a more complex representation in the case of the *which-N'* phrase. At the embedded pronominal subject, immediately before the subcategorizer, the WHICH condition does result in slightly faster reading-times by about 10 milliseconds, but this trend is not significant by subjects or items. Thus, prior to the verb, the more informative *which-N'* phrases do not produce faster reading-times, which emphasizes the point that the observed processing facilitation must connect to operations that take place at the retrieval and integration site.

Concerning the second point, the data illustrates nearly identical reading-times for the BASELINE and WHICH conditions, following the complementizer.<sup>3</sup> This suggests that the processing facilitation from the use of the more informative *wh*-phrase

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<sup>3</sup>It should be noted that the higher reading-times for the complementizer *that* emerge only in the residual reading-times, due to the shorter length of the word, as compared to *whether*. Across conditions, the raw reading-times at the complementizer are virtually identical.



**Figure 1:** Residual reading-times in experiment 1, ranging from first word after *wh*-phrase to three words after retrieval site.

provides a non-negligible benefit in processing. That is, some small but significant decrease in processing difficulty may be viewed as immaterial if processing difficulty remains at an extremely high level. Given the fact that reading-times in the WHICH condition are essentially equivalent to those of the baseline, however, the evidence argues for a meaningful interpretation of the facilitation. Finally, due to the fact that the BASELINE and WHICH conditions produce similar reading-times, both significantly faster than the BARE condition, the perception of unacceptability for *wh*-island violations involving vague or non-specific filler-phrases may reasonably have its origins in processing-related differences, as discussed more thoroughly in the final section of this paper.

#### 4 Experiment 2: Wh-dependencies Outside Islands

The memory facilitation hypothesis makes a general prediction about the relationship between the linguistic form used to represent a discourse entity and the amount of cognitive resources necessary to re-access that representation later in discourse. In this sense, it says nothing in particular about syntactic islands, and thus the predictions ought to be observable outside the domain of islands. Furthermore, it is conceivable, given the atypical status of island-violations, that people adopt abnormal processing strategies when they encounter them. Accordingly, within this section, I examine how the informativity of an extracted element affects processing in another difficult, but unquestionably grammatical environment, i.e. nested dependencies.

## 4.1 Materials and Participants

The twenty experimental items in this study were all nested dependency interrogatives of the sort illustrated in (6). The interrogatives varied in terms of whether the fronted, inanimate *wh*-phrase was a bare *wh*-item (SIMPLE), a *which*-N' phrase (WHICH), or a *which*-N' phrase with an additional adjective (COMPLEX). These interrogatives acted as the comprehension questions for preceding sentences, as in the previously described study.

Thirty-five native English-speaking Stanford University undergraduates participated in this study to fulfill a course requirement in a linguistics class. The subjects had not participated in the previous experiment on *wh*-islands.

- (6) Scooter hid from the reporter who talked about the recent ABC political poll on a recent evening news segment.

SIMPLE: What did the reporter that Scooter avoided discuss during an evening news segment?

WHICH: Which poll did the reporter that Scooter avoided discuss during an evening news segment?

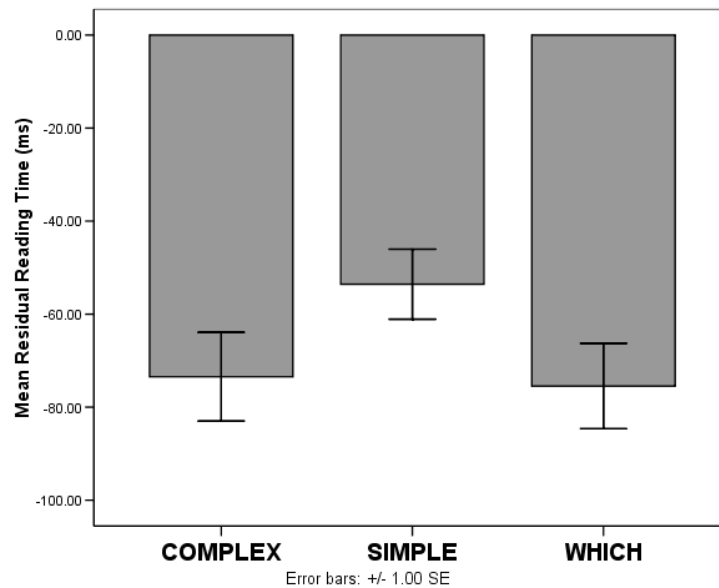
COMPLEX: Which political poll did the reporter that Scooter avoided discuss during an evening news segment?

Eighty-eight fillers were included in the item list, including an equal number of subject relatives to prevent expectation of object relatives. Across each experimental list, subjects saw an equal number of questions beginning with *who*, *what*, and *which*, such that there was no experimental bias toward one type of question. Question-answer accuracies again showed no effect of condition, as all conditions produced extremely high and consistent accuracies across conditions (COMPLEX= 94.5%, *SE*= 1.6; MID= 95.0%, *SE*= 1.4; SIMPLE = 94.7%, *SE*= 2.0).

## 4.2 Results

The reading-time data reveals that the “complex” *which*-N' phrase containing an extra adjective produces faster reading-times at the verb than the bare *wh*-phrase ( $F(1,34) = 5.315$ ,  $p < .05$ ;  $F(1,19) = 6.634$ ,  $p < .05$ ). Similarly, the use of the *which*-N' phrase without the adjective also results in faster reading-times at the critical region of the verb ( $F(1,34) = 9.473$ ,  $p < .01$ ;  $F(1,19) = 10.392$ ,  $p < .01$ ). As in the *wh*-island study, this processing advantage for the more informative conditions spills over on to the next several words after the retrieval site. At the next word, the effect of informativity is even more pronounced (COMPLEX vs. SIMPLE:  $F(1,34) = 9.610$ ,  $p < .01$ ,  $F(1,19) = 5.486$ ,  $p < .05$ ; WHICH vs. SIMPLE:  $F(1,34) = 9.202$ ,  $p < .01$ ,  $F(1,19) = 7.446$ ,  $p < .05$ ).

Interestingly, at the verb (*avoided* in (6) above) immediately preceding the actual subcategorizing verb, the effect of informativity is evident: the COMPLEX condition results in faster reading-times than the SIMPLE condition, and there is a non-significant trend in the same direction for the comparison between the WHICH and SIMPLE condition (COMPLEX vs. SIMPLE:  $F(1,34) = 5.627$ ,  $p < .05$ ;  $F(1,19) = 3.898$ ,  $p = .063$ ; WHICH vs. SIMPLE:  $F(1,34) = 2.268$ ,  $p = .141$ ;  $F(1,19) = 3.037$ ,



**Figure 2:** Residual reading-times at matrix verb (e.g. *discussed*) in experiment 2

$p = .098$ ). This result, though, is unsurprising given a memory retrieval account, since processing of this verb also requires retrieval of a filler. A retrieval process would then locate two different fillers located in memory, including the relevant *wh*-phrase. The processor then needs to decide which of the available fillers in memory is the correct one. According to the retrieval-based account, retrieval of a more informative *which*-phrase happens faster, allowing the processor to dismiss it as the wrong filler in favor of the closer subject NP.

Prior to the verbs, however, the more informative *wh*-phrases fail to produce any noticeable processing advantage. As in the *wh*-island investigation, there is a small difference at the embedded subject (COMPLEX: mean RT = 262.07 ms, SE = 5.07; SIMPLE: mean RT = 274.26 ms, SE = 5.48; WHICH: mean RT = 262.39, SE = 5.34), which does not reach significance by either subjects or items.<sup>4</sup>

As is evident from Figure 2, however, there is no significant difference between the WHICH and COMPLEX conditions, which likely stems from an insufficient difference in informativity. The COMPLEX condition adds only one word, an adjective, to the description used in the WHICH condition. This extra feature does relatively little in terms of narrowing down the appropriate answer. In contrast, the difference between a bare *wh*-word like *what* and a *which*-N' phrase involves more than the presence or absence of one single feature. The latter type of phrase introduces the *kind* of relevant individual, which brings along with it a host of inferable features, depending upon the particular head noun. Thus, in order to observe a significant processing difference, two phrases must be at some minimal informational distance from each other.

<sup>4</sup>These numerical trends at the embedded subjects may actually stem from processing differences at the immediately preceding complementizer that spill over on to the next word, or they may, in fact, simply reflect noise in the data as they consistently fail to reach statistical significance.

Together with the results from experiment 1, the evidence from this experiment advances the idea that the processing advantage for more complex and informative *wh*-phrases in *wh*-dependencies extends beyond the context of syntactic islands. The predictions of the memory facilitation hypothesis are verified here in a perfectly grammatical context, signifying that the benefit conferred by the *which-N*' phrases in experiment 1 is not simply dependent upon the island environment.

## 5 Experiment 3: Informativity and Non-Wh-Phrases

Just as the memory facilitation hypothesis makes no particular claims about processing within islands, it also makes no assertions about the kinds of phrases for which the hypothesis should be relevant. Accordingly, although both studies covered here so far concern the processing of *wh*-dependencies, the same pattern of results should be observable with other types of NPs, given the proper conditions. In this section, therefore, I present the results of a third experiment, where I explore how manipulating the amount of information encoded in an indefinite noun phrase influences its subsequent retrieval.

### 5.1 Materials and Participants

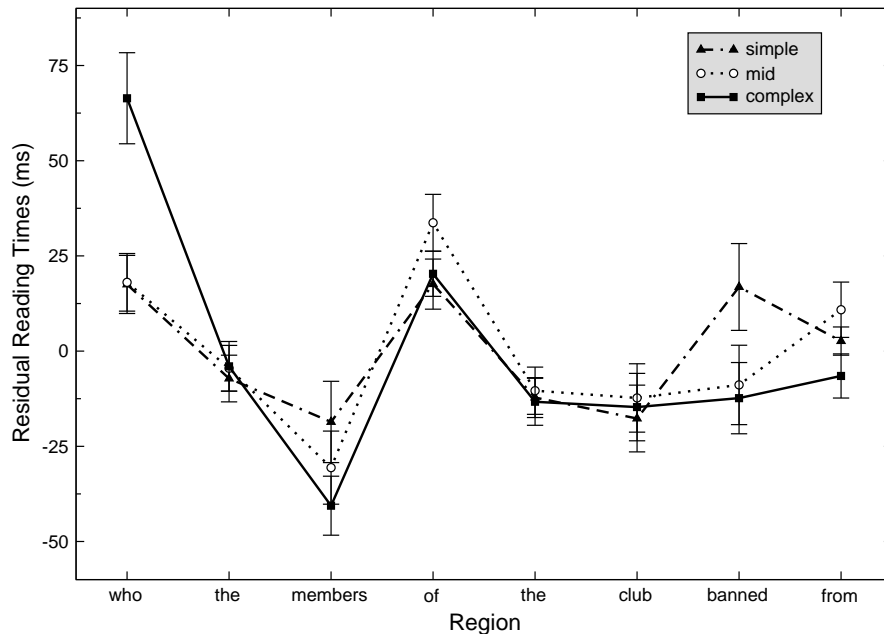
Sixteen clefted indefinites constituted the experimental data set. Conditions varied in terms of how many adjectives preceded the head noun: zero (SIMPLE), one (MID), or two (COMPLEX). In all items, the clefted indefinite was followed by a relative clause containing a five-word subject NP and then a transitive verb with an object gap, requiring the retrieval of the clefted indefinite phrase. In contrast to the other two experiments, these stimuli were followed by comprehension questions, rather than acting as the comprehension questions themselves.

- (7) SIMPLE: It was a communist who the members of the club banned from ever entering the premises.  
MID: It was an alleged communist who the members of the club banned from ever entering the premises.  
COMPLEX: It was an alleged Venezuelan communist who the members of the club banned from ever entering the premises.

The materials for this experiment were included in the item set for the previous experiment. Thus, eighty-eight other items acted as fillers for this set of stimuli. As in the other experiments, question-answer accuracy was unaffected by condition (COMPLEX = 94.4%, *SE* = 3.23; MID = 94.9%, *SE* = 3.15; SIMPLE = 94.4%, *SE* = 3.32).

### 5.2 Results

Paralleling the results from the previous studies, the reading-time data from this experiment show a processing advantage for more informative fillers beginning at the retrieval site. Both the COMPLEX and MID conditions exhibited faster reading than the SIMPLE condition, exclusively at the retrieval and integration site. The contrast



**Figure 3:** Residual reading-times in clefted indefinites study, beginning with the first word after the indefinite.

proved to be significant when considering the differences between the COMPLEX and SIMPLE conditions ( $F(1,34) = 4.136, p = .05, F(1,15) = 5.631, p < .05$ ), but only marginally so in the comparison of the MID and SIMPLE conditions ( $F(1,34) = 3.171, p < .01, F(1,15) = 2.857, p = .112$ ). The MID and COMPLEX conditions, however, showed no significant differences at the verb. The presence or absence of one adjective distinguished these conditions, as was the case with the two kinds of *which-N'* phrases in the preceding experiment. Hence, not just any single addition of information necessarily improves retrieval. Again, this does not contradict the memory facilitation hypothesis, as the hypothesis does not specify how much information must be added to some encoding in order to effect significant differences in retrieval time.

Spillover effects were not observed in this study, undoubtedly due to the relative processing ease of the sentences. At the first word after the retrieval site, reading-times level out across conditions. Unlike the other experiments discussed so far, the materials in this study lacked both syntactic island environments and nested dependencies, making these stimuli relatively easy to comprehend. Also in line with the predictions of the facilitation hypothesis, significantly faster reading-times for the more informative conditions with additional modifying material did not surface prior to the verb where retrieval of the filler occurs, as depicted in Figure 3. In fact, as the reading-time graph indicates, the most informative condition (COMPLEX) initially led to a highly significant slowdown in processing immediately after the indefinite noun phrase.

The results of this experiment add several key findings to those from the previous experiments: (1) even in relatively simple syntactic constructions, a significant difference emerges from encoding more or less information in the description of

a discourse entity that must be retrieved for purposes of interpreting a filler-gap dependency; (2) this effect is not unique to *wh*-phrases. This experiment consequently shows that facilitated processing occurs with the retrieval of more informative phrases, even when introducing new entities into the discourse, and that this effect likely reflects a general property of language processing.

## 6 Discussion

In all three experiments presented here, it was found that the amount of information encoded in the extracted element of a filler-gap dependency significantly impacts processing times at the subcategorizer, where at least some features of the filler must be retrieved. While more complex encodings initially demand a greater quantity of cognitive resources to build a richer linguistic representation, this early investment of resources is rewarded when that same representation needs to be re-accessed. Localization of this effect to the retrieval site supports the interpretation that it ultimately derives from differences in memory retrieval and not, say, storage effects.

The evidence presented here parallels other research which uncovers similar effects in other syntactic environments, including Superiority-violations and complex noun phrase constructions (Hofmeister *et al.* 2007a; Hofmeister *et al.* 2007b). Note, however, that the processing advantage conferred by a more informative extracted element need not exclusively stem from issues of retrievability. For instance, Hofmeister, Sag & Snider (2007) advocate the view that, at least in some cases, comprehenders are less likely to garden-path a filler-gap dependency when they hear a more informative filler-phrase, (e.g. *Which book did you hear the rumor that they sold?* vs. *What did you hear the rumor that they sold?*). Hence, the reason why the content of an extracted element influences acceptability may include other factors in addition to retrievability. Nevertheless, the memory facilitation hypothesis predicts that, while other factors may contribute to processing differences prior to and at the retrieval site, a significant "informational distance" between two filler-phrases should consistently result in processing differences at the retrieval site.

The underlying question behind this investigation was the following: why should the content (or amount of content) in an extracted element affect the acceptability of the extraction? The evidence laid out here promotes an explanation where differences in processing difficulty account for at least some, if not much, of this gradience. This perspective, of course, depends upon the aforementioned assumption that differences in processing difficulty can be responsible for acceptability contrasts. One reason for believing in the reasonableness of such an assumption comes from corroborative acceptability evidence. In a controlled acceptability study, where subjects rated embedded versions of the *wh*-island stimuli from Experiment 1 for naturalness on a scale of 1-7, participants judged embedded sentences like (8b) more acceptable than the minimally different counterpart in (8a) ( $F(1,14) = 17.796, p < .001$ ;  $F(1,19) = 13.811, p < .001$ ).

- (8) a. Only a few individuals repeated who Albert learned whether we dismissed after the annual performance evaluations.
- b. Only a few individuals repeated which employee Albert learned whether we dismissed after the annual performance evaluations.

On one hand, this merely confirms the intuitions of linguists, discussed at the outset of this paper, in a more controlled fashion. On the other hand, it shows that acceptability judgments pattern along with reading-time evidence in the same context with the manipulation of a single non-syntactic factor.

There is, of course, an alternative explanation for this symmetry in the data. As acceptability reflects merely an endpoint in a series of cognitive processes, gradience in acceptability may emerge from either performance-related factors, such as memory retrieval, or from the grammar itself, which may be organized in such a way that accumulating violations produce worse and worse acceptability. Taking the latter perspective, the processing differences noted in the reading-time data may arise from the acceptability contrasts generated grammar-internally, rather than vice versa. In other words, people should read marked constructions slower than unmarked (or less marked) constructions.

As an explanation for localized processing differences, however, this view brings with it the idea that an evaluation of ungrammaticality could be formed and used fast enough to influence processing at the first word where a violation could theoretically be noticed. To be clear, perceptions of grammatical deviance undoubtedly enter into the equation of processing difficulty *at some point* during sentence processing. But data from event-related potentials (ERPs), in fact, show that the neural correlates of syntactic and morphological violations do not surface until at least 500 ms after word onset (e.g. Coulson *et al.* 1998), implying that subsequent use of this markedness information must be delayed by at least that amount. Furthermore, speeded grammaticality tasks indicate that, with a variety of grammatical violations, people essentially perform at chance when given less than half a second to respond (McElree & Griffith 1995). Thus, if well-formedness is behind the processing differences noted at the embedded verb in experiment 1, then differing assessments of grammaticality at the embedded verb must take place in a remarkably short period of time to have any effect on processing at that word, given that the verb was read under 300 ms on average in all experimental conditions. Even granting such a possibility, however, the grammar-internal explanation would have nothing to say about the parallel results found in experiments 2 and 3, for those experiments deal with unequivocally grammatical constructions. Hence, two explanations for what by all appearances seems to be the same phenomenon would have to be posited.

Another reason for dispreferring the grammar-internal account is one based solely on economy of explanation. A grammar-internal characterization demands the appropriate linguistic machinery to calculate gradient acceptability, presumably unrelated to any other cognitive function, as well as the rules and principles of the grammar, not to mention exceptions to those rules, whether that be D-linking or some conception of relativized movement. In contrast, accounting for gradience via general processing principles capitalizes upon the need for those same principles in other cognitive domains. For instance, Bradshaw & Anderson (1982) show that long-term sentence recall improves when presentation of a sentence occurs along with other causally-related sentences, as opposed to the sentence being presented in isolation. They explain this finding by arguing that elaboration upon a topic or proposition increases the available set of retrieval paths, thereby increasing chances for successful retrieval. Expanding upon this line of research to recall of visual information, Wiseman *et al.* (1985) find that picture recall improves when pictures

are presented simultaneously with related text. The relationship between information encoding and memory retrieval, therefore, seems likely to represent a general feature of language processing, and may even be independent of language.

Ultimately, additional evidence from other areas and methods of investigation like ERPs, functional magnetic resonance imaging (fMRI), and speed-accuracy trade-offs can help decide such debates on a case by case basis. As one example of this, Fiebach *et al.* (2004), in a fMRI study, report two different sources of neural activation for complex grammatical sentences and ungrammatical structures in German. Such evidence, combined with the results from other experimental methodologies, can convincingly pinpoint the source of gradient acceptability in a variety of linguistic constructions. For the case at hand, however, the burden of proof lies with the advocate of the grammar-internal explanation to show how the available data can be captured better. The retrieval-based account of the gradient in extractability, in contrast to the grammar-internal approach, offers a means of rationalizing the gradient in extractability in a range of different linguistic constructions, yet at the same time, it avoids introducing any new mechanism, linguistic or otherwise, to handle these facts.

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