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An Empirical Investigation of Featural Similarity in Wh-islands

Sandra Villata (Corresponding author)

University of Enna "Kore", Italy

E-mail: sandra.villata@unikore.it

Julie Franck

University of Geneva, Switzerland

E-mail: julie.franck@unige.ch

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Abstract

According to the most recent version of Relativized Minimality, the ungrammaticality of weak islands is the result of featural similarity between elements in an intervention configuration. The theory posits that only features triggering movement have the potential to induce intervention effects leading to ungrammaticality. However, recent advancements in the theory have extended the set of features claimed to generate intervention effects to encompass lexical restriction. This theoretical move encounters several empirical challenges. In this paper, we address this question in 3 acceptability judgment experiments in French. We explore how featural similarity influences acceptability judgments across both wh-islands and minimally different grammatical structures, that-clauses extraction, focusing on three distinct features: (i) the feature associated with question operators, (ii) lexical restriction, both anticipated to show intervention effects according to the most recent version of Relativized Minimality, and (iii) animacy, which is not expected to show such effects. Results indicate that featural similarity in lexical restriction and animacy exerts a mild influence on acceptability ratings in both islands and grammatical structures, contrary to what predicted by Relativized Minimality, while similarity in the feature associated with question operators exerts a strong influence. We propose an empirically motivated account that restricts the set of features relevant to grammar-based effects à la Relativized Minimality to core syntactic features triggering movement, and groups together the milder effects arising from similarity in other linguistic features, like lexical restriction and animacy, as resulting from

similarity-based interference in memory.

Keywords: Islands, Intervention, Relativized Minimality, Animacy, Lexical restriction, Similarity-based interference, Retrieval, Encoding

1. Introduction

1.1 Theoretical Background

Long-distance dependencies (also known as filler-gap dependencies) are unbounded: the distance between a wh-element like *what* (the filler) and its point of semantic interpretation (the *gap* location) can be arbitrarily long without compromising the grammatical status of the sentence. The unboundedness of long-distance dependencies, however, is not without constraints. A well-known constraint is that the wh-element cannot be extracted over another element that shares its same features, like *who* in (1), which bears the +Q feature proper to all interrogative elements. This constraint is known as Relativized Minimality and was proposed by Rizzi (1990) to account for the ungrammaticality of weak islands, a specific subset from the island catalogue (Ross 1967; see Szabolcsi 2006 for a review).

(1) *What$_i$ do you wonder who solved __$_i$?

According to Relativized Minimality, weak islands were no longer conceived as syntactic domains from which elements could not escape. Instead, it posits that they arise due to the intervention of an element endowed with the same features of the moved element along the dependency. The most recent formulation of the principle is provided in (2) (Rizzi 2001, 2004, 2011; Friedmann, Belletti & Rizzi 2009; Villata, Rizzi & Franck 2016):

(2) Given a configuration

… X … Z … Y …

A local relation is disrupted between X and Y if

(a) Z structurally intervenes between X and Y, and

(b) Z fully matches the specification in morphosyntactic features of X.

The first criterion of the principle (2a) defines the structural configuration of *intervention* in terms of c-command: an element Z intervenes between X and Y when X c-commands Z and Z c-commands Y. The second criterion of the principle (2b) states that to generate an *intervention effect*, Z must have the same morphosyntactic features of X. (Note 1) Given the focus on features in the definition of intervention effects, this version of the principle is known as Featural Relativized Minimality (henceforth, fRM; see Rizzi 2001, 2004; Starke 2001; Villata, Rizzi & Franck 2016). According to the principle, the morphosyntactic features that can disrupt a local relation are exclusively those that trigger movement. Examples of features triggering movement are the [+Q] feature defining question operators, the [+R(el)] feature defining the head of relative clauses, the [+Top] feature defining elements in topic position, and the [+Foc] feature defining elements in focus (Rizzi 2001, 2004).

fRM distinguishes three fundamental configuration sets between the moved element (X) and

the intervener (Z) based on their featural specification, illustrated in (3).

(3)	X	Z	Y
a. Identity:	+A	+A	+A
b. Inclusion:	+A,+B	+A	+A,+B
c. Disjunction:	+A	+B	+A

An example of sentence for each configuration is provided in (4). (4a) is ungrammatical because the intervening element *who* carries the same morphosyntactic features of the moved element *what*, both bearing the [+Q] feature of question operators. In contrast, both (4b) and (4c) adhere to the principle of fRM: in (4b) the feature set of the intervener is included in the feature set of the moved element, resulting in an incomplete feature match that escapes locality effects; in (4c) no feature is in common between X and Z, resulting in a configuration of disjunction (4c).

(4) a. IDENTITY

X Z Y

*__What__$_i$ do you wonder **who** solved $\_\__i$?

+Q +Q +Q

b. INCLUSION

X Z Y

Which problem$_i$ do you wonder **who** solved $\_\__i$?

+Q,+N +Q +Q,+N

c. DISJUNCTION

X Z Y

What$_i$ do you think that **he** solved $\_\__i$?

+Q +Pro +Q

Recent advancements in the development of fRM have marked a significant shift in the theory. The theory's explanatory scope has been extended beyond defining the boundaries of grammar to encompass variations in the processing difficulty of grammatical sentences. Specifically, fRM has been proposed to explain the delayed acquisition of object relative clauses in children and the processing difficulties observed in adults for object relative clauses compared to the processing of subject relative clauses (e.g., Adani et al. 2010, Belletti et al. 2012; Friedmann et al. 2009). To capture these facts, the set of features considered relevant for calculating intervention effects has been extended to include lexical restriction (Friedmann et al. 2009; see Bentea et al. 2016 for a discussion). Furthermore, three recent acceptability studies on wh-islands showed that sentences instantiating different

configurations of feature identity do not exhibit uniform levels of degradation (Villata et al. 2016). Specifically, when both wh-elements are lexically restricted, as in (5), the sentence, despite instantiating a feature identity configuration, receives significantly higher acceptability ratings when compared to a configuration of identity (4a), but also in comparison to a configuration of inclusion (4b).

(5) **Which problem** do you wonder **which student** solved __?

+Q,+N +Q,+N +Q,+N

Villata et al. (2016) named the featural configuration instantiated in (5) *complex identity* (where *complex* refers to the lexically restricted nature of wh-elements like *which problem*) to distinguish it from (4a), which was labeled *bare identity* (where *bare* refers to the non-restricted nature of wh-elements like *who* or *what*). Drawing on Friedmann et al. (2009) and on the observation that, in some languages, lexical restriction contributes to the identification of the landing site of movement (e.g., Alboiu 2002, Munaro 1999, Soare 2009), the authors included lexical restriction among the features entering in the calculation of intervention effects à la Relativized Minimality. They further suggested that structures instantiating complex identity could be interpreted as cases of inclusion (see Villata et al. 2016 for further discussion). Since lexical restriction contributes to the identification of the site of movement, but does not trigger movement on its own, this feature was claimed to belong to the category of *non-criterial features*, while features able to trigger movement on their own were labeled *criterial features* (Rizzi 1997, 2004). Although this explanation potentially accounts for the improvement of complex identity (5) compared to bare identity (4a), it does not account for the higher acceptability of complex identity (5) compared to inclusion (4b), since the explanation assumes that both (5) and (4b) are inclusion sets.

1.2 Motivation of the Study

While the revised version of fRM brings the benefit of broadening the empirical coverage of the theory from solely addressing weak islands to encompassing all long-distance dependencies involving a configuration of intervention - whether grammatical or not - this move introduces several challenges to the theory. These challenges motivate our study and are summarized here.

First, although wh-islands with two lexically restricted elements (complex identity) were argued to instantiate a case of inclusion, empirical findings show that they are consistently judged more acceptable than the typical case of inclusion (Atkinson et al. 2016 for English; Villata et al. 2016 for French). The higher acceptability ratings observed for complex identity in comparison to inclusion have been accounted for in terms of a grammar-external mechanism ultimately rooted in the functioning of the memory system. However, this explanation suggests that the source of the increased acceptability for complex identity as compared to inclusion is grammar-external, while that of inclusion as compared to bare identity is grammar-internal, to be ultimately conceived as a fRM-type effect. As the critical factor at play in modulating the acceptability ratings of both complex identity and inclusion is lexical restriction, this approach amounts to say that the effect of similarity in a very same

feature, [+N], is sometimes grammar-internal and sometimes grammar-external.

Second, although wh-islands involving feature inclusion are rated higher than those involving feature identity, their acceptability ratings remain low (Atkinson et al. 2016; Villata et al. 2016). Nevertheless, fRM considers them to be above the grammatical cut-off point of adult grammar, assumed to be between bare identity (considered ungrammatical) and inclusion (considered grammatical).

Third, unlike the minor contrast observed between structures positioned immediately below and immediately above the proposed threshold of adult grammar (assumed to be between bare identity and inclusion), a large difference in acceptability ratings is found between wh-islands instantiating a configuration of inclusion and that-clause extraction, although both configurations are deemed to be grammatical (Villata et al. 2016).

Forth, number and gender features, which were argued to affect the comprehension of object relatives due to fRM-type effects (Belleti et al. 2012), also affect comprehension when these features fail to trigger movement, and even in structures that involve no intervention at all, as in subject relatives (Villata & Franck, 2020). In line with this, the facilitation observed in the comprehension of object relative clauses when the subject is pronominalized, which were also argued to stem from intervention effects (Friedmann et al. 2009), were also found in the comprehension of subject relative clauses, in both children (e.g., Arnon 2010) and adults (e.g., Gordon et al. 2001). Although the effects reported in subject relatives are often smaller than those in object relatives (but not always, see Adani 2012 and Adani et al. 2014), the critical point is that they do arise, independently of intervention.

This paper delves into the implications of these empirical findings for the theory of grammar. The hypothesis we want to pursue is that the set of features relevant to the computation of intervention effects is restricted to similarity in criterial features, i.e., features triggering movement independently of other features. Within this framework, the boundary of grammaticality is set by the overlap in criterial features between the moved element and the intervening element. Subtle variations in acceptability observed in both grammatical and ungrammatical sentences are ascribed to external factors ultimately tied to principles of the memory system recruited during parsing, when elements are encoded and retrieved from memory (Villata et al., 2018; Villata & Franck, 2020). Under this proposal, both a theory of grammar (fRM) and a theory of memory processing are required to account for the full pattern of available results.

Building upon the assumption that milder modulations (small effect sizes) in acceptability ratings arise from the ease with which memory processes are executed, while grammatical violations lead to more substantial effect sizes, this approach posits the following predictions regarding acceptability ratings: 1) featural similarity in lexical restriction as well as in other linguistic features that do not trigger movement exerts an influence on acceptability ratings; 2) the effect of similarity in these features is discernible in both grammatical and ungrammatical sentences; 3) these features have comparable effect sizes, which in turn are markedly smaller than the effect size of similarity in criterial features.

This paper outlines three acceptability judgment experiments in French designed to assess these predictions. Experiment 1 directly compares the effect sizes of similarity in a criterial feature, [+Q], and lexical restriction, [+N], using a 7-point Likert scale. The manipulation of [+Q] underlies the contrast between wh-islands, in which both the moved element and the intervening element carry the [+Q] feature (both are wh-elements), and that-clauses, in which only the moved element carries the [+Q] feature (only the extractee is a wh-element). Experiment 1 thus replicates Villata et al. 2016's experiments, but with a more minimal grammatical comparison for wh-islands, namely that-clause extraction. Experiment 2 tests the effect of similarity in animacy, a feature that has been unanimously claimed to not trigger movement, with a two-alternative forced-choice method. Only sentences with lexically restricted noun phrases are used in order to maximize the effect of animacy, which is more salient on full noun phrases (e.g., *which professor*) than on functional particles (e.g., *who*). Experiment 3 tests the effect of all three features, i.e., [+Q], lexical restriction, and animacy, in a fully-crossed design with a 7-point Likert scale as in Experiment 1.

To anticipate the results, similarity in all three features affects sentence acceptability. Similarity in lexical restriction and animacy affects both grammatical that-clauses and ungrammatical wh-islands, and they show similar effect sizes. Importantly, their effect size is substantially smaller compared to that of [+Q]. Drawing upon these observations, we conclude with a discussion regarding the different role of features triggering and not triggering movement in modulating acceptability judgments providing a new taxonomy of features for intervention effects.

2. Experiment 1

2.1 Method

2.1.1 Participants

Forty-nine French native speakers participated in the experiment. Participants were aged between 18 and 26, and took part in the experiment in exchange for course credit.

2.1.2 Materials and Design

Sixteen items were generated by manipulating two variables: (i) STRUCTURE TYPE (that-clause vs. wh-island) and (ii) LEXICAL RESTRICTION (bare vs. restricted). The variable STRUCTURE TYPE tests for the effect of the [+Q] criterial feature (the extractee and the intervener are similar in wh-islands since they are both question operators, whereas they are dissimilar in that-clauses as only the extractee is a question operator in that context). The variable LEXICAL RESTRICTION tests for the effect of the [+N] feature (in restricted conditions the two elements are dissimilar in terms of lexical restriction, as the extractee is restricted and the intervener is not, whereas in bare conditions the two elements are similar as they are both bare). The effect of similarity in the [+Q] criterial feature will be assessed contrasting wh-islands and that-clauses, while the effect of the [+N] feature will be assessed contrasting restricted and bare conditions in wh-islands and that-clauses. In that-clauses, the bare condition is obtained by having an extracted bare wh-element and an intervening pronoun as the subject of the embedded clause, while the restricted condition contains a lexically restricted wh-extractee

and an intervening definite description. This was based on the hypothesis that pronouns are less specified than definite descriptions, mirroring the distinction between bare and restricted wh-elements (Elbourne, 2005). All extracted objects were inanimate, while all subjects were animate. Half of the wh-islands contained the main verb *se demander* (*wonder*), while the other half contained *savoir* (*know*). All that-clauses included the main verb *croire* (*believe*). The experimental items were intermixed with 96 filler sentences consisting of wh-islands, superiority violations, and grammatical wh-in situ questions. Experimental items were divided into 4 lists. An example set for the 4 experimental conditions is provided in (6)-(10) (English translations are provided beneath each sentence together with the specification of the relevant features).

(6) THAT-CLAUSE, BARE

Qu'est-ce que tu crois qu'il a résolu?

What do you believe that he solved?

+Q

(7) THAT-CLAUSE, RESTRICTED

Quel problème crois-tu qu'il a résolu?

Which problem do you believe that he solved?

+Q,+N

(8) WH-ISLAND, BARE

Qu'est-ce que tu te demandes qui a résolu?

What do you wonder who solved?

+Q +Q

(9) WH-ISLAND, RESTRICTED

Quel problème te demandes-tu qui a résolu?

Which problem do you wonder who solved?

+Q, +N +Q

2.1.3 Procedure

Participants were asked to rate the acceptability of each sentence on a 7-point Likert-scale (1 corresponding to a totally unacceptable sentence and 7 to a perfectly acceptable sentence) by pressing one of the seven numbered buttons on the keyboard. Each sentence was presented on a computer screen one at a time. Participants were tested individually in experimental booths. Participants first saw 3 examples of sentences and their respective ratings (1, 4, and 7). They were then presented with 10 training sentences to familiarize them with the Likert scale. The experiment was programmed with E-prime. There was no time limit. Three short pauses were administered during the task. The whole session lasted about 20 minutes.

2.1.4 Data Analyses

Prior to analysis, we *z*-score transformed results by participant to eliminate common forms of scale biases. A 2x2 linear mixed effects model was fitted to the data using the lmerTest package (Kuznetsova et al. 2017) in RStudio (Posit team, 2023), with random intercepts and slopes for both subjects and items, and structure type and lexical restriction as fixed factors. *P*-values were calculated by way of the Satterthwaite's approximation to degrees of freedom (Kuznetsova et al. 2017). All predictive factors were dichotomous and centered by coding one level of the factor as -1 and the other as 1. To quantify the effect sizes of both independent variables, Cohen's *d* was calculated for each of them. Cohen's *d* is a standardized measure of effect size that quantifies the difference between two conditions (Cohen, 1988). Typically, a value of 0.2 represents a small effect, 0.5 a medium effect, and 0.8 or higher a large effect.

2.2 Results

Our first question is whether both similarity in the [+Q] criterial feature and lexical restriction [+N] affects acceptability ratings. Figure 1 shows the mean acceptability ratings in *z*-scores for the four conditions, while a summary of the fixed effects is reported in Table 1. Results attested to a significant main effect of STRUCTURE TYPE, with higher acceptability ratings for that-clauses than for wh-islands (M = 1.23 vs. M = -0.55; $p < .001$). This attests to an effect of the [+Q] feature: when both elements carry the [+Q] feature, as it is the case for wh-islands, acceptability ratings significantly drop relatively to that-clauses, where only the extractee carries the [+Q] feature. A main effect of LEXICAL RESTRICTION was also observed, with higher scores when the extracted element is restricted than when it is bare (M = 0.45 vs. M = 0.24; $p < .001$). Our second question is whether lexical restriction affects the acceptability of both islands and that-clauses. A significant interaction between STRUCTURE TYPE and LEXICAL RESTRICTION was attested ($p = .003$). Additional models revealed a significant effect of lexical restriction in wh-islands ($\beta = 0.152$, $SE = 0.031$, $t = 4.960$, $p < .001$), and a marginal effect in that-clauses ($\beta = 0.057$, $SE = 0.031$, $t = 1.859$, $p = .063$).

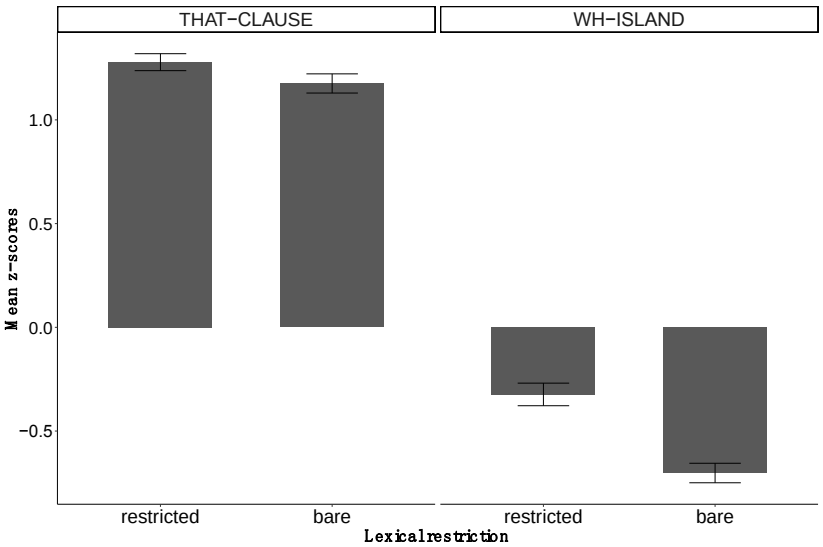

Figure 1. Mean acceptability in *z*-scores for the 4 experimental conditions of Experiment 1. Error bars indicate standard errors

Table 1. Summary of the fixed effects for Experiment 1

Variable	Estimate	Std. Error	*t*	*p*
Intercept	0.34	0.038	8.791	<.001
Structure type	-0.89	0.022	-40.954	<.001
Lexical Restriction	0.10	0.022	4.821	<.001
Structure type * Lexical Restriction	0.047	0.022	2.193	.003

Our third question concerns the effect sizes of similarity in both features. To that aim, we calculated Cohen's *d*. The effect size of [+Q] is large (d = 2.78), indicating that similarity in this feature has a strong effect on acceptability ratings. This is visible in Figure 1 when we compare the mean acceptability ratings for that-clauses (M = 1.23) to the mean acceptability ratings for wh-islands (M = -0.55). The effect size of similarity in [+N] is negligible (d = 0.19), but not far from the conventional threshold for a small effect (which is set at d = 0.2). When we consider the effect of [+N] separately in wh-islands and that-clauses, its size is small in wh-islands (d = 0.48), and negligible in that-clauses (d = 0.18). The negligible effect size of lexical restriction in that-clauses (which is however not far from the conventional threshold for a small effect size) is likely due to the fact that these sentences were nearly at ceiling (M = 6.43 on raw scores), leaving little room for the effect to reach the first traditional threshold for a significant effect size.

2.3 Discussion

Altogether, Experiment 1 shows three critical findings. First, the variable STRUCTURE TYPE, which tests for the effect of similarity in the [+Q] criterial feature on acceptability ratings, has a large effect, as indicated by Cohen's *d*. Second, the effect of LEXICAL RESTRICTION, which tests for similarity in the [+N] non-criterial feature on acceptability ratings, is significant, but its effect size is notably smaller as compared to that of the [+Q] criterial feature. Third, LEXICAL RESTRICTION affects both grammatical sentences (that-clauses) and wh-islands.

Experiment 2 expands on these findings and tests the effect of similarity in animacy, a feature that has been claimed to not trigger movement, using a two-alternative forced-choice method. The goal of this experiment is to explore whether similarity in another feature that does not trigger movement also exerts an influence on acceptability ratings in wh-islands and that-clauses, akin to the observations made about lexical restriction in Experiment 1 and in the existing literature (e.g., Goodall 2015, Atkinson et al. 2016, Villata et al. 2016).

3. Experiment 2

3.1 Method

3.1.1 Participants

Sixty French-native speaker participants took part in the experiment. Participants did not take part in Experiment 1.

3.1.2 Materials and Design

Twelve item sets were generated by manipulating the ANIMACY of the extracted element (animate vs. inanimate) keeping the intervening element animate leading to two conditions, one labeled 'animacy match' and the other 'animacy mismatch'. Sentences were lexically matched to form minimal contrasts that only diverged on the syntactic property of interest, animacy. Each pair contrasts a sentence with animacy mismatch (a) against a sentence with animacy match (b), either in wh-islands (10) or in that-clauses (11). Consequently, participants were asked to judge which sentence between (10a) and (10b) on the one hand, and which sentence between (11a) and (11b) on the other hand was the most acceptable. Therefore, this experiment tests for the effect of similarity in animacy in wh-islands and that-clauses separately (no pair contrasted wh-islands and that-clauses directly).

The resulting 24 pairs (half testing for similarity in animacy in wh-islands, half in that-clauses) were split into 6 lists, resulting in 4 experimental pairs per list, 2 testing for animacy in wh-islands and 2 in that-clauses, thus reducing the chances of satiation effects (Snyder 2000). The experimental pairs were intermixed with 13 pairs which serve as fillers and were constituted by a mix of grammatical and ungrammatical long-distance dependencies. An example of pair in wh-islands is provided in (10) and one in that-clauses in (11) (English translation are provided underneath each example).

(10) WH-ISLAND PAIR

a. ANIMACY: Quel cours te demandes-tu quel étudiant a apprécié?

MISMATCH *Which class do you wonder which student appreciated?*

-Anim +Anim

b. ANIMACY: Quel professeur te demandes-tu quel étudiant a apprécié?

MATCH *Which professor do you wonder which student appreciated?*

+Anim +Anim

(11) THAT-CLAUSE PAIR

a. ANIMACY: Quel cours crois-tu que l'étudiant a apprécié?

MISMATCH *Which class do you believe that the student appreciated?*

-Anim +Anim

b. ANIMACY: Quel professeur crois-tu que l'étudiant a apprecié?

MATCH. *Which professor do you believe that the student appreciated?*

+Anim +Anim

3.1.3 Procedure

The sentences, arranged in pairs, were vertically presented on a computer screen one pair at a time. Participants were asked to select the sentence that they found the most acceptable between the animacy mismatch sentence (a) and the animacy match sentence (b) either in wh-islands (10) or in that-clauses (11). The experiment was run using Qualtrics (Provo, Utah). There was no time constraint. The session lasted about 5 minutes.

3.1.4 Data Analyses

Data were analyzed through a logistic regression model using the lmerTest package (Kuznetsova et al. 2017) in RStudio (Posit team, 2023). In order to test whether similarity in animacy affects wh-islands and whether it affects them similarly to that-clauses, we ran a model with ANIMACY as a dependent variable and STRUCTURE TYPE (wh-islands vs. that-clause) as a fixed factor, with random intercepts for both subjects and items. In this model, a significant effect of STRUCTURE TYPE would indicate that animacy affects differently wh-islands and that-clauses. Responses were coded as 1 when participants selected the animacy mismatch condition and as 0 when they selected the animacy match condition. Proportions thus reflect the percentage of cases in which the animacy mismatch condition was selected over the animacy match condition in that-clauses and wh-islands separately. Contrasts were sum-coded (that-clauses were set as -1 and wh-islands as +1), such that the intercept of the model represents the grand mean of animacy mismatch proportions across wh-islands and that-clauses. A positive significant intercept means that the grand mean is significantly higher than the chance level.

3.2 Results

Figure 2 shows the proportion of selection of the animacy mismatch condition over the animacy match condition in that-clauses and wh-islands. Participants selected the animacy mismatch condition 59% of the times in that-clauses, and 64% of the times in wh-islands. The positive, significant intercept (p =.02) indicates that, overall, animacy mismatch conditions are preferred over animacy match conditions. Moreover, the absence of a significant main effect of STRUCTURE TYPE suggests that the two proportions did not statistically differ (p = .248), suggesting that the effect of similarity in animacy in wh-islands and that-clauses is comparable. A summary of the fixed effects is reported in Table 2.

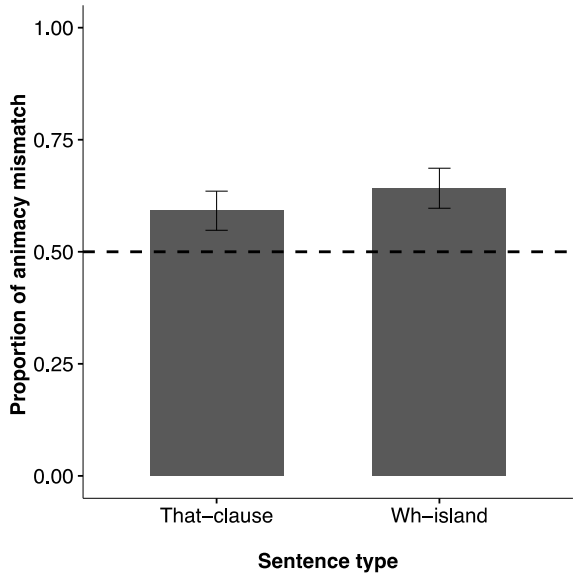

Figure 2. Proportion of choices for the animacy mismatch condition over the animacy match condition in that-clauses and wh-islands in Experiment 1. Error bars indicate standard errors. The horizontal dotted line indicates chance level.

Table 2. Summary of the fixed effects for Experiment 3. Logits for estimates have been transformed into probabilities to ease interpretability

Variable	Estimate	Std. Error	*t*	*p*
Intercept	0.615	0.204	0.907	.022
Structure Type	0.550	0.174	1.154	.248

3.3 Discussion

Experiment 2 shows that sentences with a mismatch in animacy are more acceptable than sentences with a match in animacy both in wh-islands and that-clauses. This means that animacy, a feature non-triggering movement, has a comparable effect in grammatical (that-clauses) and ungrammatical sentences (wh-islands). This is reminiscent of what we found in Experiment 1 for lexical restriction, which also had a small effect size in both wh-islands and that-clauses.

The two-alternative forced-choice task, being designed to explicitly test for differences between two conditions that only differ on the critical property of interest, has the advantage to significantly increase statistical power (see Sprouse & Almeida 2017 for a thorough discussion). However, this task is less sensitive than the Likert scale as a precise measure of effect size (see Myers 2009, Sprouse et al., 2013, Sprouse & Almeida 2017), and it does not allow for comparisons between conditions that were not presented in pairs. Experiment 3 addresses these gaps and tests for all three features of interest – [+Q], lexical restriction, and

animacy – in both wh-islands and that-clauses, using a 7-point Likert scale.

4. Experiment 3

4.1 Method

4.1.1 Participants

Forty-two native speakers of French participated in the experiment. None of the participants who took part in this experiment had participated in Experiment 1 or Experiment 2.

4.1.2 Materials and Design

Thirty-two item sets with 8 experimental conditions each were generated. Three variables were manipulated in a 2x2x2 design: (i) STRUCTURE TYPE (that-clause vs. wh-island), which tests for similarity in [+Q], (ii) the LEXICAL RESTRICTION of the wh-elements (both bare vs. both lexically restricted) (Note 2), which tests for similarity in [+N], and (iii) the ANIMACY of the extracted element while keeping the intervening element animate, leading to animacy match conditions and animacy mismatch conditions testing for the effect of similarity in animacy in acceptability ratings. An example set is reported in (12)-(19) (English translation are provided below each example). Items were divided in four lists. Each participant read two conditions per item set. The experimental sentences of each list were intermixed with 64 filler sentences.

(12) THAT-CLAUSE, BARE, ANIMACY MATCH

Qui est-ce que tu crois qu'il a apprécié?

Who do you believe that he appreciated?

+Q, +Anim +Anim

(13) THAT-CLAUSE, BARE, ANIMACY MISMATCH

Qu'est-ce que tu crois qu'il a apprécié?

What do you believe that he appreciated?

+Q, -Anim +Anim

(14) THAT-CLAUSE, RESTRICTED, ANIMACY MATCH

Quel professeur crois-tu que l'étudiant a apprécié?

Which professor do you believe that the student appreciated?

+Q, +N, +Anim +N, +Anim

(15) THAT-CLAUSE, RESTRICTED, ANIMACY MISMATCH

Quel cours crois-tu que l'étudiant a apprécié?

Which class do you believe that the student appreciated?

+Q, +N, -Anim +N, +Anim

(16) WH-ISLAND, BARE, ANIMACY MATCH

Qui te demandes-tu qui a apprécié?

Who do you wonder who appreciated?

+Q, +Anim +Q, +Anim

(17) WH-ISLAND, BARE, ANIMACY MISMATCH

Qu'est-ce que tu te demandes qui a apprécié?

What do you wonder who appreciated?

+Q, -Anim +Q, +Anim

(18) WH-ISLAND, RESTRICTED, ANIMACY MATCH

Quel professeur te demandes-tu quel étudiant a apprécié?

Which professor do you wonder which student appreciated?

+Q, +N, +Anim +Q, +N, +Anim

(19) WH-ISLAND, RESTRICTED, ANIMACY MISMATCH

Quel cours te demandes-tu quel étudiant a apprécié?

Which class do you wonder which student appreciated?

+Q, +N, -Anim +Q, +N, +Anim

4.1.3 Procedure

We used the same procedure as in Experiment 1.

4.1.4 Data Analyses

Prior to analysis, acceptability judgments from each participant were *z*-score transformed. A 2x2x2 linear mixed-effects model was fitted using the *lmerTest* package in the RStudio (Posit team, 2023), with random intercepts and slopes for both subjects and items, and STRUCTURE TYPE, LEXICAL RESTRICTION, and ANIMACY as fixed factors. All predictive factors were dichotomous and centered by coding one level of the factor as -1 and the other as 1. *P*-values were calculated by way of the Satterthwaite's approximation to degrees of freedom (Kuznetsova et al. 2017). Effect sizes were calculated through Cohen's *d*.

4.2 Results

Our first question is whether similarity in the [+Q] criterial feature, lexical restriction [+N], and animacy affects acceptability ratings. Results show that similarity in all three features do. Grammatical conditions were rated higher than ungrammatical ones (M = 0.702 vs. M = -0.672), thus attesting for an effect of similarity in the [+Q] criterial feature; restricted sentences were rated higher than bare ones (M = -0.008 vs. M = 0.111), attesting to an effect of similarity in lexical restriction; sentences with a mismatch in animacy were rated higher

than sentences with a match in animacy (M = -0.038 vs. M = 0.068), attesting to an effect of similarity in animacy.

Our second question is whether similarity in non-criterial features – lexical restriction and animacy – affects the acceptability ratings of both islands and non-islands. The interaction between STRUCTURE TYPE and LEXICAL RESTRICTION reveals that the effect of lexical restriction is significant both in that-clauses (β = 0.033, *SE* = 0.017, *t* = 1.950, *p* =.051) and wh-islands (β = 0.157, *SE* = 0.017, *t* = 9.247, *p* <.001). However, its effect size is different in the two conditions, as indicated by Cohen's *d* (small for wh-islands, *d* = 0.48, negligible for that-clauses, *d* = 0.08). The interaction between LEXICAL RESTRICTION and ANIMACY shows that the effect of animacy is significant in that-clauses (β = 0.114, *SE* = 0.071, *t* = 6.680, *p* <.001), but not in wh-islands (β = 0.007, *SE* = 0.071, *t* = -0.465, *p* =.642). Closer inspection of the data reveals that the lack of an animacy effect in wh-islands is due to the reversed effect that animacy has in restricted and bare wh-islands conditions. In restricted wh-islands, animacy has a significant effect (β = 0.07, *SE* = 0.022, *t* = 3.193, *p* =.001), with animacy mismatch conditions being rater higher than animacy match ones. In bare wh-islands, the reverse pattern is observed, with animacy match conditions being rated higher than animacy mismatch ones (β = -0.08, *SE* = 0.022, *t* = -3.900, *p* <.001). The effect size of animacy in restricted conditions is comparable in wh-islands and that-clauses, and small in both (*d* = 0.23 and *d* = 0.29 respectively). A summary of the fixed effects is reported in Table 3. Figure 3 reports the mean z-score ratings for the 8 experimental conditions.

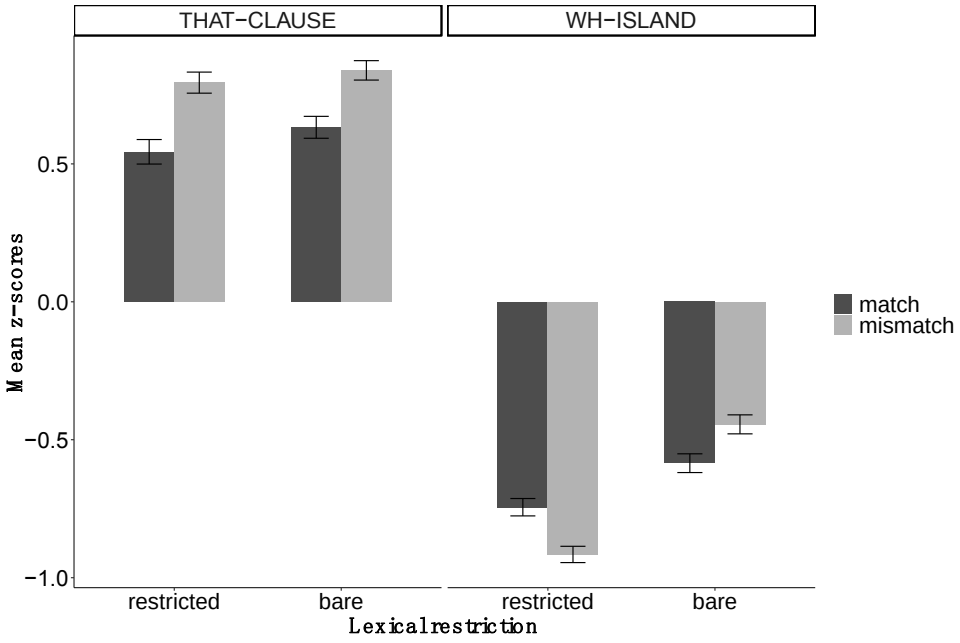

Figure 3. Mean acceptability in *z*-scores for the 8 experimental conditions of Experiment 3. Error bars indicate standard errors.

Table 3. Summary of the fixed effects for Experiment 3

Variable	Estimate	Std. Error	*t*	*p*
Intercept	0.015	0.045	0.333	0.741
Structure type	-0.687	0.012	-57.002	<.001
Lexical Restriction	0.095	0.012	7.916	<.001
Animacy	0.053	0.012	4.409	<.001
Structure type* Lexical restriction	0.062	0.012	5.177	<.001
Structure type* Animacy	-0.061	0.012	-5.070	<.001
Lexical restriction* Animacy	0.035	0.012	2.878	.004
Structure type* Lexical restriction* Animacy	0.044	0.012	3.704	<.001

4.3 Discussion

Experiment 3 reports four critical findings. First, acceptability ratings are influenced by similarity in the [+Q] criterial feature as well as two non-triggering movement features, lexical restriction and animacy. Second, the effect size associated with similarity in the [+Q] criterial feature is larger than that of similarity in animacy and lexical restriction. Third, acceptability ratings are influenced by similarity in animacy and lexical restriction in both grammatical sentences and ungrammatical restricted sentences. Forth, similarity in animacy and lexical restriction have comparable effect sizes. Animacy yields a small effect size in both grammatical and ungrammatical restricted sentences, while the effect size of lexical restriction is negligible in grammatical sentences and small in wh-islands.

The reverse effect of animacy in bare wh-island conditions is surprising. Findings from the literature in non-island contexts indicate either no effect of animacy (e.g., Adani 2012; Bentea, Durrleman & Rizzi 2016) or an ameliorative effect of animacy mismatch (e.g., Fanselow et al. 2011; Schelesewsky & Bornkessel 2004; Bornkessel-Schlesewsky & Schlesewsky 2009). One possible explanation for the reverse effect we observed may be a garden path effect. In bare animacy mismatch conditions, the extracted wh-element may serve as a direct object of the main verb (*Qu'est ce que tu te demandes _? – What do you wonder?*). This possibility is unavailable both in bare match conditions (**Qui te demandes-tu _? – *Who do you wonder?*) and restricted conditions (**Quel professeur te demandes-tu _? –*

**Which professor do you wonder?; *Quel cours te demandes-tu? – *Which class do you wonder?*). The lower ratings observed in bare wh-islands with animacy mismatch compared to those with animacy match may thus be the result of the processing cost associated with the need to reanalyze the initial incorrect attachment once the embedded clause is reached. Since this reversed effect is not observed in the corresponding grammatical structures, we must conclude that this garden-path cost has a detectable impact in acceptability ratings only when the sentence is ungrammatical, and the parser is already grappling with structure building.

Lastly, in the restricted conditions, both the intervener (e.g., *which student*) and the extractee (e.g., *which professor*) carry the [+N] feature. Consequently, unlike experiment 1, where only the extractee was lexically restricted, here the restricted condition should be a condition of similarity. Nevertheless, restricted conditions received higher ratings than bare ones in both islands and non-islands, as in experiment 1. This can be explained by considering that, even though lexically restricted wh-elements share the same syntactic form [+Q, +N], they differ across several semantic dimensions (Hofmeister et al. 2013). This is because lexical restriction is a single feature from a syntactic standpoint, while semantically it embodies a bundle of features that encompasses all the semantic features that are associated with each noun phrase, such as *professor* and *student* in (18). Some of these semantic features will be unique (those distinguishing semantically the noun phrase *professor* from the noun phrase *student*). It is in virtue of these unique semantic features that restricted conditions are conditions of dissimilarity.

5. General Discussion

5.1 Summary of the Main Findings

Three acceptability judgment experiments tested the effect of similarity in three features, one triggering movement and two non-triggering movement, in the acceptability of long-distance dependencies in French. The hypothesis we intended to test is that similarity in criterial features generates a radical shift in acceptability, attesting to ungrammaticality, while similarity in features non triggering movement (lexical restriction included) only mildly modulates acceptability ratings, without changing the grammaticality of the sentence. Three critical predictions were tested to provide an empirical test for the aforementioned hypothesis. First, not only similarity in lexical restriction but also similarity in other linguistic features non-triggering movement modulates acceptability ratings. We tested animacy, a semantic feature that is unanimously claimed to not trigger movement. Second, the effect size of lexical restriction should be comparable to that of other features non-triggering movement and substantially smaller than that of criterial features which establishes the divide between grammatical and ungrammatical sentences. Third, the effect of features non-triggering movement should be observed both in grammatical and ungrammatical sentences, under the reasonable hypothesis that memory processes are at play in both.

Results from the three experiments can be summarized as follows. The effect of similarity in the [+Q] feature is large, and defines the divide between grammatical (that-clauses) and ungrammatical (wh-islands) sentences. Similarity in lexical restriction and animacy influences the acceptability ratings of both wh-islands and grammatical sentences

(that-clauses). Moreover, the effect sizes of similarity in lexical restriction and animacy on acceptability ratings is small, and notably smaller as compared to the effect size of similarity in the [+Q] criterial feature. Taken together, these findings indicate that the effect of similarity in lexical restriction aligns more closely with that of similarity in a feature not triggering movement, animacy, than with similarity in a criterial feature, [+Q].

5.2 A Bipartite Taxonomy of Features

According to fRM, the [+N] feature associated with lexical restriction holds a unique status and is asserted, in conjunction with the [+Q] criterial feature, to contribute to the calculation of intervention effects. However, our findings show that lexical restriction produces a similar effect to other features that do not trigger movement but are not anticipated to induce intervention effects as per fRM. This lends empirical support to a bipartite classification of features, which departs from the one put forth by fRM: criterial features such as [+Q], on the one hand, and features that do not trigger movement, such as [+N] and [Animacy], on the other hand. While similarity in the former generates ungrammaticality, similarity in features that do not trigger movement only mildly modulate acceptability ratings in both grammatical and ungrammatical sentences. Therefore, we propose to distinguish between two classes of similarity effects. The first class of similarity effects is generated by features triggering movement. Similarity in terms of these features underlie fRM-type intervention effects. They occur in configurations where a c-commanding element intervening on a long-distance dependency shares the same criterial feature as the extracted one, resulting in ungrammaticality. This is the case of all wh-islands, including those that instantiate configurations of inclusion ([+Q,+N]…[+Q]) and complex identity ([+Q,+N]…[+Q,+N]) previously considered grammatical by fRM. Intervention effects are thus limited to features triggering movement (criterial features), and fRM serves as a theory defining the boundary of grammar.

The second class of similarity effects pertains to non-criterial features. These features include animacy and lexical restriction, but also agreement features that were shown to affect the comprehension of both grammatical object relative clauses and subject relative clauses (e.g., Belletti 2012, Villata & Franck 2020; cfr. section 1.2), and potentially other linguistic features not yet tested. Effects stemming from similarity in these features differ from fRM-type effects in two major respects. First, their effect size is significantly reduced as compared to that of criterial features. Second, they arise irrespective of whether the sentence is grammatical (that-clauses, object relatives) or ungrammatical (wh-islands), and regardless of whether the sentence involves intervention (wh-islands, that-clauses, object relatives) or not (subject relatives). It therefore appears reasonable to posit that these effects do not originate from properties of the grammar, but rather from the mechanisms of memory underlying sentence processing, such as encoding and retrieval. In the following sections, we provide a brief discussion of memory-based effects and the mechanisms underlining those. Subsequently, we delve into a more detailed discussion of the effects of lexical restriction and animacy.

5.2.1 Memory-based Effects at Retrieval and Encoding

In this section, we provide a brief summary of psycholinguistic evidence showing the key role of memory in the resolution of long-distance dependencies (for a more in-depth discussion, we refer the reader to Jäger, Engelmann & Vasishth 2017). It has been shown that long-distance dependencies involve the retrieval of the extracted element at some later point in the sentence, typically when the verb is encountered (e.g., Stowe 1986; Bever & McElree 1988; Osterhout & Swinney 1993). This retrieval mechanism has been argued to be *content-addressable*, meaning that the target is retrieved through a direct access based on retrieval cues. Retrieval cues are triggered by the verb and form a subset of the features of the target (e.g., McElree 2000; Lewis & Vasishth 2005; Van Dyke & McElree 2006; McElree 2006; Lewis, Vasishth & Van Dyke 2006). Key evidence for this hypothesis comes from the finding that memory retrieval is sensitive to similarity-based interference. When the target closely resembles distractors stored in memory, the retrieval process takes longer and becomes less accurate. This occurs because retrieval cues align with multiple items, leading to cue overload (e.g., Lewis et al. 2006; McElree 2006; Van Dyke & McElree 2006; Van Dyke 2007).

Let us now consider how the effects of lexical restriction and animacy can be rooted in the process of memory retrieval of the distant element. In a sentence like *Which problem do you wonder which student solved?*, the embedded verb *solved* is likely to prompt the retrieval of *which problem* based on cues such as +inanimate, +solvable and so forth. However, in the absence of lexical restriction, as in *What do you wonder who met?*, or in sentences lacking both lexical restriction and animacy mismatch information, as in *Who do you wonder who met?*, the parser has fewer cues to rely on for retrieving the intended element. This leads to increased processing difficulties and, consequently, lower acceptability ratings (e.g., Hofmeister & Sag 2010, Hofmeister et al. 2013). It is important to note again that for lexical restriction, what holds relevance in terms of memory processes is not the [+N] syntactic feature *per se* (which is not relevant as a retrieval feature), but rather the bundle of semantic features carried by restricted elements.

Although most studies have concluded that interference occurs during retrieval, empirical evidence indicates that it may also arise when elements are being encoded in memory (e.g., Barker et al. 2001; Gordon et al. 2001, 2002; Fedorenko et al. 2006; Hofmeister & Vasishth 2014; Kush et al. 2015; Jäger et al. 2015; Villata et al. 2018). Encoding interference has initially been argued to be caused by a mechanism of *feature overwriting*, wherein two elements that share the same feature compete for it. The element that loses the competition also loses the feature, resulting in a compromised memory representation (e.g., Nairne 1990, Oberauer & Kliegl 2006). More recently, it has been suggested that encoding interference may also arise from a mechanism of *activation leveling*, which equalizes the activation of elements sharing the same feature (Villata et al. 2018). On this view, lexical restriction and animacy mismatch both contribute to enhance the quality of the memory representations of the elements stored in memory, which is then expected to ease retrieval when the embedded verb is reached (under the assumption that high-quality representations are easier to retrieve than low-quality ones).

5.2.2 Lexical Restriction

Wh-islands with two lexically restricted wh-elements was found to be more acceptable than those with two bare wh-elements (see also Atkinson et al. 2016, Villata et al. 2016). Similar findings have been reported for structures involving a superiority violation. These sentences are more acceptable and faster to process when the two wh-elements are lexically restricted (e.g., *Mary wondered* ***which book which boy*** *read*) than when they are bare (e.g., *Mary wondered* ***what who*** *read*; Hofmeister et al., 2013). Although wh-islands and superiority violations differ with respect to their underlying structures (see Shlonsky et al. 2020 for a discussion), both involve the retrieval from memory of a moved wh-element when the verb is reached. The increased acceptability ratings of lexically restricted wh-islands and superiority violations can be explained by considering, as per Hofmeister et al. (2013), that despite sharing a common syntactic form, [+N], lexically restricted wh-elements differ across multiple semantic dimensions. These semantic differences contribute to their enhanced distinctiveness, a factor known to mitigate similarity-based interference during retrieval, encoding, or both.

It is interesting to note that our report that not only the acceptability of wh-islands, but also the acceptability of that-clauses improves in restricted configurations is prima facie in contrast with reports from the literature showing that object relative clauses are harder to comprehend when the two arguments are lexically restricted (e.g., *The barber that the lawyer admired climbed the mountain*) as compared to when the object is lexically restricted and the subject is not, as when it is a pronoun (e.g., *The barber that you admired climbed the mountain*, Gordon et al. 2001), a wh-operator (as in free relatives, *Show me the one that the boy is wetting*), or an impersonal pro subject (e.g., *Show me the horse that someone is brushing*, Friedmann et al. 2009). However, these findings differ from those presented here in two main respects. First, whereas in studies investigating object relative clauses fully lexically restricted sentences (both elements are restricted) are compared against sentences in which the extracted element is restricted and the intervening one is bare, in the studies presented here lexically restricted sentences are always compared to bare sentences (both elements are non-restricted). Second, studies manipulating lexical restriction in object relative studies exclusively tested sentences where both elements are animate, whereas studies reported here tested configurations involving animacy mismatch. Consequently, further investigation with maximally comparable materials is necessary before drawing any conclusion about consistency or inconsistencies of lexical restriction effects across grammatical structures.

5.2.3 Animacy

Results show that animacy impacts both fully grammatical sentences containing an extraction out of a that-clause and wh-islands: sentences with animate subjects are more acceptable if the object is inanimate than if it is animate. These results are in line with the vast literature on object relative clauses attesting to the critical role of animacy in the comprehension of grammatical structures: the well-known advantage of subject relative clauses over object relative clauses can be neutralized when the head of the object relative is inanimate and the

subject is animate (see Gennari and MacDonald 2008, Mak et al. 2002, 2006, Traxler et al. 2002, for adults; Arosio et al. 2010, Bentea and Durrleman 2014, Bentea et al. 2016, Corrêa 1995, for children). This effect could be explained by the role of similarity during object retrieval: the object is easier to retrieve when it is more distinct from the subject.

However, the generalization that emerges from the literature is that similarity only affects sentences with animate subjects: no difference is found between sentences with an inanimate subject and an inanimate object, on the one hand, and sentences with an inanimate subject and an animate object, on the other hand, which are both processed similarly to sentences with an animate subject and an animate object (see Mak et al. 2002, 2006; Traxler et al. 2002, 2005). This finding may suggest that animacy specifically plays a role in retrieving the subject of the sentence, since animacy is a typical property of subjects. The report that similarity in animacy only impacts sentences with animate subjects suggests that if the verb searches for an animate element and the element that qualifies for being the subject (because of grammatical features like its structural position and nominative case) is animate, the presence of another animate element penalizes the process, while if the element that qualifies for being the subject is inanimate, the animacy of the other element does not matter. More research is necessary to understand precisely the way cues are used, or not, by the parser.

5.3 Processing-based Accounts of Islands

The proposal put forward in this paper claims that wh-islands are banned by the grammar in virtue of a grammatical principle, Featural Relativized Minimality. Some authors, however, have argued that the degradation in acceptability ratings associated with islands is the result of a combination of processing demands in working memory that combine super-additively: when the cognitive demands exceed a certain threshold, a decrease in acceptability is observed (see, amongst others, Kluender & Kutas 1993; Kluender 1998; Hofmeister et al. 2007, 2013; Hofmeister & Sag 2010). Factors with high processing demands may include long-distance dependency processing, similarity-based interference, and clause boundary processing. In support to this view, the processing of clause boundaries has been shown to involve a processing cost even in sentences without long-distance dependencies, which suggests that it is a factor of complexity in itself (Kluender & Kutas 1993). In this vein, one could argue that even the effects of features triggering movement are rooted in processing. Their more robust effect in shaping acceptability judgments may be due to the fact that since long-distance dependencies involve movement, an intervening element endowed with an interrogative feature may be a particularly suitable candidate for retrieval, as it is recognized as potential filler for the gap. From this perspective, also the effects that we ascribed to a grammatical principle would be rooted in processing.

Processing-based accounts for island effects are appealing because of their parsimony: instead of distinguishing between grammar-based and processing-based phenomena, all island phenomena are processing-based. However, these accounts rely on a variety of factors of different types (long-distance dependency cost, clause boundary cost, similarity cost, working memory cost, etc.), the exhaustive list of which is yet to be established (Hofmeister & Sag 2010). Moreover, some of these factors, like working memory, were argued to be

irrelevant and the available evidence for the independent difficulty associated with island structures suggests that they do not always incur a processing cost (Sprouse, Wagers & Phillips 2012, Phillips 2013). In sum, there is no general consensus concerning the general picture arising from processing models, and the definite resolution to this debate is yet to be determined (Sprouse, Wagers & Phillips, 2012).

5.4 Conclusions

Three acceptability judgment experiments in French have been conducted in order to investigate the role of similarity in a criterial feature (the question operator) and in two non-criterial features (lexical restriction and animacy) in the modulation of acceptability ratings. Results show that the [+Q] criterial feature exerts a large role in acceptability ratings as it turns the sentence into an ungrammatical one when shared both by the extracted element and the intervening one. On the contrary, similarity in both lexical restriction and animacy modulates the acceptability ratings of both wh-islands and grammatical sentences to a similar extent. Results also showed that although these features modulate acceptability ratings, their role is much reduced compared to the role played by criterial features triggering movement, which have a large effect on acceptability ratings. To account for this set of facts, two families of features have been distinguished: features triggering movement, leading to effects assumed to be constrained by the grammar, and features that do not trigger movement, whose effects are assumed to be grounded in principles of the memory system. The first set of features defines the boundaries of grammaticality in virtue of the principle of fRM. The second set of features operates at the processing level, modulating the ease with which elements of the sentence are encoded or retrieved from memory as the sentence structure is being built, whether it is grammatical or not. This approach successfully addresses the various challenges faced by fRM. Nevertheless, it shares common ground with fRM by emphasizing the significance of structural intervention and features triggering movement in delineating the grammatical boundary. This approach also leverages a shared principle found in both fRM and memory theories – similarity – to explain processing difficulties and/or ungrammaticality. While the proposed demarcation between performance and competence seems to be the most fitting framework based on current knowledge, it remains open to scrutiny and potential refinement in future research.

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Notes

Note 1. There is a subtle but critical distinction between *intervention*, which refers to the structural configuration in (2a), and *intervention effect*, which refers to the combination of criteria (2a) and (2b). Intervention effects arise when the intervening c-commanding element bears the same featural specification of the moved element, thus causing sentence ungrammaticality. Therefore, object relatives, object clefts, that-clause extraction are all configurations of intervention (i.e., there is always an intervening element, usually the subject, c-commanding the gap of the moved element). However, no intervention effect arises in these contexts, as the featural specification of the intervening element is never identical to that of the moved element, preserving the well-formedness of the sentence.

Note 2. In contrast to Experiment 1, where only the extracted wh-element was restricted in the lexically restricted condition, in Experiment 2 both wh-elements are restricted. This choice is motivated by the attempt to maximize the effect of animacy, which may be more salient as a feature of full noun phrases (e.g., *which professor*) than of functional particles (e.g., *who*).

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