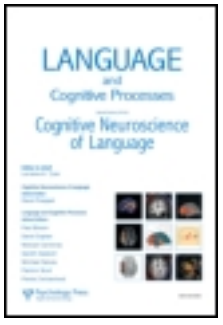

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On the origin of islands

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On the origin of islands

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There is considerable controversy on island constraints on wh-dependencies in the psycholinguistic literature. One major point of contention is whether islands result from processing limitations such as working memory capacity or from domain-specific linguistic knowledge. The current study investigates whether islands can be reduced to processing considerations, by examining processing of another long-distance dependency, cataphora. If wh-dependencies with the licensing element (the verb or preposition) falling inside an island entail an unbearable memory load on the parser, then other dependencies, including cataphora, with a licensing element (the antecedent), falling inside an island, should yield a similar processing difficulty. The results from a self-paced reading experiment demonstrate that online formation of a cataphoric dependency is not affected by island constraints. We conclude that islands are not fully reducible to processing considerations and therefore must – at least in part – be of grammatical origin.

Keywords: islands; cataphora; processing-based accounts of islands; sentence processing; parsing

1. Introduction

Long-distance dependencies are relations between two elements in a sentence, in which one element is dependent upon the other one in its grammatical features and/or its interpretation, and where a potentially unbounded amount of material can occur between the two elements. A well-studied type of long-distance dependency is a *wh-dependency* between a wh-filler and a verb (or the preposition) (Clifton & Frazier, 1986), as in (1a), in which the dependent element, the wh-phrase *which film*, precedes the licensing element, the verb (or the preposition). Another type of dependency is *cataphora* as in (1b) where the dependent element, the pronoun *his*, precedes the licensing element, the antecedent:

(1) a. It was discovered which film [the studio notified Jeffrey Stewart about __]

b. His managers revealed [that the studio notified Jeffrey Stewart about the new film.]

Although long-distance dependencies may be potentially unbounded, they are subject to constraints on the relative positioning of the dependent element and the licensor. For example, although a wh-phrase can be associated with a gap in an embedded complement clause as in (1a), it cannot be associated with a gap inside a relative clause (RC) as in (2).[1] Such a restriction is known as the RC island condition and is a member of a larger class of constraints on wh-dependencies, 'island constraints' (Ross, 1967):

(2) *It was discovered which film [$_{NP}$ the studio [$_{RC}$ that notified Jeffrey Stewart about __]] selected a novel for the script.

Constraints on cataphora can be illustrated by comparing (3a) and (3b): whereas *Jeffrey Stewart* can serve as an antecedent for the pronoun *his* in (3b), it cannot for the pronoun *he* in (3a). This is because (3a) violates the so-called binding condition C (BCC: Chomsky, 1981) on coreference well-formedness, whereby the pronoun cannot c-command its antecedent (informally, in a tree structure a node c-commands all its sibling nodes or their descendants, i.e., *he* c-commands *Jeffrey Stewart* in (3a) but *his* does not c-command *Jeffrey Stewart* in (3b)):

(3) a. *He revealed [that the studio notified Jeffrey Stewart about the new film.]

b. His managers revealed [that the studio notified Jeffrey Stewart about the new film.]

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In theoretical linguistics, constraints on long-distance dependencies have been understood as grammatical constraints that regulate well-formedness of sentence structures and are specific to the type of dependency (Chomsky, 1977, 1981; Ross, 1967).[2] For example, the BCC on cataphora discussed above is a structural constraint formulated in terms of c-command (the pronoun cannot c-command its antecedent). Importantly, while it applies to all coreference dependencies, it does not apply to wh-dependencies (in fact, the opposite must hold with wh-dependencies, i.e., the wh-phrase must c-command the gap). Similarly, the island constraints on wh-dependencies have been formulated in terms of syntactic nodes (wh-dependencies may not span across certain nodes such as Inflection Phrase (IP) and Noun Phrase (NP)).[3] Cataphoric dependencies, on the other hand, are not affected by such nodes (Chomsky, 1977) and are licit in syntactic configurations that make wh-dependencies illicit, as can be seen by comparing (2) with (4).[4]

(4) His managers revealed that [$_{NP}$ the studio [$_{RC}$ that notified Jeffrey Stewart about the new film]] selected a novel for the script.

Examples like (2) and (4) are thus explained by the structural differences. The relevant structures can be illustrated in Figures 1 and 2.

More recently, however, it has been suggested that at least some grammatical constraints on long-distance dependencies – island constraints, in particular – result from more general considerations involving processing load.[5] Such accounts, which we term 'complexity accounts', argue that the process of locating a gap inside a RC in (2) incurs a high, even unbearable, burden on the parser during online sentence processing (Hawkins, 1999; Hofmeister & Sag, 2010; Kluender, 1998; Kluender & Kutas, 1993). When a wh-dependency is processed, the wh-phrase must be kept in working memory until it is associated with its licensor,[6] the verb (or the preposition), and this incurs a storage

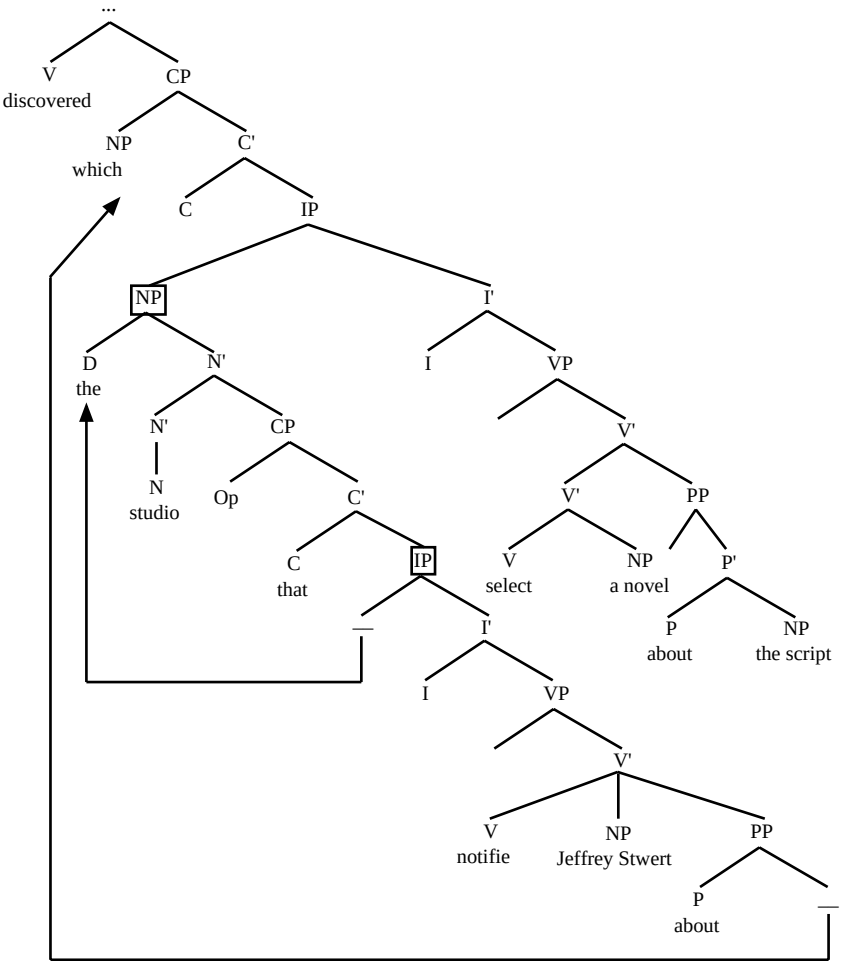

Figure 1. The structure of the example (2): an illicit dependency between the wh-phrase and the gap (indicated by t) spans over an IP-node, an NP-node and another IP-node.

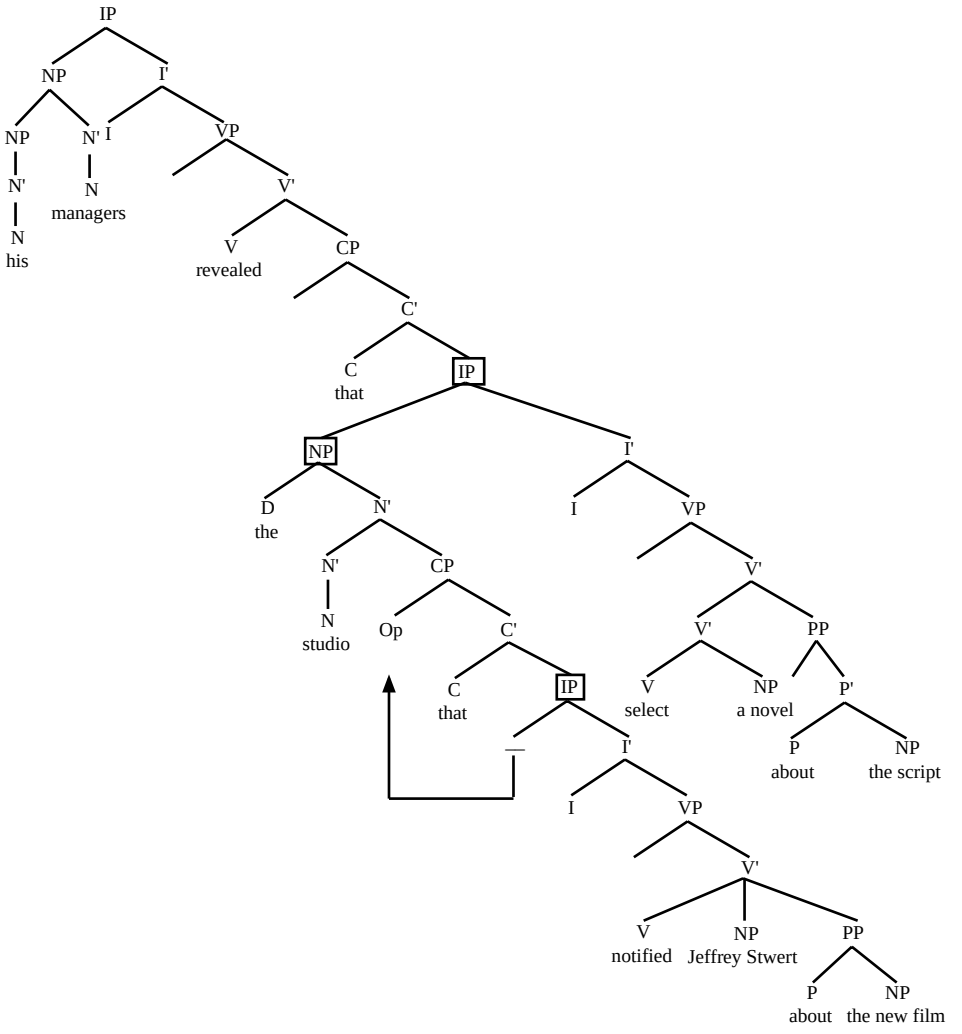

Figure 2. The structure of the example (4): a licit dependency between the pronoun (his) and its antecedent (Jeffrey Stewart) that spans over an IP-node, an NP-node and another IP-node.

cost (Fiebach, Schlesewsky, & Friederici, 2001; Fiebach, Schlesewsky, & Friederici, 2002; Gibson, 1998; Pickering & Barry, 1991). In addition, in RC islands, two extra sources of difficulty cause a burden on the processor. First, both the head of the RC (*the studio* in (2)) and the relative pronoun (*that* in (2)) are referentially processed, and the processing difficulty arises depending on the nature of such element, e.g., its definiteness (we may call this 'intervention costs') (Gibson, 1998; Hofmeister and Sag, 2010; Warren and Gibson, 2002). Second, carrying the filler across the RC boundary is expected to cause difficulty (Kluender, 1998, p. 253). Under the complexity account, island violations are perceived as unacceptable because the combined burden of all of these processing difficulties exceeds an acceptability threshold, as stated by Kluender (1998, p. 258) '...the *grammaticality* of relative and wh-islands can be *reduced* to the interaction of this set of processing primitives' (emphasis by authors).

Part of the appeal of the complexity account is that processing factors which explain island violations also explain a range of other seemingly disparate phenomena, such as gradations in the acceptability of centre embedding constructions (Gibson, 1998, among others), as well as the difficulty of object RCs as compared to subject relatives (Carreiras, Duñabeitia, Vergara, de la Cruz-Pavía, & Laka, 2010; and see Hsiao & Gibson, 2003 for recent review). Our study tests the generality of the processing complexity account by considering its application to cataphoric dependencies. Consider (4), which includes a licit cataphoric dependency between *his* and *Jeffrey Stewart*, and compare it with (2) which illustrates an illicit wh-dependency that violates an island constraint.

Examples (4) and (2) share a number of features that are relevant to the complexity account. In both

sentences, a dependent element has to be stored in memory before the long-distance dependency can be resolved; in (4), it is the pronoun *his*, while in (2) it is the wh-phrase *which film*. Moreover, in both sentences these dependencies have to straddle both a definite NP (*the studio*) and a RC boundary. Under complexity accounts, it is these factors that lead to the perception of unacceptability in the island violation in (2). Yet, in (4), there is no perceived unacceptability, at least at an intuitive level. The apparent acceptability of (4) may appear to be hard to explain with the complexity account, given the similarities between (4) and (2) noted above, and also because such accounts that rely on general processing complexity considerations should not be stipulated to apply only to particular constructions or grammatical operations such as wh-dependencies. However, the intuitive contrast in acceptability judgements *per se* does not constitute direct evidence against the complexity approach, for which the original predictions are formulated regarding how dependencies are formed in real-time. The cataphoric dependency in (4), rather than being established immediately during online processing, may be established late as a result of some coercion, e.g., when no other antecedent for the pronoun is found (see Garrod, Freudenthal, & Boyle, 1994; Garrod & Terras, 2000; Sanford, Moar, & Garrod, 1988, for evidence that formation of referential and other dependencies can be delayed). In order to test the prediction of the complexity account, we need to know whether the parser attempts to link the pronoun and its antecedent across the RC island [$_{NP}$ *the studio* [$_{RC}$ *that* . . .]] immediately during online processing.

2. Active dependency formation

Much research on wh-dependencies has shown that upon encountering a wh-phrase the parser triggers a search for a licensor (e.g., a verb that assigns the thematic role to the fronted wh-phrase) and aims to complete the dependency as soon as possible (Aoshima, Phillips, & Weinberg, 2004; Clifton & Frazier, 1986; Frazier, Clifton, & Randall, 1983; Frazier & Flores D'Arcais, 1989; Lee, 2004; Phillips, 2006; Stowe, 1986; Wagers & Phillips, 2009). To do so, it postulates a gap at every relevant position (at least temporarily) even before bottom-up information confirming the presence of the gap becomes available (Crain & Fodor, 1985; Frazier & Flores D'Arcais, 1989; Stowe, 1986; Tanenhaus, Boland, Garnsey, & Carlson, 1989). The parser's preference for the shortest dependency has been linked to the necessity to minimise the cost of storing the wh-phrase in working memory (Chen, Gibson, & Wolf, 2005; Gibson, 1998; Pickering & Barry, 1991). Importantly, despite attempting to complete the dependency as soon as possible, the parser does not search for a licensor in positions that are inside an island (Bourdages, 1985; McElree & Griffith, 1998; Phillips, 2006; Pickering, Barton & Shillcock, 1994; Stowe, 1986; Traxler & Pickering, 1996). Such an observation, namely that island constraints are respected immediately during online processing and are not delayed, is exactly what the complexity account of islands predicts. The syntactic account, on the other hand, explains the same finding via the claim that the parser has immediate access to grammatical constraints.

Online cataphora formation also involves an active search mechanism: upon encountering a pronoun that does not have an antecedent in the preceding discourse the parser triggers an active search for an antecedent in the following discourse (Kazanina, Lau, Lieberman, Yoshida, & Phillips, 2007; van Gompel & Liversedge, 2003), and this search leads to a processing cost, which can be interpreted in terms of working memory load (Filik & Sanford, 2008). For example, Kazanina et al. (2007) used the self-paced reading technique to examine the processing of sentences with cataphora such as (5a/b). They found that *quarterback*, the stereotypically male head noun, was read significantly more slowly in (5b) than in (5a), i.e., when it mismatched in gender with the preceding pronoun *his*/*her*. On the basis of this gender mismatch effect (GMME), the authors argued that the parser considered the dependency between the pronoun and the subject of the *while* clause – the earliest potential antecedent position – even before relevant bottom-up information about the antecedent became available.[7] The same study showed that the parser does not search for an antecedent in illicit positions that are c-commanded by the pronoun, thus respecting the BCC: the parser did not even temporarily consider the subject's position in (5c/d) which is c-commanded by the pronoun *he*/ *she* (as indicated by the similar RTs at *quarterback* in (5c) vs. (5d)):

(5) a/b. His/her managers chatted amiably with some fans while the talented, young **quarterback** signed autographs for the kids, but Carol . . . .

c/d. He/she chatted amiably with some fans while the talented, young **quarterback** signed autographs for the kids, but Steve/Carol . . .

Because a cataphoric pronoun triggers an active search for an antecedent, the pronoun itself needs to be held in working memory until it is interpreted, i.e., until its antecedent is found in the following input. Hence, under the complexity account, cataphoric dependencies with the antecedent located inside a RC as in (4) should

have a similar effect on the parser as in a wh-dependency in (2): a working memory overload resulting from processing the RC structure while storing an open dependency.

Note that pronoun dependencies and wh-dependencies can be treated distinctly in a fully processing-based approach if the parsing process is construed as consisting of two non-overlapping stages. For example, Berwick and Weinberg (1986, pp. 169–171) suggest that wh-dependency formation takes place entirely during the structure building stage, whereas the indexing of the pronoun and the antecedent takes place after the structure of the whole sentence is built. Thus in Berwick and Weinberg's view, wh-dependencies and pronoun dependencies should be processed differently. Therefore, their theory provides a fully processing-based account of the difference between wh-dependencies and pronoun dependencies in terms of island sensitivity. Simply put, they are construed during different parsing stages and are therefore sensitive to resource constraints in different ways. Although such an account is appealing, there is an obstacle to their approach, namely active dependency formation. If wh-dependency and pronoun-dependency were construed during different parsing stages, it remains unclear why pronoun dependencies would be formed actively, in a way that is very similar to wh-dependencies (see Kazanina et al., 2007). Active dependency formation in the processing of cataphora instead points to the fact that cataphoric dependencies are also formed during structure building ('construction of the tree' in Berwick and Weinberg's terms).

The experiment section uses the self-paced reading technique to test whether real-time processing of cataphoric dependencies abides by the RC island constraint, i.e., whether the parser searches for an antecedent of a cataphoric pronoun inside a RC. We compare this with the effect of the BCC on the formation of cataphora.

3. Experiment

3.1. Participants

Seventy-two undergraduate students from Northwestern University participated in the experiment for course credit. All participants were native speakers of English and gave informed consent for participation.

3.2. Design and procedure

Twenty-eight sets of sentences such as (6) were created using a 2×2 design with factors PRONOUN CASE (genitive vs. nominative) and GENDER CONGRUENCY (gender match vs. gender mismatch). In the genitive conditions, the first potential antecedent for the pronoun, *Jeffrey Stewart*, is located inside an RC. If the parser considers such a relation at an early stage of processing notwithstanding that the antecedent is located inside an RC, longer reading times should be found at the NP *Jeffrey Stewart* in the gender incongruous (6b) as compared to the gender congruous (6a) (similarly to what has been found for other cases of licit cataphora by Kazanina et al., 2007; van Gompel & Liversedge, 2003). Conversely, the lack of a difference in RTs at *Jeffrey Stewart* in (6a) vs. (6b) would suggest that the parser skips the positions inside an RC during its active search for an antecedent in online processing, as predicted by the complexity approach. Two nominative conditions were included in which coreference between the pronoun and the NP *Jeffrey Stewart* violates BCC as the pronoun c-commands the NP. If the parser abides by grammatical constraints on coreference during the formation of a cataphoric dependency, then candidate antecedents that are subject to BCC should not be considered at the earliest stages of dependency formation. If so, we expect similar mean RTs at the NP *Jeffrey Stewart* regardless of whether this NP matches (as in (6c)) or mismatches (as in (6d)) in gender with the preceding pronoun (as previously found by Kazanina et al., 2007). Thus in all conditions, the critical NP *Jeffrey Stewart* was located inside an RC, but only in the nominative conditions was it additionally subject to the BCC.

(6) See Table 1.

The gender of the genitive and nominative pronoun was balanced across stimuli sets: half of the sets used the masculine pronouns *he* and *his*, and the other half used the feminine pronouns *she* and *her*. The gender-match and gender-mismatch sentences differed only in the gender of the pronoun in the first clause, which either matched or mismatched in gender of the direct object inside the RC (*Jeffrey Stewart*). This was always a gender-unambiguous proper name and the same across the four conditions. Additionally, to ensure that the cataphoric pronouns received a grammatical antecedent in every case, the target structures were embedded further in a sentence introduced by the conjunction *but* (see Table 1). The gender of the final clause subject (*Annie*/*Andy*) was chosen such that each sentence had a unique grammatical antecedent for the genitive or nominative pronoun.

Twelve English speakers rated the acceptability of experimental materials using a 1 (not acceptable) to 5 (fully acceptable) scale. Mean ratings (standard deviation) for conditions (6a–d) were 3.63 (1.18), 3.58 (1.42), 3.45 (1.66) and 3.70 (1.07), respectively, and did not significantly differ from one another (2×2 ANOVA with factors CASE (genitive vs. nominative) and

Table 1. A full sample set of stimuli from the self-paced reading experiment. The critical NP inside a relative clause is underlined.

(a) *Genitive/gender match*
His managers revealed that the studio that notified Jeffrey Stewart about the new film selected a novel for the script, but Annie did not seem to be interested in this information.
(b) *Genitive/gender mismatch*
Her managers revealed that the studio that notified Jeffrey Stewart about the new film selected a novel for the script, but Annie did not seem to be interested in this information.
(c) *Nominative/gender match*
He revealed that the studio that notified Jeffrey Stewart about the new film selected a novel for the script, but Andy did not know which one.
(d) *Nominative/gender mismatch*
She revealed that the studio that notified Jeffrey Stewart about the new film selected a novel for the script, but Annie did not know which one.

GENDER CONGRUENCY (gender match vs. gender mismatch) all Fs < 1). Thus sentences in different conditions were equally acceptable to English speakers. We also verified whether speakers indeed accept coreference in our experimental materials between the cataphoric pronoun and the proper name inside the RC. Thirty-six native English speakers made judgements in response to the question 'how plausible is it that the underscored pronoun and the underscored noun refer to the same person' on a scale from 1 (impossible) to 7 (absolutely natural). Mean ratings (standard deviation) for conditions (6a–d) were genitive, gender match: 4.61 (2.00); genitive, gender mismatch: 2.00 (1.76); nominative, gender match: 2.62 (1.80); and nominative, gender mismatch: 1.73 (1.55), respectively. A 2×2 ANOVA with factors CASE (genitive vs. nominative) and GENDER CONGRUENCY (gender match vs. gender mismatch) revealed that there was a significant main effect of CASE ($F1(1,35) = 51.96$, $p = 0.0001$; $F2(1,27) = 285.00$, $p = 0.0001$), with coreference rated as more plausible in the genitive than the nominative conditions, and a significant interaction of CASE $\times$ GENDER CONGRUENCY ($F1(1,35) = 38.56$, $p = 0.0001$; $F2(1,27) = 36.00$, $p = 0.0001$). Pairwise comparisons revealed that the match condition was significantly more acceptable than the mismatch condition within the genitive pair ($F1(1,35) = 58.06$, $p = 0.0001$; $F2(1,27) = 144.62$, $p = 0.0001$) and within the nominative pair ($F1(1,35) = 21.76$, $p = 0.0001$; $F2(1,27 = 36.15)$, $p = 0.0001$). However, the significant interaction indicates that the acceptability difference between the two genitive conditions is much larger than the difference between the two nominative conditions. Thus, the results support our claim that cataphoric coreference is generally acceptable when the pronoun does not c-command the antecedent, and that it is very much less acceptable when the c-command relation holds, despite the fact that in both cases the antecedent is located within an RC island.[8]

Twenty-eight sets were distributed among four lists in a Latin Square design, and combined with 72 filler sentences. To mask experimental sentences, the fillers bore a number of similarities with the target items (e.g., sentence length or amount of clauses per sentence), and included no instances of unresolved anaphora.

3.3. Procedure

A word-by-word moving window task (Just, Carpenter, & Woolley, 1982) was conducted on a laptop PC running Linger (Doug Rhode, MIT). Each sentence was followed by a yes/no comprehension question.

3.4. Analysis

Only trials for which the corresponding comprehension question was answered correctly were included in the analysis. Four participants whose comprehension accuracy was below 50% were excluded from the analysis. The average comprehension accuracy for the remaining 68 participants was 85% (85.1–87.5% for individual conditions; mean accuracy did not differ by condition: all Fs < 1). The regions used for the analysis corresponded to single words, except for the regions corresponding to the end of the clause that combined several words (due to variation in the clause length between items). Reading times at each region were analysed using linear mixed effects regression analysis (LMER; Baayen, 2008), and p-values were derived from Monte Carlo Markov chain simulation. All analyses reported below include crossed random intercepts for participants and items. Random slope parameters for the interaction of fixed effects with random effects were not included, as they did not significantly improve model fit. Predictor variables were centred prior to analysis.

3.5. Results

LMER analysis of reading times revealed a significant main effect of CASE at the main verb (region 3, $\beta = 55.89$, $t = 4.25$, $p < 0.001$) which is expected due to lexical differences in the preceding region between the

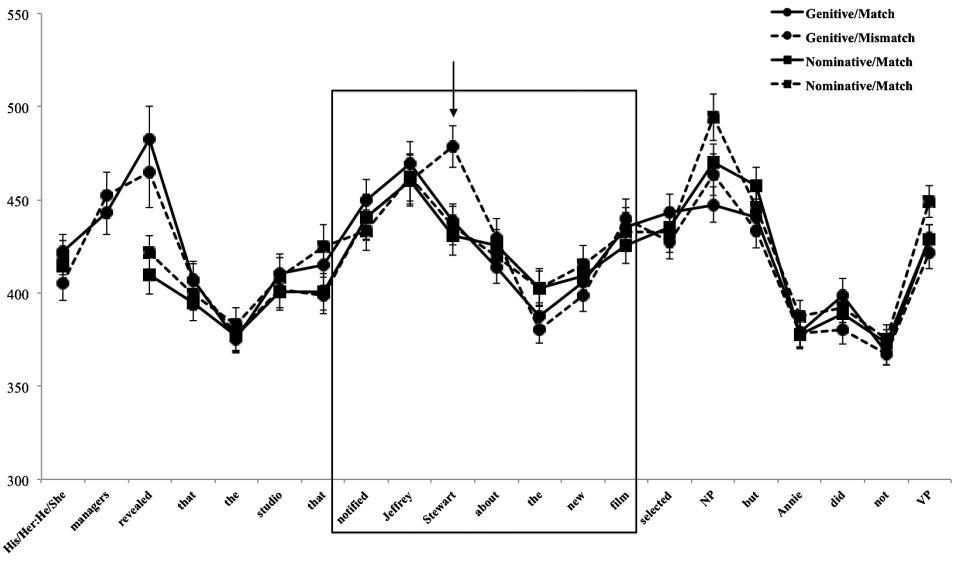

Figure 3. The mean reading times for each region for all conditions are presented. The box on the graph highlights the critical relative clause. The arrow points to the direct object in the relative clause at which the gender mismatch effect was found in the genitive pair only.

genitive and nominative conditions (*managers* vs. *he/she*) (Figure 3).

The critical regions are regions 9 and 10, which correspond to *Jeffrey Stewart*. No significant effects were found at the first name. Importantly, in region 10 (the surname *Stewart*) the main effects of CASE ($\beta = 26.20$, $t = 2.93$, $p < 0.001$), GENDER ($\beta = 22.64$, $t = 2.53$, $p < 0.001$) and the interaction CASE × GENDER ($\beta = 40.01$, $t = 2.23$, $p < 0.05$) were all significant.[9] Pairwise comparisons revealed significantly longer reading times for the last name in the gender-incongruous variant than in the gender-congruous variant in the genitive condition (GMME, mean RTs: gender match −438.34 ms, gender mismatch −478.46 ms; $t = 3.35$, $p < 0.001$) but not in the nominative condition (gender match −430.97 ms, gender mismatch −436.37 ms; $t < 1$).

Given our study design there is a possibility that the effects found in region 10 (the last name) may be strategic. In our materials the nominative pronoun always matches the subject of the final *but* clause in gender. However, the genitive pronoun mismatches in gender with the final subject in half of the sentences, specifically whenever it matches in gender with the name inside the RC. Therefore, unlike in the nominative conditions when the pronoun is genitive, it cannot be always linked to the subject of the final clause because the latter may be of opposite gender. The genitive conditions, therefore, may prompt a strategy whereby the parser examines the object inside the RC because the gender of the final clause subject is not always a licit antecedent for the pronoun. In order to test whether the GMME in the genitive conditions resulted from such a strategy or from a genuine active dependency formation, we examined the effect of trial order (i.e., the order in which the items were encountered by each participant). If the GMME emerged due to the described strategy, we expect that there is an interaction between the trial order and the GMME (i.e., it is expected that the GMME grows as each participant gets more exposure to the stimuli during the experiment). Hence, we added the log-transformed TRIAL ORDER[10] as a fixed factor in LMER and analysed the reading times in region 10. The LMER analysis revealed that there is no interaction of CASE × GENDER × TRIAL ORDER ($t = -0.38$), CASE × TRIAL ORDER ($t = 0.84$) or GENDER × TRIAL ORDER ($t = 0.76$) while there is a main effect of TRIAL ORDER ($\beta = -191.37$, $t = -11.90$, $p < 0.001$). The main effect of TRIAL ORDER suggests that reading times become faster as participants proceed through the experiment. Importantly, however, the lack of an interaction between TRIAL ORDER and other fixed factors suggests that the GMME in region 10 is not due to strategic effects described above, but rather the consequence of active dependency formation.

In the remainder of the sentence, there was a near significant main effect of CASE ($t = 1.81$, $p = 0.069$), GENDER ($t = 1.77$, $p = 0.075$) but no significant interaction ($t < 1$) at region 16. There were no significant differences in any other region.

4. Discussion

We found a GMME at the antecedent *Jeffrey Stewart* (in particular, at the last name *Stewart*) in the genitive conditions, but no such effect in the nominative conditions. The presence of a GMME indicates that the parser actively searched for an antecedent in the

direct object position in the RC, i.e., a cataphoric dependency was formed into an island, across an RC boundary. The lack of a GMME in nominative conditions indicates that the parser did not consider the NP in this position as a potential antecedent for the preceding pronoun, as such a dependency would violate BCC. In sum, a cataphoric dependency can be formed across an island domain as long as it does not violate binding constraints, in particular, BCC.

The finding that the parser does not search for an antecedent of a cataphoric pronoun in positions that are c-commanded by the pronoun, i.e., it abides by BCC in real time, replicates Kazanina et al.'s (2007) findings and further strengthens their claim that cataphoric dependencies are processed using a grammatically constrained active search mechanism. The finding that cataphoric dependency formation is unaffected by the RC island represents a potential argument against complexity approaches.[11] As explained in Section 1, the complexity approach considers that island effects with filler-gap dependencies are due to the processing complexity induced by intervening material between the dependent element (the wh-phrase) and the controlling element (the gap/verb). A direct extension of the complexity approach to cataphora would predict that when similar intervening material is found between the members of a cataphoric dependency, real-time formation of the dependency should be disrupted. Conversely, our findings are compatible with approaches that distinguish two different types of long-distance dependencies (filler-gap dependencies and cataphoric dependencies) and that claim that these dependencies are restricted by different set of constraints (island constraints and BCC) even though both of them involve real-time active dependency formation processes. Note that in a previous study, the type of island that we have tested (a finite RC island in the subject position) was reported to block online wh-dependency formation, when a similar moving window methodology was used (Phillips, 2006), and thus the difference between the cataphora-dependency formation and wh-dependency formation is clear.

One potential objection to our conclusion is the idea that our cataphora examples may be relatively easy to process because they are interpreted using pragmatic, referential mechanisms, thus allowing the support of a non-syntactic level of representation. This may have the effect of improving the acceptability of our cataphoric dependencies, in the same way that certain types of islands are improved when an extracted wh-phrase is D-linked (e.g., *which boy*) relative to when it is a single word (e.g., *who*) (Pesetsky, 1987). According to Hofmeister and Sag (2010), the extra information afforded by a D-linked wh-phrase leads to facilitation in memory retrieval at the point of dependency resolution, leading to increased acceptability relative to bare wh-phrases.[12] Thus, one might argue that if referential information facilitates retrieval of the cataphoric pronoun, allowing the dependency to be formed across the intervening RC boundary, then our results can be explained using processing considerations. However, given that our stimuli were presented as stand-alone sentences, the referential information afforded by our cataphoric pronouns (*he*/*his*) was minimal. We also note that RC islands of the type examined in our study appear to be immune to D-linking effects. For example, Phillips (2006) used D-linked *wh*-phrases in his experiment, but found no evidence for the formation of a wh-dependency at a potential gap-site in a finite RC island.

To conclude, our findings challenge approaches that attribute island effects to the processing complexity induced by intervening material between the elements of a long-distance dependency. Complexity accounts, which attribute island effects to the effect of processing complexity of the online dependency formation process, need to explain why the same complexity does not affect the formation of cataphoric dependencies. Our finding is hardly expected from complexity-based accounts, which rely on general processing complexity considerations that should not be stipulated to apply only to wh-filler-gap dependencies.

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Notes

1. The unacceptability of the sentences is indicated by an asterisk, *.
2. For previous studies on island constraints, see Chomsky (1977, 1981, 1986, 1995, 2001), Huang (1982), Lasnik and Saito (1992), Rizzi (1990), Uriagereka (1999) among others.
3. Islands are mostly treated as structural constraints on non-transformational grammatical frameworks as well: In the lexical functional grammar (LFG) they are understood as constraints on C-structure (Kaplan & Bresnan, 1982) or on F-structure (Kaplan & Zaenen, 1989); in generalised phrase structure grammar (GPSG), islands are constraints on the configuration in which the [slash] feature appears.
4. In most theories, wh-filler-gap dependencies and pronoun-antecedent dependencies are treated differently.

See Chomsky (1977), Ross (1967) and Hornstein, Lasnik, and Uriagereka (2007) under transformational framework. For non-transformational frameworks, see Pollard and Sag (1994) for Head Driven Phrase Structure Grammar (HPSG) and Kaplan and Bresnan (1982) for Lexical Functional Grammar (LFG). Both reject the position that the binding relation is configurationally sensitive.

5. Similar extra-grammatical approaches to islands have been proposed, for example, by Levine and Hukari (2006) using the HPSG framework, and by Steedman and Baldridge (2011) using the combinatorial categorial grammar (CCG) framework.
6. As suggested by Kluender and Kutas (1993) the wh-element is retrieved from the memory at the gap position, and this retrieval process may incur additional costs. This may also hold true for cataphoric dependencies. When a pronoun is associated with its antecedent, the information carried by a pronoun (e.g., gender, number, person, animacy, case and so on) is to be retrieved, and such retrieval may incur additional costs.
7. The fact that cataphoric dependencies are formed actively is all the more notable, as a pronoun may have an intra-sentential antecedent and/or refer to an unspecified discourse referent (with wh-dependencies, on the other hand, a wh-phrase must have a gap within the same sentence).
8. The fact that the match condition is rated as significantly more acceptable than the mismatch condition within the nominative pair might be taken to suggest that a pronoun can find an antecedent in an island even if it c-commands the antecedent. However, the rating difference between these two conditions might simply reflect an increased willingness for participants to accept a gender-matched antecedent relative to a mismatched one, even though both conditions might be perceived as ungrammatical (recall that participants were required to evaluate a specific coreference relation between underlined words in the sentence). For present purposes, the important point is the overall acceptability of the genitive match condition (with ratings in the upper part of the scale) relative to the other three conditions (with ratings in the lower part of the scale).
9. Addition of random slopes did not affect the pattern of significance, and did not significantly improve model fit.
10. The trial order is generated based on the SBIN information in the output of Linger, which specifies the position of the item in the sequence seen by the subject. Results did not differ whether or not this variable was log transformed (CASE $\times$ GENDER $\times$ TRIAL ORDER ($t = -0.63$)). We have also examined the order effect based directly on the SBIN information. Results did not differ depending on whether or not the SBIN variable was log-transformed either (i.e., there was no interaction between SBIN (or log-SBIN) and the other factors (CASE and GENDER): CASE $\times$ GENDER $\times$ SBIN ($t = -0.71$); CASE $\times$ GENDER $\times$ LOG-SBIN ($t = -0.72$)).
11. A reviewer suggested that the current results might be explained in terms of relativised minimality (henceforth RM) (Rizzi, 1990). However, we do not consider this proposal here because, among other reasons, (1) RM does not offer a good treatment of strong island phenomena (see Boeckx, 2008; Nunes & Uriagereka, 2000; Stepanov, 2007 among others for related discussion) and (2) RM is intended to apply to configurations where the two elements of a dependency are in a c-command relation, which is not the case in our pronoun condition.
12. Note that some studies have shown that D-linking contributes to extra processing cost (see De Vincenzi 1996; Donkers, Hoeks, & Stowe, 2011; Kaan, Harris, Gibson, & Holcomb, 2000) rather than facilitating the process as argued by Hofmeister and Sag 2010.

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