Default is Different: Relations and Representations in Agreement Processing

Dustin A. Chacón^a

^aNeuroscience of Language Laboratory, NYU Abu Dhabi, Abu Dhabi, UAE

ARTICLE HISTORY

Compiled October 26, 2021

ABSTRACT

Theories of agreement processing typically focus on the mechanisms by which comprehenders relate the morphological features of the agreement-controlling NP and those of the verb. However, agreement is fundamentally a syntactic relation. In this paper, I examine the processing of default agreement with clausal subjects ('[CP That the doctors studied hard] was reassuring') vs. the processing of agreement with near-synonymous NPs ('[NP The fact that the doctors studied hard] was reassuring'). In the NP subject case there is a syntactic agreement dependency between the head noun *fact* and the verb *was*, but not in the CP case. I show that the agreement processing profile for CP subjects differs from those of NP subjects. This suggests that agreement configurations with similar morphology and semantics may be processed using different strategies when embedded in different syntactic structures.

KEYWORDS

psycholinguistics; syntax; sentence processing; agreement attraction; default agreement; cue-based retrieval

1. Introduction

Real-time sentence comprehension depends on rapid encoding and retrieval of linguistic material in memory. Examining the conditions under which these mechanisms misfire is informative for understanding the general memory architecture supporting sentence comprehension. One particularly well-studied case is the *agreement attraction effect*. This phenomenon is when an agreement error is affected by the presence of an *attractor*, a noun phrase (NP) that overlaps in features with head of agreement (i.e., verb), but is not grammatically accessible. For instance, in (1), the plural verb *are* is not licensed, because the subject is the singular NP *key*. Whereas this error is clear in (1-a), the error is less noticeable in (1-b) due to the attractor *cabinets*, which matches in number features with the verb *are*. This effect is robustly observed in both production (Bock & Miller, 1991; Brehm & Bock, 2013; Franck, Lassi, Frauenfelder, & Rizzi, 2006; Hartsuiker, Schriefers, Bock, & Kikstra, 2003; Staub, 2009; Vigliocco, Butterworth, & Garrett, 1996) and comprehension (Dillon, Mishler, Sloggett, & Phillips, 2013; Lago, Shalom, Sigman, Lau, & Phillips, 2015; Nicol, Forster, & Veres, 1997; Pearlmutter, Garnsey, & Bock, 1999; Tanner, Nicol, & Brehm, 2014; Tucker, Idrissi, & Almeida,

2015; Wagers, Lau, & Phillips, 2009). In production experiments, this is realized as an increased rate of ungrammatical verb forms for conditions with an attractor compared to those without. In comprehension experiments, agreement attraction is realized as an increase in acceptability ratings or a decrease in processing time for conditions with the attractor compared to those without.

- (1) a. *The [NP key_[-Pl] to the cabinet_[-Pl]] are_[+Pl] old
- b. ?The [NP key_[-Pl] to the cabinets_[+Pl]] are_[+Pl] old

One class of models of agreement processing attributes agreement attraction to inaccurate encoding of syntactic information in memory. Feature percolation models posit that the number feature encoded on the NP *cabinets* may overwrite the number feature of the NP headed by *key* by “percolating” up the syntactic structure, resulting in an erroneously licensed agreement relation (Franck et al., 2006; Vigliocco et al., 1996). However, there is little evidence from interpretation that the number feature of the head noun has been misrepresented in memory, i.e., comprehenders do not understand (1-a) as a sentence describing multiple keys (Patson & Husband, 2016; Schlueter, Parker, & Lau, 2019). The Marking and Morphing model, proposed by Eberhard, Cutting, and Bock (2005), similarly attributes agreement attraction to misencoding information in memory. Instead of positing that features traverse the syntactic structure, the Marking and Morphing model directly relates the morphological marking of the verb and the intended conceptual interpretation of the sentence. According to this model, NP number and message-level information about the meaning of the sentence asserts an early effect on the expected number value of the verb, which is then probabilistically and continuously modulated by other NPs. Evidence in support of this direct link between number marking and sentence meaning are “notional plurality” effects, in which the interpretation of the head noun affects the magnitude of the agreement attraction effect. For instance, *the signature on the cheques* triggers erroneous plural agreement more often than *the cage with the gorillas* in production, because *signature* is interpreted distributively, i.e., each cheque has its own signature, despite both NPs surfacing with the same syntax (Humphreys & Bock, 2005; Vigliocco et al., 1996). Other conceptual aspects of the message-level interpretation have been attested to affect the robustness of agreement attraction, which is compatible with this model (Brehm & Bock, 2017; Lorimor, 2007; Solomon & Pearlmutter, 2004).

A separate family of proposals attribute agreement attraction to similarity-based interference (Badecker & Kuminiak, 2007; Lewis & Vasishth, 2005; Wagers et al., 2009). These models depend on content-addressable, cue-based memory access mechanisms. On this view, encountering the verb *are* in (1-b) triggers a retrieval of a representation in memory that matches the features of verb, e.g., an NP that is a plural subject; [+Pl,+Subj]. Because *cabinets* partially matches on the [+Pl] feature, the comprehender may erroneously retrieve this noun instead of the target *key*, causing the perception that a grammatical dependency has been built (Wagers et al., 2009). These models have gained traction in part because cue-based retrieval architectures have been used to explain a variety of sentence processing phenomena (Lewis & Vasishth, 2005; McElree, 2006; McElree, Foraker, & Dyer, 2003).

Agreement is typically characterized as a core relation in syntactic theory (Chomsky 2000, 2001, among others). However, the role of the syntactic agreement relation itself is obscured in theories of agreement processing. It is reasonable to suppose that the syntactic relation itself is a causal factor for triggering the relevant processes. For instance, comprehenders may retrieve a feature-matching NP at the verb because the

analysis of the sentence up to this point contains an agreement dependency that must be satisfied in order to arrive at a well-formed analysis of the sentence. If agreement processes are conditional on the presence of a syntactic agreement relation, then agreement attraction should be weaker in constructions without it. In other words, if the features of the verb are not dependent on an NP, then the comprehender may not attempt to relate the features of the verb with those of any noun, thereby mitigating the chance of perceiving the verb as grammatical. Alternatively, the comprehender may attempt to link the morphological features of nouns and verbs regardless of whether there is a specific agreement dependency. For instance, processing a plural verb may trigger reactivation of plural nouns regardless of the syntactic context that the verb is embedded in. This might occur because processing a verb requires retrieving its arguments in order to assign it a semantic interpretation, and morphological cues are a useful heuristic for accessing these arguments. If so, then the details of the syntactic structure itself may not play a significant role in determining whether agreement attraction occurs. I suggest that existing theories as reviewed above are compatible with both possibilities. In part, this is because Western European languages like English normally exhibit obligatory subject-verb agreement in the vast majority of constructions (see Bhatia 2019 for discussion on this issue in Hindi-Urdu), making it difficult to distinguish these possibilities.

The role that features of the syntactic analysis plays on processing agreement has been considered in previous studies. However, non-syntactic factors have been identified as better or alternate explanations in many cases. For instance, it is observed that more deeply embedded attractor NPs exert a weaker effect on the verb than less deeply embedded attractors (Vigliocco et al., 1996). This effect of syntactic depth may be instead attributable to the semantic prominence of these arguments, or their “semantic integratedness”, rather than the depth of syntactic embedding *per se* (Solomon & Pearlmutter, 2004). Similarly, attractor NPs located in adjuncts exert a stronger effect on agreement processing than argument NPs (Van Dyke & McElree, 2011). However, this too may be better explained by differences in the status of the interpretation (Parker & An, 2018). Generally, apparent effects of structure may be incorporated by altering the quantitative parameters of the model, such as assigning different weights to NPs or to the retrieval cues themselves (e.g., Dillon et al. 2013) or by “factoring out” these features into the morphology and feature makeup, e.g., replacing [+Subj] feature for nominative or ergative case features (see Bhatia 2019). In this way, syntactic information may only be indirectly relevant to how the comprehension system checks features in an agreement relation, as opposed to the primary reason these processes are executed. It is worth noting that many of the prior studies examining the effects of syntactic structure on agreement processing specifically target the position of the attractor NP, and not the features of the agreement relation itself.

One finding that may suggest a key role of the agreement relation itself is the *grammatical asymmetry*, the finding that ungrammatical sentences are facilitated by attractors, but grammatical sentences are not hampered by them. That is, grammatical sentences like *the key to the cabinets is on the table* are rarely perceived to be unacceptable in judgment tasks or cause increases in reading times, indicating that the plural attractor *cabinets* does not interfere with the dependency between the singular subject *key* and the singular verb *is*. To explain this, Wagers et al. (2009) proposed that retrieval at the verb is an error-driven process that is only launched when the larger goal of building the agreement dependency is not met. Mechanistically, comprehenders initially predict the form of the verb on the basis of the features of the subject NP, since these elements participate in an agreement relation. When this prediction

is not met, the comprehender searches for a feature-matching NP in an attempt to find a licenser for the verb. Thus, the retrieval of the subject NP at the verb is contextually determined based on which grammatical principles the comprehender must satisfy, and retrieval occurs when the verb’s features had been previously identified as being dependent on those of a prior NP. However, Hammerly, Staub, and Dillon (2019) argue that these results are equally compatible with models that do not rely on error-driven retrieval once a yes-bias is adequately incorporated into the analysis (see also Staub 2009). If so, the grammatical asymmetry does not necessarily imply that processes supporting agreement are triggered for any specific reason, syntactic or otherwise.

To further examine this issue, I explore the case of agreement with clausal subjects. In English, NPs and verbs are morphologically marked for number. Clauses (complementizer phrases; CPs) may serve as arguments of a verb like NPs, although they do not bear number features. For instance, in (2-b), *that doctors studied long and hard* is the subject of the sentence. This is in contrast with the near-synonym¹ in (2-a), in which the subject of the clause is the singular NP headed by the *fact*.

- (2) a. [NP_[-PI] The **fact**_[-PI] [CP that doctors_[+PI] study]] **is**_[-PI] reassuring
 b. [CP That doctors_[+PI] study] **is**_[-PI] reassuring

The key contrast here is primarily a syntactic one. The morphological features of the verb *is* are identical, and the conceptual content of the subjects are nearly so. However, the nature of the agreement relation is different; the singular verb *is* in (2-b) is not licensed by an overt singular noun, and the CP does not head an agreement relation. Any difference in processing behavior is therefore likely attributable to the properties of the relation between the subject and the verb. I present on two experiments that explore whether acceptability judgments and reading times are affected by the number marking on inaccessible NPs in these constructions. The data do not conclusively demonstrate an absence of agreement attraction in sentences with CP subject as predicted if the presence of the agreement relation is critical for triggering the processes described above. However, agreement attraction is qualitatively more robust for sentences with NP subjects compared to CP subjects in Experiment 2, and there is an interaction between attractor number and verb number that for sentences with NP subjects that is not observed for sentences with CP subjects. This suggests that these qualitative differences in the representation of agreement affect the processing strategies.

2. Processing algorithms and structural representation

In this section, I briefly survey how syntactic and psycholinguistic theories may jointly characterize the relationship between a CP subject and its verb. It is not straightforward to deduce clear hypotheses about processing behavior given particular analyses of CP subject configurations, in part because processing theories were primarily focused on typical dependent-head agreement relations. My goal in this paper is to examine whether different syntactic structures that are semantically and morphologically similar may nonetheless exhibit different processing profiles due to the nature of the subject-verb relation. More exhaustively describing and testing the hypothesis space of processing and representational theories and how they interact must be left for future

¹For discussion on the differences in meanings, see Pietroski (2000) and Halpert and Schueler (2013).

research.

2.1. Representation of CP Subjects

In syntactic theory, CP subjects may be analyzed as true subjects of the clause that trigger a default agreement rule (Alsina & Vigo, 2017; McCloskey, 1991). Alternatively, CP subjects can be characterized as syntactically related to a null NP that is marked for the relevant features (Alrenga, 2005; Davies & Dubinsky, 2000; Kayne, 2010; Koster, 1978; Moulton, 2013), which may then directly control agreement. This NP may be a constituent with the CP, e.g., functioning as a silent noun like *fact*. Or, it may occur in the canonical argument position, while the CP appears in another position, e.g., as an adjunct. Thus, the following three representations are among the possibilities, with subscripting indicating which feature sets participate in an agreement relation:

- (3) a. [TP [CP That doctors ...] [VP is_[-PL] surprising]]
 b. [TP [NP $\emptyset$ <sub>[-PL]_i] [CP That doctors ...]] [VP is<sub>[-PL]_i surprising]
 c. [[CP That doctors ...] [TP [NP $\emptyset$ _{[-PL]_i] [VP is_[-PL]_i surprising]]]}</sub></sub>

The default agreement analyses can be characterized in at least two ways. First, in Agree-based theories in mainstream generative syntax (Chomsky, 2000, 2001), the Auxiliary node (T^0) may fail to probe a syntactically-available NP to control agreement. In this case, T^0 surfaces as a default form as a “Last Resort” under some conditions (Béjar 2003, see Preminger 2014). Alternatively, default agreement theories may not necessarily require a “failure” of an attempted agreement process. For instance, Alsina and Vigo (2017) propose a hybrid Optimality Theory (OT) and Lexical-Functional Grammar (LFG) analysis, in which different f(unctional)-structures compete. They propose a series of violable and ordered OT constraints that check whether the clause’s f-structure matches in features with the f-structure of a prominent argument. The rankings of the OT constraints produce the variability in agreement systems across the world’s languages. Default agreement is the emergence of a lower-ranked f-structure when no other NP argument is an eligible agreement controller, e.g., due to animacy, definiteness, or case, depending on the particular ordering of rankings in the language. On approaches like this, default agreement does not necessarily imply the failure of an agreement operation, i.e., the verb does not need to attempt to agree with an NP “first” before tolerating default features.

Approaches that postulate a null NP element are motivated by several linguistic considerations. First, many of the world’s languages directly nominalize clausal arguments, i.e., CPs transparently surface inside of an NP when they function as an argument to a verb. Many other languages associate clausal arguments with a pleonastic NP that surfaces in the prototypical argument position (Abrusán, 2011; Kallulli, 2006; Kastner, 2015; Kornfilt, 1985). Languages like English, in which CP arguments do not have obvious nominal properties, may therefore also be analyzed as associating argument CPs with null NPs. Secondly, the homophony between complementizers and demonstratives (e.g., *that* in English) has been taken as evidence that these constructions may be analyzed similarly (Kayne, 2010). Finally, concerns of adequately characterizing the compositional semantics of CP arguments and the similarities between CP arguments and relative clauses have motivated a connection between CP arguments and nominal expressions (Moulton, 2013, 2020).

For the purposes of this paper, I assume that comprehenders represent canonical

subject-verb agreement as an explicit formal identity relation between the feature sets of the subject NP and the verb, as in unification-based theories of grammar (Bresnan, Asudeh, Toivonen, & Wechsler, 2016; Pollard & Sag, 1994). For CP subject case, the features of the verb are not dependent on those of a previous NP's, null or otherwise. I will continue to use $[-Pl]$ and $[+Pl]$ as shorthand for a more detailed agreement feature set.

(4) a. **Subject NP-Verb Agreement:**

b. **Default Agreement:**

2.2. Syntactic relations in agreement processing

Theories of agreement processing must involve some mechanism to check whether the morphosyntactic features of the head lexical item of the agreement controller and the verb match. However, whether these mechanisms are deployed every time a verb is encountered or whether they are conditionally deployed is largely underspecified, as discussed earlier. As stated above, cue-based retrieval models (Badecker & Kuminiak, 2007; Lewis & Vasishth, 2005; Wagers et al., 2009) can be designed such that processing a verb involves accessing an NP in short-term memory that is indexed with the same morphosyntactic features, e.g., processing a $[+Pl]$ verb requires retrieving a $[+Pl]$ NP, regardless of its syntactic context. If so, there is no apparent reason for CP subjects and NP subjects to exhibit different processing profiles, since the 3rd singular verb *is* in (3) has the same morphological feature specification, and because retrieval is hypothesized to be insensitive to the syntactic features of the subject.

If, for typical subject-verb agreement, these processes are executed because the comprehender had previously identified the construction as one in which the verb's morphological features must match those of a previous NP's, then it is less obvious that CP subjects should exhibit the same processing profile as NP subjects. This is

because sentences containing CP subject constructions do not exhibit the property of requiring a match between the features of the verb and the subject’s head lexical item. I refer to models that incorporate mechanisms for relating morphosyntactic features as **morphologically-conditioned** models, and models that condition these mechanisms on the basis of satisfying specific syntactic relations **syntactically-conditioned** models.

Although the distinction between morphologically-conditioned and syntactically-conditioned models is clear for cue-based retrieval theories, a similar contrast could be formulated for continuous-evaluation theories. For instance, in the Marking and Morphing model (Eberhard et al., 2005), the comprehension system does not store number features for specific nouns, but rather represents a continuously evaluated number value (“singular-and-plural”, SAP) until encountering the verb. A straightforward morphologically-conditioned implementation of this model projects an SAP value for the verb in all sentences. A syntactically-conditioned implementation might posit that comprehenders do not represent a SAP value for the verb upon detecting that the sentence is a CP-subject construction, as CPs do not bear number features. In other words, a SAP value is only projected after the comprehender has identified the sentence as containing an NP-verb agreement relation.

In this paper, I aim to test whether a distinction needs to be drawn between CP subject and NP subject agreement configurations. If so, theories of agreement processing must accommodate a means of distinguishing the kind of syntactic structures that the agreement dependency is embedded in, as in the syntactically-conditioned models I described. If no difference is found between NP and CP subject-verb configurations, then this suggests that morphologically-conditioned models are sufficient. In the next two sections, I discuss in more detail how these syntactically-conditioned models might work depending on the representations assumed for CP subject sentences. However, this is not an exhaustive exploration of the hypothesis space, and adjustment of other parameters of the theory may make divergent predictions.

2.3. *Retrieval Theories*

As discussed above, cue-based retrieval theories hold that upon encountering the verb in subject NP-verb agreement configurations, the comprehension system retrieves from short-term memory a representation of an NP that licenses the features of the verb. The cues for this retrieval are the morphosyntactic features that are encoded on the verb, plus potentially other features, such as syntactic position (e.g., [+Subj]), or semantic features (Schlueter, Williams, & Lau, 2018). This retrieval may be error-driven, i.e., the comprehension system only attempts to retrieve the agreement controller when an initial prediction of the features of the verb are not met (Wagers et al., 2009).

In the NP-subject agreement configurations, there is likely an initial stage of encoding the expected features of the verb. While the subject NP is processed, (e.g., *the fact*), its morphosyntactic features must be encoded and stored in short-term memory, and an expectation for the feature set of the verb is also encoded. On a syntactically-conditioned implementation, the comprehender also represents that there is an explicit dependency of the verb’s feature on those of the noun, i.e., these features must be shared. The partial structural built at this point on the syntactically-conditioned analysis is shown in (5), with predicted material in grayscale.

Error-driven cue-based retrieval, Syntactically-conditioned:

- A. $[_{TP} [_{NP} \text{The fact}_{[-Pl]} [_{CP} \text{that doctors}_{[+Pl]} \text{study ...}]] \dots \text{are}_{[+Pl]} \dots$ (misretrieval of attractor: attraction effect)
- B. $[_{TP} [_{NP} \emptyset_{[-Pl]} [_{CP} \text{That doctors}_{[+Pl]} \text{study ...}]] \dots \text{are}_{[+Pl]} \dots$ (misretrieval of attractor: attraction effect)
- C. $[_{TP} \dots [_{CP} \text{That doctors}_{[+Pl]} \text{study ...}]] \dots \text{are}_{[+Pl]} \dots$ (processing difficulty; mismatch in expectation)

Error-driven cue-based retrieval, Morphologically-conditioned:

- D. $[_{TP} [_{NP} \text{The fact}_{[-Pl]} [_{CP} \text{that doctors}_{[+Pl]} \text{study ...}]] \dots \text{are}_{[+Pl]} \dots$ (misretrieval of attractor: attraction effect)
- E. $[_{TP} [_{NP} \emptyset_{[-Pl]} [_{CP} \text{That doctors}_{[+Pl]} \text{study ...}]] \dots \text{are}_{[+Pl]} \dots$ (misretrieval of attractor: attraction effect)
- F. $[_{TP} \dots [_{CP} \text{That doctors}_{[+Pl]} \text{study ...}]] \dots \text{are}_{[+Pl]} \dots$ (misretrieval of attractor: attraction effect)

Figure 1. Illustration of retrieval profiles for sentences with NP and CP subjects and unlicensed plural verbs for the family of cue-based retrieval models.

(5)

If an unexpected verb form that mismatches in expected features is encountered, then retrieval occurs. For NP-subject cases, agreement attraction is predicted if there is a plural attractor NP as depicted in Figure 1A and 1D, although in the syntactically-conditioned case this occurs in order to satisfy the grammatical requirement that the verb's features are shared with those of an NP. In other words, retrieval occurs because the syntactic context requires that the verb's features are shared with those of the subject NP, and the risk of agreement attraction occurs because the wrong NP may be misidentified as the licenser. On a morphologically-conditioned implementation, agreement attraction occurs because processing the unexpected verb triggers a search for a feature-matching NP without necessarily being conditioned by a specific syntactic requirement.

For the CP-verb agreement configurations analyzed here, the mechanisms play out differently. First, comprehenders must detect that they are processing a sentence with a CP subject, i.e., they must identify that the subject of the sentence is not headed by any particular noun in the input sentence. This then impacts how the comprehender fixes a prediction of the upcoming verb form. Upon detecting the subject’s category, they must fix an expectation for a 3rd person singular verb. This may either be due to a default agreement rule that applies in this circumstance, or it may be mediated by projecting a null NP that is marked for 3rd person singular. Assuming a default agreement analysis, the syntactically-conditioned parsing strategy would build a partial representation of the sentence up to this point like the one in (6), with predicted material in grayscale. Importantly, on a syntactically-conditioned analysis, this representation has no formal requirement that the verb’s features are shared with those of any NP in the previous sentence.

(6)

Upon encountering the unexpected verb form, the morphologically-conditioned analysis predicts that comprehenders should attempt to retrieve a plural NP, regardless of the subject phrase’s structure, shown in Figures 1E and 1F. On a syntactically-conditioned analysis, the content of the subject phrase matters. If comprehenders represent a null NP that serves as the target of agreement, then agreement processing may proceed similarly to the situations with overt NP subjects, and therefore be subject to the same pattern of agreement attraction as with overt NPs (see Section 6.2; Kim, Brehm, and Yoshida 2019), sketched in Figure 1B. However, if CP subjects trigger a default agreement rule as in (6), then the structure built up to this point does not require that the verb shares its features with any NP. Thus, upon detecting an unexpected plural verb, either no retrieval is attempted, or retrieving a plural NP would not serve to satisfy any particular syntactic requirement, as the comprehender was not attempting to a relation between the verb’s features and those of any NP’s. This is illustrated in Figure 1C.

Up to this point, I have only discussed retrievals cued by number features, represented as $[\pm\text{Pl}]$. However, number agreement in English is likely mediated by other features, which may yield differences between NP and CP subject configurations without resorting to the kind of syntactically-conditioned model that I propose. Here, I suggest that two plausible features that may facilitate agreement processing – a local subject feature $[\pm\text{Subject}]$ and a categorial feature $[\pm\text{N}]$ – do not make the same prediction as a syntactically-conditioned model.

First, I consider a feature $[\text{+Subject}]$. This feature indexes the local subject of a verb, to distinguish agreement controlling subjects from embedded subjects. If both NP and CP subjects are assumed to carry this feature, and only NPs are marked with a number feature, then the feature specifications are as in (7):

- (7) a. $[\text{NP Subject}_{[-\text{Pl}, +\text{Subject}]} [\text{NP Attractor}_{[+\text{Pl}]}]] \text{Verb}_{[+\text{Pl}, +\text{Subject}]}$

- b. [CP Subject_[+Subject] [NP Attractor_[+Pl]]] Verb_[+Pl, +Subject]

Given this analysis, the verb does not match in features with its local subject, because neither the subject NP or CP carries the [+Pl] feature. The key difference here is that the CP subject is unmarked for $[\pm\text{Pl}]$, but the NP subject is explicitly marked for a different feature specification. Another analysis that is frequently assumed (e.g., Wagers et al. 2009) is that plural marking in English is a privative feature, i.e., plural NPs are marked with a unary feature [Pl] and singular NPs lack this feature altogether. If so, then there is no apparent difference in the feature specification between NP and CP subjects, as neither is specified for [Pl]. However, if number in English is represented as a binary contrast between [+Pl] and $[-\text{Pl}]$, then the verb mismatches with a specified feature in the NP case but not in the CP case in (7). To my knowledge, the distinction between a retrieval cue failing to match with the target vs. mismatching with the target is not well understood. On a study of Russian gender agreement attraction Slioussar and Malko (2016) compared agreement attraction with masculine, feminine, and neuter gender verbs, targets, and attractors. Interestingly, they found that, in comprehension, attraction was strongest for feminine attractors than masculine or neuter attractors. Asymmetrical patterns such as this have been argued to indicative a privative feature. However, because the grammar of Russian draws a distinction between masculine and neuter, it is insufficient to postulate a privative [Fem] feature to capture the entire gender system. Put differently, if neuter gender is represented as an unmarked feature in Russian, then masculine gender must be explicitly marked, and the agreement attraction profile in Russian does not distinguish between a mismatch in feature specification and the absence of a feature on the target. If neuter and masculine gender are represented explicitly as gender features like the feminine gender, then asymmetrical attraction profiles are not necessarily indicative of a privative feature, since no gender in Russian is privative. Thus, drawing a distinction between NP and CP subjects on this grounds seems unmotivated.

Similarly, agreement processing may also be mediated by a $[\pm\text{N}]$ feature, representing the syntactic category of the agreement controller. If so, then the feature specification is as in (8). If cue-based retrieval is affected by the number of competing partial matches, their relative activation levels, and the number of matching and mismatchin features, as in the ACT-R implementation (Lewis & Vasishth, 2005), then agreement attraction may still be predicted to be stronger for CP subjects compared to NP subjects. For instance, in (8-b), the verb matches in one feature with both the target and the attractor, whereas in (8-a), it matches in two features with the target and only one with the attractor.

- (8) a. [NP Subject_[+N, -Pl, +Subject] [NP Attractor_[+N, +Pl]]] Verb_[+N, +Pl, +Subject]
 b. [CP Subject_[+Subject] [NP Attractor_[+N, +Pl]]] Verb_[+Pl, +Subject]

These considerations notwithstanding, it is possible that there are other feature specifications that may mimic the predictions of a syntactically-conditioned model or yield other differences between NP and CP subjects. I did not consider, for instance, features corresponding to the semantics of NP vs. CP subjects, nor other syntactic features, such as nominative case. However, I leave articulating, defending, and modeling these feature choices to future work.

Continuous evaluation models, Syntactically-conditioned:

Continuous evaluation models, Morphologically-conditioned:

Figure 2. Illustration of retrieval profiles for sentences with NP and CP subjects and unlicensed plural verbs for the family of continuous evaluation models.

2.4. Continuous Evaluation Theories

In contrast to cue-based retrieval theories, continuous evaluation theories highlight processes that occur before the verb is encountered. However, for the purposes of this paper, the possible hypotheses outlined above can be more or less translated into continuous evaluation models without much change. For NP subject cases, comprehenders access and encode the lexical features of the subject NP, while also projecting the number features of the upcoming verb. As other nouns are processed, their features are also accessed, which may then interfere with the encoded representation of the upcoming verb number value. The new number features may be bound to the “wrong” NP, as in feature-percolation models (Franck et al., 2006; Vigliocco et al., 1996), or they may affect the expected predicted form of the verb directly (Eberhard et al., 2005). Upon encountering an unlicensed verb form (e.g., *are*), the expectation for the grammatical verb form has been reduced, resulting in less processing difficulty at the unlicensed verb than without the attractor. These processes make the same prediction whether the comprehender is also explicitly encoding a formal dependency between the features of the verb and the subject NP, as in the syntactically-conditioned conditions with a structure as in (5) or not. This is sketched in Figures 2A and 2D.

For CP subject configurations, the predictions diverge depending on the processing strategy and representation. Again, if comprehenders actively maintain the number information of the subject phrase in anticipation of the verb regardless of the syntactic contact, then agreement attraction is predicted across the board, as in Figures 2D–2F. Syntactically-conditioned implementations may make different predictions. If CP subjects are associated with a null NP that controls agreement, then comprehenders must build this NP shortly after identifying the category of the subject. Afterwards, the

processes unfold similarly to the NP subject case, with no obvious difference in predictions from typical agreement cases, sketched in Figures 2B and 2E. On a default agreement analysis, there is no need to build an explicit relation between the features of an NP and the verb, since CP subjects do not carry morphological number information, yielding a structure like in (6). Thus, there is no motivation to attend to number information of any NPs until encountering the verb, and there is no target node for an attractor’s [+Pl] feature to percolate to. This is sketched in Figure 2C.

In summary, if the goal of agreement processing is to build a syntactic relation between the features of two phrases, then processing behavior may be different in configurations where the relations are different, as is the case for CP vs. NP subjects. Alternatively, if the comprehension system executes a routine to match verb features with an NP regardless of the properties of the larger syntactic structure, then there is no obvious difference in prediction between NP and CP subject configurations. The possibility of a null NP analysis of CP subjects complicates this hypothesis space, and I turn to the issue of null NPs in Section 6.2.

In this paper, I report on two experiments comparing agreement attraction with NP and CP subjects. In Experiment 1, I show that agreement attraction is detectable for sentences containing NP subjects, but fail to find a significant effect of agreement attraction for CP subjects. In Experiment 2, I show that the number features on an attractor NP exert less effect on the processing of the main verb when embedded in a CP subject compared to an NP subject. Taken together, these results suggest that agreement attraction is more detectable for sentences with NP subjects compared to sentences with CP subjects. Whether this is because the effect is completely absent in CP subjects, as predicted by syntactically-conditioned strategies, or whether it is merely a weaker effect cannot be determined by these data. Additionally, in Experiment 2, a secondary agreement attraction effect is encountered that is inconsistent with the grammatical asymmetry generalization, i.e., an attractor causes slower reading times for a grammatical dependency but not for ungrammatical dependencies. I attribute the difference to the semantic salience of the head noun (e.g., *fact*) used in the stimuli.

3. Experiment 1: Speeded Acceptability Judgment Task

3.1. *Rationale*

The goal of Experiment 1 was to determine whether the effect of an attractor NP varied as a function of the syntactic category of the subject phrase. If comprehenders deploy a syntactically-conditioned agreement processing strategy and CP subjects are represented as triggering default agreement, i.e., there is no explicit relationship between the feature-set of the verb and any particular lexical item in the subject phrase, then agreement attraction is predicted to be weaker or absent. Otherwise, no difference in agreement attraction is predicted.

3.2. *Participants*

Ninety-nine participants were recruited for Experiment 1 from Prolific. Participants were required to be located in the USA and self-identify as a monolingual English speaker.

3.3. Materials

For Experiment 1, there were 32 sets of items distributed in a $2 \times 2 \times 2$ design. The crucial manipulations were Subject Type {NP, CP}, Verb Number {SG, PL}, and Attractor Number {SG, PL}. The stimuli are exemplified in (9), and the full set is given in the appendix.

- (9) a. **NP Subject; SG Attractor, SG Verb**
 [NP The fact_[-PI] [CP that the environmentalist_[-PI] protested while getting sunburnt]] was_[-PI] actually really amusing to the oil mogul.
- b. **NP Subject; SG Attractor, PL Verb**
 [NP The fact_[-PI] [CP that the environmentalist_[-PI] protested while getting sunburnt]] were_[+PI] actually really amusing to the oil mogul.
- c. **NP Subject; PL Attractor, SG Verb**
 [NP The fact_[-PI] [CP that the environmentalists_[+PI] protested while getting sunburnt]] was_[-PI] actually really amusing to the oil mogul.
- d. **NP Subject; PL Attractor, PL Verb**
 [NP The fact_[-PI] [CP that the environmentalists_[+PI] protested while getting sunburnt]] were_[+PI] actually really amusing to the oil mogul.
- e. **CP Subject; SG Attractor, SG Verb**
 [CP That the environmentalist_[-PI] protested while getting sunburnt]] was_[-PI] actually really amusing to the oil mogul.
- f. **CP Subject; SG Attractor, PL Verb**
 [CP That the environmentalist_[-PI] protested while getting sunburnt]] were_[+PI] actually really amusing to the oil mogul.
- g. **CP Subject; PL Attractor, SG Verb**
 [CP That the environmentalists_[+PI] protested while getting sunburnt]] was_[-PI] actually really amusing to the oil mogul.
- h. **CP Subject; PL Attractor, PL Verb**
 [CP That the environmentalists_[+PI] protested while getting sunburnt]] were_[+PI] actually really amusing to the oil mogul.

In the NP Subject sentences, sentences contained an NP subject that was headed by a singular noun and a clausal complement, such as *claim*, *rumor*, and *report*. In the CP Subject equivalents, the determiner and noun were excluded, and the subject only consisted of the clause. In both NP and CP Subject sentences, the verb must be singular in order to be grammatical. This is because in the NP Subject cases the head noun is marked singular, and because in the CP Subject cases singular verb agreement is the default form required by the structure of the sentence. In all target items, the subject NP embedded in the main clause subject (*the environmentlist(s)*) was either singular or plural. In the critical conditions, this NP served as the attractor. The verb in the embedded clause (*protested*) was always marked in the past tense. The past tense was chosen because it is formally identical in the singular and plural in English, and thus did not vary across conditions. After the embedded verb, there was a three-word long spillover region (*while getting sunburnt*), which did not include any referential NPs. The spillover region was included to ensure that the processing of the embedded subject NP and the main verb were separable in the self-paced reading experiment (Experiment 2). After this spillover region, the main clause verb was either singular *was* or plural *were*. After this, there were six or seven words of spillover region (*actually really amusing to the oil mogul*).

An additional 30 filler sentences were included, which contained both singular and

plural verbs and sentences with both NP and CP subjects. The filler sentences were approximately matched for length and complexity, and 12 of these filler items were ungrammatical. The ungrammatical sentences had various kinds of errors, including agreement errors.

The PL Verb Number conditions are predicted to be accepted less frequently, because plural verbs are not licensed in any of the target items. The research question is whether the PL Attractor Number increases the acceptance rates for the PL Verb Number in comparison to the SG Attractor Number. If so, this is an indication of agreement attraction. Specifically, I predicted that the improvement associated with the plural attractor will be observable in sentences with NP Subjects, but will be diminished or absent in sentences with CP Subjects.

4. Methods

Participants accessed the experiment through the Prolific platform. After reading and agreeing to the consent form, they clicked a link to the experiment hosted on IbexFarm (Drummond, 2018). Participants were told that they would see sentences automatically displayed on a screen word-by-word, and that they would be asked to decide whether this sentence was acceptable. An “acceptable” sentence was defined as one that a native speaker would use. After the instructions, participants were exposed to practice trials to acclimate them to the task. The practice trials consisted of five clearly grammatical and five clearly ungrammatical sentences. The experiment began after the practice trials. Sentences were displayed using a rapid serial visual presentation (RSVP) design, in which the sentence unfolded word-by-word, with each word displayed for 500ms each in the center of the screen. Each sentence was preceded with a fixation cross and followed by a period, both of which were displayed for 500 ms. After the sentence ended, participants made their judgment by using the mouse or keyboard. Upon completing the study, participants were provided with a code to enter into Prolific to receive compensation. Participants were compensated 30 AED or its GBP equivalent (≈ 6.20 GBP), and in total the experiment took approximately 10–20 minutes.

4.1. Results

For analysis of the fillers, I constructed a logit mixed effects model using the `glmer` function in the `lme4` package in R (Bates, Maechler Martin, & Walker, 2016; R Core Team, 2017). This model included a fixed effect for condition (Good Filler, Bad Filler), with random effects by participant. As expected, good fillers were rated significantly higher than bad fillers ($\beta = 2.9$, $SE = 0.11$, $z = 26.0$, $p < 0.001$). Good fillers were accepted 85.6% ($SE = 0.9\%$) of the time, and bad fillers accepted 26.4% ($SE = 0.3\%$) of the time.

For analysis of the target items, 48 subjects’ data for 3 conditions (NP Subject, SG Verb, SG Attractor; NP Subject, PL Verb, SG Attractor; NP Subject, PL Verb, PL Attractor) in one item and 3 conditions (NP Subject, SG Verb, PL Attractor; NP Subject, PL Verb, SG Attractor; NP Subject, PL Verb, PL Attractor) in another were removed due to a typographical error in the stimuli. Afterwards, I constructed a mixed-effects model with a “maximal” structure in the sense of Barr, Levy, Scheepers, and Tily (2013), which included response as dependent variable, fixed effects and their interaction terms for Subject Type, Verb Number, and Attractor Number, and random slopes and random intercepts for Subject Type, Verb Number, Attractor Number and

Figure 3. Interaction plot of the rates of acceptance by condition in Experiment 1. Error bars correspond to one standard error above and below the mean.

their interaction terms by participant and random effects by item. This model had a singular fit, likely due to the small number of observations per cell per participant. I removed random slopes until reaching a model that had a non-singular fit. Although this results in a less conservative model, previous pilot versions of these studies demonstrated that participants identified the goal of the experiment with larger number of stimuli, necessitating a smaller number of target items. This resulting model kept random intercepts by participant and random effects by Subject Type by participant. The factors were sum coded with CP Subject, PL Attractor, and PL Verb coded as 1, and NP Subject, SG Attractor, and SG Verb coded as -1 . The p -values were estimated using lmerTest package (Kuznetsova, Brockhoff, & Christensen, 2016). Afterwards, pairwise comparisons were conducted between the two levels of Attractor Number within each combination of the levels of Subject Type and Verb Number. This was done to see whether the presence of the plural attractor increased rate of acceptance compared to the singular attractors. For pairwise comparisons, p -values were corrected with Bonferroni correction. The mean acceptance rates by condition in Experiment 1 are graphed in Figure 3. The results of the mixed effects model are given in Table 1.

The research question that Experiment 1 addressed was whether a plural attractor would improve acceptance rates for ungrammatical plural verbs, and whether this effect was different for sentences with NP subjects vs. CP subjects. The strongest evidence in favor of this hypothesis would be a three-way interaction between the factors Subject Type, Verb Number, and Attractor Number. However, no interaction term was significant ($ps > 0.05$). This may be in part because the experimental design used a small number of observations per cell per participant, meaning that there may not have been enough data to reveal significant interactions.

In pairwise comparisons, effect of Attractor Number was observed in PL Verb for both sentences with CP and NP subjects. The acceptance rates for NP Subject, PL

	β	SE	z	p
(Intercept)	0.73	0.14	5.2	< 0.01
Subject Type	-0.36	0.08	-4.6	< 0.01
Verb Num.	-1.32	0.05	-24.0	< 0.01
Attractor Num.	0.13	0.05	2.7	< 0.01
Subject Type $\times$ Verb Num.	0.02	0.05	0.43	0.67
Subject Type $\times$ Attractor Num.	0.01	0.05	0.14	0.89
Verb Number $\times$ Attractor Num.	0.08	0.05	1.56	0.12
Subject Type $\times$ Verb Num. $\times$ Attractor Num.	-0.02	0.05	-0.35	0.73

Table 1. Results of logit mixed-effects model for Experiment 1. The structure of the model was: Answer $\sim$ Subject Type * Verb Number * Attractor Number + (1 + Subject Type | Participant) + (1 | Item). P -values below 0.05 are in bold.

Verb, PL Attractor were significantly higher than NP Subject, PL Verb, SG Attractor ($\beta = 0.44$, $SE = 0.16$, $z = 2.69$, $p < 0.01$), and the acceptance rates for CP Subject, PL Verb, PL Attractor were significantly higher than CP Subject, PL Verb, SG Attractor ($\beta = 0.40$, $SE = 0.18$, $z = 2.26$, $p = 0.02$). These pairwise comparisons suggest an attraction effect regardless of the syntactic category of the subject, as the plural attractor increased acceptance rates for ungrammatical sentences compared to equivalent sentences without the plural attractor. The pairwise comparisons were not significant for the SG Verb comparisons for either level in Subject Type ($ps > 0.05$). This is consistent with the grammatical asymmetry generalization, i.e., there is no effect of attractor on the grammatical sentences.

The results from Experiment 1 are ultimately inconclusive with regard to the hypothesis that agreement attraction is reliably more robust with NP subjects compared to CP subjects. If both CPs and NPs were subject to agreement attraction, then a Attractor Number $\times$ Verb Number interaction was predicted, and if the effect was selective to NP subjects, then a three-way interaction was predicted. There were no significant interactions between Subject Type, Verb Number, or Attractor Number in the mixed effects model analysis. However, the pairwise comparisons suggested an effect of attractor number on ratings for ungrammatical verbs for both categories of subject. Thus, these findings must be taken as preliminary.

4.2. Discussion

The goal of Experiment 1 was to compare the agreement attraction profile for sentences with NP subjects vs. those with CP subjects. If comprehenders are only susceptible to agreement attraction if they had explicitly encoded an agreement relation, then it was predicted that there should be less evidence of agreement attraction for CP subjects compared to NP subjects. Regardless, it was predicted that there would be clear evidence for agreement attraction with NP subjects. However, there were no significant interactions in the mixed effects model fit to the entire dataset for either NP or CP subjects indicative of attraction. The lack of interaction effects may in part be due to the complex trial structure and the small number of observations per cell per participant. However, the *post-hoc* pairwise comparisons were consistent with attraction effects for both subject categories.

In part, the lack of clear effect may also have been due to the acceptability judgment paradigm. This paradigm does not directly probe for the time course of processing, but rather the overall assessment of the acceptability of the sentence after the parse

has been completed. In Experiment 2, I examine the real-time profile of agreement processing in sentences with NP Subjects and CP Subjects using the self-paced reading paradigm. This allows for directly measuring the processing time after the verb across conditions.

5. Experiment 2: Self-Paced Reading Task Comparing Subject NPs and Subject CPs

5.1. *Rationale*

The goal of Experiment 2 was to probe whether sentences with NP subjects and CP subjects were susceptible to agreement attraction, by measuring the processing times at the verb directly. Specifically, as in Experiment 1, the goal of Experiment 2 was to test the hypothesis that agreement attraction is more robust for sentences with NP subjects compared to sentences with CP subjects, as predicted by syntactically-conditioned agreement processing strategies. In Experiment 1, the results failed to conclusively demonstrate whether the profile of agreement attraction differed between sentences with NP and CP subjects. *Post-hoc* analyses suggested an attraction effect for both subject types, but the main statistical analysis did not show evidence of agreement attraction for either subject category. This may in part be due to the complexity of the trial structure and the small number of observations per participant per condition, or it may have been due to the nature of the task in Experiment 1, in which the dependent measure was the acceptability judgment registered after the sentence was processed. In Experiment 2, I used the self-paced reading paradigm, which directly probes for the processing times at and after the verb. This may more clearly reveal the effect that the attractor NP has on the processing dynamics.

5.2. *Participants*

One hundred and twenty-eight participants were recruited for Experiment 2 from Prolific. As in Experiment 1, participants were required to be located in the USA and self-identify as native English speakers. Nine participants were removed due to low accuracy on the comprehension questions ($< 75\%$), and were replaced by new participants in the same list as one of the removed participants.

5.3. *Methods*

After accessing the experiment on Prolific, participants read and agreed to the consent form. Afterwards, they were directed to the experiment hosted on IbexFarm (Drummond, 2018). They were given instructions on the task, and then read through five practice sentences to become accustomed to the task, a self-paced reading paradigm (Just, Carpenter, & Woolley, 1982). The experiment began after the practice trials. Each sentence was initially displayed as a series of dashes, with spaces and punctuation marks intact. When the participant pressed the space bar, the first set of dashes was replaced by the first word. After pressing the space bar again, the first word was replaced with dashes and the second word was revealed. In this way, participants progressed through the sentence word-by-word. They were not able to go backwards in the sentence, and were therefore instructed to read carefully but at a natural pace. After each sentence, participants read and responded to a yes/no comprehension question. The

responses were given using the mouse or the keyboard. The time spent on each word and the comprehension questions were recorded in the browser, and then uploaded to the server at the end of the experiment. Upon completing the study, participants were provided a code to enter into Prolific for compensation. They were compensated 30 AED or its GBP equivalent (≈ 6.20 GBP) for their time, approximately 20 minutes.

5.4. Materials

The target stimuli were the same as in Experiment 1. A different set of filler items were prepared for Experiment 2. Since participants were not explicitly asked to rate the acceptability of sentences, I included no additional ungrammatical sentences apart from those in the target stimuli. There were 32 filler sentences, which contained both singular and plural verbs and sentences with both NP and CP subjects. The filler sentences were approximately matched for length and complexity.

5.5. Results

After removing the six participants with low comprehension accuracy, the mean accuracy on comprehension questions was 93.1%. All incorrect trials were removed from the analysis. Reading times were then visually inspected. Because there was a significant amount of variability in reading times and substantial right skew, I removed extreme reading time values and computed the residual reading times for analysis. First, all reading times that were above 5000ms and below 100ms were removed. Then, all reading times that were more than 3 standard deviations from the mean reading time per condition, item set, and region were removed. In total, after removing trials with incorrect responses and extreme values, 12.4% of the observations were excluded. Then, the reading times were converted to their natural log. This ensured that the reading times were more normally distributed. Then, the residual log reading times were computed using a linear model, with the log reading times as dependent measure, and with word length, log position of the sentence in the list, and restricted cubic spline of the word position in the sentence as factors and with random effects by participant, as suggested by Jaeger (2008). This was done in part because the target regions were not in the same linear position in the sentences, i.e., the verb and subsequent spillover regions were two words later in the NP Subject sentences compared to their counterparts in the CP Subject sentences, and because the ungrammatical and grammatical verbs were different lexical items (*were* vs. *was*). Afterwards, the residuals were z-scored, to scale them to values with larger magnitudes for ease of reporting and visualization. The mean scaled residual log reading times by region and condition are plotted in Figure 4.

For analysis, three linear mixed effects models were fit to the scaled residual log reading times at the verb, the first spillover region after the verb (*actually*), and the second spillover region after the verb (*a*). The models included Verb Number, Attractor Number, and Subject Type and their interaction terms as factors, and with random slopes for Verb Number, Attractor Number, Subject Type, and their interactions by participant, and with random effects by item. Random effects and intercepts by participant were not included, since this variance was already accounted for in the initial regression stage. These models had a singular fit, so I removed random slopes until reaching a converging, non-singular fit. Each model’s final structure is identified in the table of results. The factors were sum coded, with CP Subject, PL Attractor, and PL

Figure 4. Above: Mean scaled residual log reading times by region and by condition. Below: Interaction plots of the mean scaled residual log reading times by condition in the three target regions of interest, the verb and the subsequent two spillover regions. Error bars represent one standard error above and below the mean in both plots.

Verb coded as 1, and NP Subject, SG Attractor, and SG Verb coded as -1 . Afterwards, as in Experiment 1, planned pairwise comparisons were conducted between the two levels of Attractor Number within each combination of the levels of Subject Type and Verb Number. For the pairwise comparisons, Bonferroni correction was applied.

Verb. The results of the mixed effects model fit to the data in the verb region are given in Table 2. There was a divergence in reading times between the NP Subject and CP Subject sentences, which may reflect a difference of the subject-predicate configuration or word position in the sentence. No other main effect or interaction was significant in this model. In the pairwise comparisons, there were no significant differences between SG Attractor and PL Attractor level within each combination of Subject Type $\times$ Attractor Number (all $ps > 0.20$).

First Spillover Region. The results of the mixed effects model fit to the reading time

	β	SE	t	p
(Intercept)	0.11	0.035	3.16	< 0.01
Subject Type	-0.073	0.015	-4.97	< 0.01
Verb Num.	0.023	0.015	1.58	0.11
Attractor Num.	0.018	0.015	-1.22	0.22
Subject Type $\times$ Verb Num.	-0.019	0.015	-1.35	0.18
Subject Type $\times$ Attractor Num.	-0.011	0.015	-0.80	0.42
Verb Number $\times$ Attractor Num.	0.007	0.015	-0.50	0.62
Subject Type $\times$ Verb Num. $\times$ Attractor Num.	-0.005	0.015	0.37	0.71

Table 2. Results of mixed-effects model for Experiment 2 in the verb region. The structure of the model was: Scaled Residual Log Reading Time $\sim$ Subject Type * Verb Type * Attractor Type + (1 | Item). P -values less than 0.05 are in bold.

	β	SE	t	p
(Intercept)	-0.037	0.032	-1.14	0.26
Subject Type	-0.10	0.014	-7.37	< 0.01
Verb Num.	0.19	0.019	6.36	< 0.01
Attractor Num.	-0.01	0.014	-0.71	0.48
Subject Type $\times$ Verb Num.	0.016	0.014	1.11	0.27
Subject Type $\times$ Attractor Num.	-0.003	0.014	-0.22	0.83
Verb Number $\times$ Attractor Num.	0.047	0.014	-3.32	< 0.01
Subject Type $\times$ Verb Num. $\times$ Attractor Num.	0.009	0.014	0.65	0.51

Table 3. Results of mixed-effects model for Experiment 2 in the first spillover region. The structure of the model was: Scaled Residual Log Reading Time $\sim$ Subject Type * Verb Type * Attractor Type + (0 + Verb Number | Participant) + (1 | Item). P -values less than 0.05 are in bold.

data in the first spillover region are given in Table 3. First, there was a divergence in the reading times in this region between the NP Subject and CP Subject sentences, similar to the prior verb region. As expected, ungrammatical plural verbs were read more slowly than their grammatical singular equivalents, likely reflecting overall sensitivity to the ungrammaticality of the plural verb. There was an interaction between Verb Number and Attractor Number, demonstrating the presence of agreement attraction effect in this region. Pairwise comparisons revealed that plural attractors reduced reading times for plural verbs with NP subjects ($\beta = -0.13$, $SE = 0.06$, $z = -2.23$, $p = 0.03$). This difference was marginal for CP Subjects ($\beta = -0.10$, $SE = 0.06$, $z = -1.79$, $p = 0.07$). This demonstrates a reliable agreement attraction effect for sentences with NP Subjects, and may suggest a similar effect for sentences with CP subjects, although this result is not significant. Additionally, there was a marginal effect on SG Verbs in the NP Subject level, such that PL Attractors increased reading times compared to SG Attractors ($\beta = 0.10$, $SE = 0.06$, $z = 1.75$, $p = 0.08$). Interestingly, this suggests an attraction effect for grammatical verbs inconsistent with the grammatical asymmetry generalization (Hammerly et al., 2019; Wagers et al., 2009). This was not detected for sentences with CP subjects ($\beta = 0.05$, $SE = 0.06$, $z = 0.87$, $p = 0.39$).

Second Spillover Region. The results of the mixed effects model fit to the reading time data in the second spillover region are given in Table 4. As before, there were significant effects of Verb Number and Subject Type, likely reflecting sensitivity to the grammaticality of the verb and the construction type, respectively. The critical three-way interaction between Subject Type, Verb Number, and Attractor Number was not significant. However, there were marginal interactions of Subject Type and Verb Number, and Subject Type $\times$ Attractor Number ($ps < 0.10$). These results may

	β	SE	t	p
(Intercept)	-0.009	0.03	-0.31	0.76
Subject Type	-0.10	0.014	-7.27	<0.01
Verb Num.	0.076	0.014	5.41	<0.01
Attractor Num.	0.017	0.014	-1.17	0.24
Subject Type $\times$ Verb Num.	0.017	0.014	1.25	0.21
Subject Type $\times$ Attractor Num.	-0.024	0.014	-1.71	0.09
Verb Number $\times$ Attractor Num.	-0.025	0.014	-1.81	0.07
Subject Type $\times$ Verb Num. $\times$ Attractor Num.	0.022	0.014	1.56	0.12

Table 4. Results of mixed-effects model for Experiment 2 in the second spillover region. The structure of the model was: Scaled Residual Log Reading Time $\sim$ Subject Type * Verb Type * Attractor Type + (1| Item). P -values less than 0.05 are in bold.

suggest an attraction effect in this region, as well as a differential effect of Subject Type on this attraction effect, as observed in the previous region.

5.6. Discussion

In Experiment 1, I explored whether agreement attraction was detectable in acceptability judgments for sentences with NP and CP subjects. The results were inconclusive, and the otherwise well-replicated agreement attraction effect with NP subjects was not detected. However, the results suggested an effect of attractor number for sentences with NP subjects and CP subjects. If this result is reliable, then this implies that the kind of agreement relation that the verb participates in does not directly impact the mechanisms deployed to process it. However, due to the inconclusive results and the low temporal resolution of the acceptability judgment paradigm, it is difficult to draw strong inferences about processing behavior from these results. In Experiment 2, I probed the processing dynamics at and after the verb directly using a task that is sensitive to processing time.

Experiment 2 was a self-paced reading task that was designed to more directly test the effect of the attractor NP on the processing of the verb and subsequent regions. In this task, reading times increased for ungrammatical plural verbs compared to grammatical singular verbs, as expected. Secondly, there was a surprising main effect of Subject Type, e.g., the critical regions of analysis had faster reading times for sentences with CP Subjects vs. sentences with NP Subjects, potentially reflecting different strategies involved in processing sentences with CP Subjects vs. NP Subjects generally.

Most relevant to the current hypothesis, the attractor NP exerted an effect on processing times in the subsequent two spillover regions. In the first spillover region, a typical agreement attraction effect, i.e., a facilitation effect of an NP on an ungrammatical plural verb, was detectable for sentences with NP subjects. The reading times trended towards a similar pattern for sentences with CP subjects, although this was not significant. Additionally, there was a marginal effect of an unexpected attraction profile, in which the plural attractor NP interfered with the processing of the grammatical singular verb with NP subjects, inconsistent with the grammatical asymmetry generalization. In the second spillover region, the typical agreement attraction effect was not as detectable with statistical significance. However, this unexpected “reverse” attraction profile hindering grammatical SG verbs paired with NP subjects specifically persisted and was detectable in the second spillover region. Thus, the presence of an

attractor appears to have a differential effect on sentences with NP subjects compared to sentences with CP subjects, consistent with the hypothesis that the processing strategies deployed for different agreement dependencies are different.

6. General Discussion

The goal of the two experiments presented here was to determine whether the psycholinguistic mechanisms deployed in processing verb number a subject-verb agreement relation are sensitive to the syntactic properties of the relation. This question is interesting because dominant models of agreement processing characterize agreement as a matching operation between the morphological features of the noun and the verb. However, agreement is a fundamental component of the syntactic analysis of the sentence. It is reasonable to suppose that the processes studied in the agreement processing literature are only launched when the comprehender is processing a specific syntactic relation, i.e., constructions in which verbs do not participate in an agreement relation do not trigger the same processes. If so, I proposed that sentences with NP subjects should be more susceptible to agreement attraction compared to sentences with CP subjects, assuming that CP subjects do not participate in an agreement relation. In Experiment 1, there was no clear evidence in support of this hypothesis. In Experiment 2, there was no three-way interaction effect between the attractor number, verb number, and subject category that would have suggested a robust difference between the agreement attraction effect on sentences with NP and CP subjects. However, in *post hoc* comparisons, the effect was more robust for sentences with NP subjects compared to sentences with CP subjects. Additionally, sentences with NP subjects displayed an unusual attraction profile, in which inaccessible plural NPs slowed reading times for grammatically licensed singular verbs with NP subjects. Neither of these effects were significant for sentences with CP subjects even in pairwise comparisons.

6.1. Limitations

The two experiments presented here have a number of limitations that must be acknowledged. First, due to the nature of agreement with clausal subjects in English, it was not possible to test sentences with grammatical plural verbs with CP subjects. This means that the design was required to have a confound between verb number and grammaticality, i.e., plural verbs were always ungrammatical and singular verbs were always grammatical. This confound is not present in most studies on agreement attraction. A more complex design may mitigate this issue. For instance, sentences with conjoined CP subjects can trigger singular or plural verb agreement, depending on the semantic relation between the two CPs. McCloskey (1991) observed that plural agreement with coordinated CPs is possible when the eventualities described by both CPs are distinct situations, (10-a), compared to coordinated CPs that describe potentially compatible eventualities, (10-b).

- (10) a. That the president will be re-elected and that he will be impeached are/?is equally likely at this point.
- b. That UNO will be elected and that sanctions will be lifted ?are/is now likely.

This property of English subject-verb agreement may allow for a more complex design that allows for testing the effect of verb number separately from the grammaticality of the sentence by leveraging aspects of the semantics of the two CPs. However, such a more complex design is likely to introduce other confounds that may affect the processing at the verb, and to my knowledge these judgments have not yet been experimentally investigated.

Another confound in the design of both experiments is that the NP Subject conditions are momentarily ambiguous between a relativization interpretation and the intended clausal complement interpretation (e.g., *The fact that the lawyers debated ...*). If comprehenders considered a relativization analysis, then they would need to resolve the filler-gap dependency between the subject noun and its gap position later in the embedded clause. In processing filler-gap dependencies, comprehenders attempt to discharge the dependency at possible gap positions, and reading times increase when a gap is not available (Fodor, 1978; Stowe, 1986; Traxler & Pickering, 1996). Pursuing a relativization analysis would result in failure to complete the filler-gap dependency at various points in the embedded CP. This may trigger participants to be particularly sensitive to other errors in these conditions, inflating the sensitivity to grammaticality errors in the NP Subject condition compared to the CP Subject condition. If so, this predicts that there should be increased reading times for the NP Subject sentences compared to the CP Subject sentences prior to the main verb. Although there were no analyses conducted on the regions before the main verb, visual inspection of the reading times is not consistent with this interpretation. If anything, reading times were inflated for the CP Subject conditions compared to the NP Subject conditions prior to the verb. Thus, it is not obvious that participants are overwhelmingly pursuing a relativization analysis in the NP Subject conditions, thereby resulting in a heightened sensitivity to grammatical errors. This may be because participants detected that many of the sentences in the experiment use the complement clause structure, and thus ranked this parse higher than the relativization analysis. Alternatively, participants may not have pursued a relativization analysis because the subject nouns in the NP Subject conditions were sufficiently biased towards the complement clause analysis. Importantly, recent evidence has suggested that comprehenders pursue a complement clause analysis over a relative clause analysis (Staub, Foppolo, Donati, & Cecchetto, 2018), mitigating this concern.

Finally, another important limitation of this study is the small number of observations per condition per participant. In previous versions of these studies, participants demonstrated that they noticed the pattern of agreement and subject category manipulation very clearly, raising concerns as to whether they used a natural processing strategy. To minimize this risk, I opted for a smaller number of stimuli and a greater number of participants. The disadvantage of this decision was that linear mixed effects models could not have a maximal random slope structure. Additionally, it meant that the lack of robust agreement attraction findings with CP subjects may reflect lower statistical power in the reported experiments, rather than a true absence of agreement attraction. Of course, the lack of robust evidence of agreement attraction with CP Subjects reported here must be taken cautiously, as any null result.

6.2. Representation of CP arguments

In theoretical syntax and semantics, there are different approaches to the representation of clausal arguments. Some analyses posit that clausal subjects correspond

to some (null) NP in the syntactic representation. Either the CP is embedded in a subject NP, or another NP is coindexed with the clausal subject. These analyses are popular, because they capture shared features between NP subjects and CP subjects and unify the semantic analysis of nominal complementation, and because they do not necessitate a special “last resort” default agreement rule.

From a sentence processing perspective, it is unclear whether these alternative approaches make significantly different predictions about the mechanisms involved in relating the subject and the verb’s number features. As I suggested in Section 2, if CP subjects are represented simply as CPs and the verb surfaces as a default form due to a special rule, then comprehenders must deploy top-down syntactic knowledge to select the default singular verb form, irrespective of any particular NP in the sentence. This processing strategy may therefore be less susceptible to the features of NPs in the sentence.

However, if CP arguments are associated with a null NP that controls agreement, then this prediction is less straightforward depending on how null NPs are processed and represented. As I suggested in Section 2, the most straightforward hypothesis is to suppose that null NPs interact with memory retrieval and encoding processes in a way completely parallel to overt NPs. There is no obvious reason why the phonetic matrix of an NP should have an effect on its status in memory once its encoded in short-term memory. Thus, insofar as the evidence presented in Experiment 2 demonstrates a difference between sentences with NP and CP subjects, it is tempting to conclude that CP subjects are not associated with a null NP, and instead must rely on an indirect relation such as a default agreement rule.

In a study examining NP ellipsis contexts, Kim et al. (2019) found evidence for agreement attraction with null content inside ellipsis sites, e.g., ratings were higher for *Derek’s key_[-PI] to the boxes_[+PI] must be on the table*, and *Mary’s [e] possibly are_[+PI] on the carpet* compared to *Derek’s key_[-PI] to the box_[-PI] must be on the table*, and *Mary’s [e] possibly are_[-PI] on the carpet*. They argued that comprehenders reaccess the syntactic structure of the ellipsis site ([e]) prior to the verb, which may cause agreement attraction if the ellipsis site contains an null correlate of the feature-matching NP (*boxes*). Thus, they concluded, null elements are capable of interfering with agreement processing.

However, there are two key differences between the findings from Kim et al. (2019) and mine. The first difference is that in my studies the null NP is the target of the agreement process, whereas the null NP is the attractor in the study by Kim et al. (2019). Secondly, the content of the null elements is different. In processing the NP-ellipsis configurations in the study by Kim et al. (2019), the comprehender retrieves the antecedent of the ellipsis site and assigns it a syntactic and semantic interpretation, which then feeds agreement processing. In other words, interpreting the ellipsis site may also affect the “notional plurality” of the sentence (Humphreys & Bock, 2005). Generally speaking, the content in the ellipsis site is semantically rich and resolution of the ellipsis is critical for identifying the meaning of the sentence. By contrast, the null NPs that are posited to correspond to CP arguments do not have any additional conceptual semantic content, regarding plurality or otherwise. This null NP is poor in conceptual content, and retrieving it has little affect on factors such as notional plurality. Because ellipsis resolution requires reaccessing syntactic material with rich conceptual content, it is feasible that its impact on agreement processes are significantly greater than a hypothetical retrieval of a null NP that serves to facilitate the integration of a different phrase into the sentence. For this reason, it is possible that representing and retrieving a null NP with minimal conceptual semantic content pro-

duces a processing profile similar to the one observed in Experiment 2. If so, then the results reported in Experiment 2 do not favor a default agreement analysis over a null NP analysis.

6.3. *Pattern of Results in Experiments 1 and 2*

The results of Experiments 1 and 2 showed a trend for typical agreement attraction with sentences with NP subjects, i.e., the ungrammatical plural verb was facilitated in the presence of an inaccessible plural attractor NP. However, in Experiment 2, there was also an unexpected effect of the inaccessible plural NP slowing the processing time of the grammatical singular verb. Differences in results in Experiments 1 and 2 may have been due to the differing experimental tasks. The filler items were different in Experiments 1 and 2, with ungrammatical fillers only being present in Experiment 1. Similarly, Experiment 1 required participants to consider the well-formedness of sentences explicitly, and participants were not notified that there would be ungrammatical sentences in Experiment 2. Thus, in Experiment 1, participants may have been more attuned to the well-formedness of the sentences, which may then result in an increased likelihood to accept a sentence with an agreement attraction configuration as grammatical, even if they were not.

However, it is unclear whether this is sufficient for explaining the pattern of results in Experiment 2, particularly the surprising intrusion on grammatical verbs. I suggest that this effect may be related to the conceptual semantic content of the head nouns (*fact*, *rumor*, *claim*, etc.). Previous findings have demonstrated that lexical features of the attractor and head noun are relevant for agreement processing (Brehm & Bock, 2017; Lorimor, 2007). In Experiment 2, the head nouns in the NP conditions are relatively devoid of conceptual semantic content, e.g., *the fact* [_{CP} *that* ...] and [_{CP} *that* ...] are roughly synonymous, referring to similar eventualities or propositions as their CP counterparts. Thus, it is possible that the head noun in these complement clause configurations may not be a strong “anchor” for the grammatical dependency. By contrast, the attractor noun (e.g., *doctors*) is more conceptually salient. The identity of the agent of the event described by the subject phrase is more likely to affect the conceptual representation built while reading the sentence and affect the response on the comprehension question than is the relatively content-less subject head noun. Thus, this may lead to an unusually higher activation level of the attractor NP, and an unusually lower activation for the head subject noun, which may favor for intrusion of the attractor NP. If this is correct, then this predicts that other “semantically content-less” agreement controllers in other contexts should also yield evidence of inhibitory agreement attraction. It also remains to be seen how this proposed explanation can adequately address the more typical pattern of results from Experiment 1, and whether this pattern can be robustly shown in acceptability judgments in other constructions.

6.4. *Other non-agreement configurations*

Default agreement with CP subjects, however represented, is one instance of a much larger class of default agreement phenomena, which occur in a wide variety of languages and configurations. The analyses sketched in this paper make similar predictions for CP subjects as other default agreement phenomena, as long as the form of the verb is not licensed by any specific NP in the sentence, but rather the syntactic configuration that it is embedded in. Ongoing work examines whether verb forms that are not

licensed by a preceding noun are similarly susceptible to agreement attraction effects like CP subject-agreement or not in English and in other languages with atypical and default agreement configurations.

One case is locative inversion in English, in which a prepositional phrase (PP) occupies the canonical pre-verbal subject position, and the agreement-controlling subject NP appears post-verbally. In these configurations, the verb agrees with the post-verbal subject in Standard American English, as in (11). In this configuration, there is a grammatical dependency between the verb form and the later subject NP, but there is no explicit agreement relation between the verb and the pre-verbal content. If comprehenders deploy a syntactically-conditioned agreement processing strategy, then agreement attraction is predicted to be largely absent with ungrammatical verbs, such as *are* in sentences like (11). This is because comprehenders should be able to identify that the first phrase is a PP, and therefore the main verb must match in features with a subsequent NP, not a previous NP. Thus, there should be no attempt to relate the features of the verb to the features of any prior NP in the sentence. By contrast, if comprehenders pursue a morphologically-conditioned processing strategy, then the plural verb may exhibit faster reading times in the presence of the plural NP *tents*, regardless of whether this verb form is licensed by a later NP or not.

- (11) Under the tents unsurprisingly is/*are a clown

7. Conclusion

Models of agreement processing privilege morphological and semantic features of the head noun and the verb, although agreement is standardly treated as a syntactic dependency. In this paper, I hypothesized that abstract features of the agreement relation may be relevant for determining the psycholinguistic mechanisms deployed in relating the subject phrase and verb. Specifically, I tested whether sentences with CPs subjects are less amenable to agreement attraction compared to sentences with NP subjects. I hypothesized that this may be the case because there is no agreement dependency between the feature-sets of the head lexical items of the subject CP and predicate VP in English, as there is in typical NP-verb agreement configurations. Although the results were not entirely conclusive, they suggest that the effect is more robust for sentences with NP subjects compared to sentences with CP subjects. This demonstrates that verbs with the same morphology in sentences with similar semantic content may be processed differently depending on the sentence’s formal syntactic characteristics, which must be accounted for in existing models of agreement processing. How fine-grained contextual information about the syntactic structure can be encoded in dominant models of agreement processing remains to be spelled out.

Acknowledgements

I would like to thank Lauren Ackerman, Claire Halpert, Cassandra Jacobs, Maayan Keshev, Alec Marantz, Jason Overfelt, Liina Pykkänen, Brian Reese, and the NeLLab for comments and feedback. I would also like to thank Annika Kohrt, Austin Kraft, Peter O’Neill and Trey Sorensen for assistance in running participants and providing feedback on earlier versions of the studies reported here.

Disclosure statement

The author has no conflict of interests to disclose.

Funding

This research was funded by grant number G1001 from the NYUAD Research Institute.

References

- Abrusán, M. (2011). Predicting the presuppositions of soft triggers. *Linguistics and Philosophy*, 34, 491–535.
- Alrenga, P. (2005). A sentential subject asymmetry in english and its implications for complement selection. *Syntax*, 8, 175–207.
- Alsina, A., & Vigo, E. M. (2017). Agreement: Interactions with case and raising. In M. Butt & T. H. King (Eds.), *Proceedings of the lfg'17 conference*. Stanford, CA: CSLI Publications.
- Badecker, W., & Kuminiak, F. (2007). Morphology, agreement and working memory retrieval in sentence production: Evidence from gender and case in Slovak. *Journal of Memory and Language*, 56(1), 65–85.
- Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language*, 68.
- Bates, D., Maechler Martin, & Walker, S. (2016). *Package 'lme4'*. Retrieved from <https://cran.r-project.org/web/packages/lme4/lme4.pdf>
- Bhatia, S. (2019). *Computing agreement in a mixed system* (Unpublished doctoral dissertation). University of Massachusetts.
- Bock, K., & Miller, C. A. (1991). Broken agreement. *Cognitive Psychology*, 23(1), 45–93.
- Brehm, L., & Bock, K. (2013). What counts in grammatical number agreement? *Cognition*, 128(2), 149–169.
- Brehm, L., & Bock, K. (2017). Referential and lexical forces in number agreement. *Language, Cognition and Neuroscience*, 32(2), 129–146.
- Bresnan, J., Asudeh, A., Toivonen, I., & Wechsler, S. (2016). *Lexical functional syntax*. Oxford: Wiley blackwell.
- Béjar, S. (2003). *Phi-syntax: A theory of agreement* (Unpublished doctoral dissertation). University of Toronto.
- Chomsky, N. (2000). Minimalist inquiries: The framework. In R. Martin, D. Michaels, & J. Uriagereka (Eds.), *Step-by-step: Essays on minimalist syntax in honor of howard lasnik* (pp. 89–155). Cambridge, MA: MIT Press.
- Chomsky, N. (2001). Derivation by phase. In M. Kenstowicz (Ed.), *Ken hale: A life in language* (pp. 1–52). Cambridge, MA: MIT Press.
- Davies, W. D., & Dubinsky, S. (2000). *Why sentential subjects do so exist (but are nonetheless kinda weird)*. (Southeastern Conference on Linguistics)
- Dillon, B., Mishler, A., Sloggett, S., & Phillips, C. (2013). Contrasting intrusion profiles for agreement and anaphora: Experimental and modeling evidence. *Journal of Memory and Language*, 69(2), 85–103.
- Drummond, A. (2018). *Ibexfarm*. Retrieved from www.spellout.net/ibexfarm
- Eberhard, K. M., Cutting, J. C., & Bock, K. (2005). Making syntax of sense: Number agreement in sentence production. *Psychological Review*, 112(3), 531–559.

- Fodor, J. D. (1978). Parsing Strategies and Constraints on Transformations. *Linguistic Inquiry*, 9(3), 427–473.
- Franck, J., Lassi, G., Frauenfelder, U. H., & Rizzi, L. (2006). Agreement and movement: A syntactic analysis of attraction. *Cognition*, 101(1), 173–216.
- Halpert, C., & Schueler, D. (2013). That sentential subjects are (linked to) dps is explained herein. *Snippets*, 28, 9–10.
- Hammerly, C., Staub, A., & Dillon, B. (2019). Cognitive psychology. *Cognitive Psychology*, 110, 70–104.
- Hartsuiker, R. J., Schriefers, H. J., Bock, K., & Kikstra, G. M. (2003). Morphophonological influences on the construction of subject-verb agreement. *Memory and Cognition*, 31(8), 1316–1326.
- Humphreys, K., & Bock, K. (2005). Notional number agreement in English. *Psychonomic Bulletin & Review*, 12(4), 689–695.
- Jaeger, F. (2008). *Modeling self-paced reading data: Effects of word length, word position, spill-over, etc.* (Blog post published at <https://hlplab.wordpress.com/2008/01/23/modeling-self-paced-reading-data-effects-of-word-length-word-position-spill-over-etc/>)
- Just, M. A., Carpenter, P. A., & Woolley, J. D. (1982). Paradigms and Processes in Reading Comprehension. *Journal of Experimental Psychology: General*, 111(2), 228–238.
- Kallulli, D. (2006). Triggering factivity: Prosodic evidence for syntactic structure. In D. Baumer, D. Montero, & M. Scanlon (Eds.), *The proceedings of the twenty-fifth west coast conference on formal linguistics* (pp. 211–219). Somerville, MA: Cascadilla Proceedings Project.
- Kastner, I. (2015). Factivity mirrors interpretation: The selectional requirements of presuppositional verbs. *Lingua*, 164, 156–188.
- Kayne, R. (2010). *Comparisons and contrasts*. New York: Oxford University Press.
- Kim, N., Brehm, L., & Yoshida, M. (2019). The online processing of noun phrase ellipsis and mechanisms of antecedent retrieval. *Language, Cognition, and Neuroscience*, 34(2), 190–213.
- Kornfilt, J. (1985). *Case marking, agreement, and empty categories in Turkish* (Unpublished doctoral dissertation). Harvard University.
- Koster, J. (1978). Why subject sentences don't exist. In S. Keyser (Ed.), *Recent transformational studies in european languages* (pp. 53–64). Cambridge, MA: Cambridge University Press.
- Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2016). *lmerTest: Tests in linear mixed effects models*. Retrieved from <https://cran.r-project.org/package=lmerTest>
- Lago, S., Shalom, D. E., Sigman, M., Lau, E. F., & Phillips, C. (2015). Agreement attraction in Spanish comprehension. *Journal of Memory and Language*, 82, 133–149. Retrieved from <http://dx.doi.org/10.1016/j.jml.2015.02.002>
- Lewis, R. L., & Vasishth, S. (2005). An activation-based model of sentence processing as skilled memory retrieval. *Cognitive Science*, 29(3), 375–419.
- Lorimor, H. (2007). *Conjunctions and grammatical agreement: When wholes differ from the sum of their parts* (Unpublished doctoral dissertation). University of Illinois at Urbana-Champaign.
- McCloskey, J. (1991). There, it, and agreement. *Linguistic Inquiry*, 22(3), 563–567.
- McElree, B. (2006). Accessing Recent Events. *Psychology of Learning and Motivation - Advances in Research and Theory*, 46(06), 155–200.
- McElree, B., Foraker, S., & Dyer, L. (2003). Memory structures that subserve sentence comprehension. *Journal of Memory and Language*, 48, 67–91.
- Moulton, K. (2013). Not moving clauses: Connectivity in clausal arguments. *Syntax*, 16(3), 250–291.
- Moulton, K. (2020). *Remarks on propositional nominalization*. Oxford: Oxford University Press.
- Nicol, J., Forster, K., & Veres, C. (1997). Subject – Verb Agreement Processes in Compre-

- hension. *Journal of Memory and Language*, 587(36), 569–587.
- Parker, D., & An, A. (2018). Not all phrases are equally attractive: Experimental evidence for selective agreement attraction effects. *Frontiers in Psychology*, 9, 1566.
- Patson, N. D., & Husband, E. M. (2016). Misinterpretations in agreement and agreement attraction. *Quarterly Journal of Experimental Psychology*, 69(5), 950–971.
- Pearlmutter, N. J., Garnsey, S. M., & Bock, K. (1999). Agreement Processes in Sentence Comprehension. *Journal of Memory and Language*, 41(3), 427–456.
- Pietroski, P. (2000). On explaining that. *Journal of Philosophy*, 97, 655–662.
- Pollard, C., & Sag, I. A. (1994). *Head-driven phrase structure grammar*. Chicago, IL: Chicago University Press.
- Preminger, O. (2014). *Agreement and its failures*. Cambridge, MA: MIT Press.
- R Core Team. (2017). *R: A Language and Environment for Statistical Computing* (Vol. 0). Retrieved from <http://www.r-project.org/>
- Schlueter, Z., Parker, D., & Lau, E. (2019). Error-driven retrieval in agreement attraction rarely leads to misinterpretation. *Frontiers in Psychology*, 10(1002).
- Schlueter, Z., Williams, A., & Lau, E. (2018). Exploring the abstractness of number retrieval cues in the computation of subject-verb agreement in comprehension. *Journal of Memory and Language*, 99, 74–89.
- Slioussar, N., & Malko, A. (2016). Gender agreement attraction in russian: Production and comprehension evidence. *Frontiers in Psychology*, 7.
- Solomon, E. S., & Pearlmutter, N. J. (2004). Semantic integration and syntactic planning in language production. *Cognitive Psychology*, 49(1), 1–46.
- Staub, A. (2009). On the interpretation of the number attraction effect: Response time evidence. *Journal of Memory and Language*, 60(2), 308–327.
- Staub, A., Foppolo, F., Donati, C., & Cecchetto, C. (2018). Relative clause avoidance: Evidence for a structural parsing principle. *Journal of Memory and Language*, 98, 26–44.
- Stowe, L. (1986). Parsing WH-Constructions: evidence for on-line gap location. *Language and Cognitive Processes*, 1(3), 227–245.
- Tanner, D., Nicol, J., & Brehm, L. (2014). The time-course of feature interference in agreement comprehension: Multiple mechanisms and asymmetrical attraction. *Journal of Memory and Language*, 76, 195–215.
- Traxler, M. J., & Pickering, M. J. (1996). Plausibility and the Processing of Unbounded Dependencies: An Eye-Tracking Study. *Journal of Memory and Language*, 35(3), 454–475.
- Tucker, M. A., Idrissi, A., & Almeida, D. (2015). Representing number in the real-time processing of agreement: Self-paced reading evidence from Arabic. *Frontiers in Psychology*, 6(MAR), 1–21.
- Van Dyke, J., & McElree, B. (2011). Cue-dependent interference in comprehension. *Journal of Memory and Language*, 65, 247–263.
- Vigliocco, G., Butterworth, B., & Garrett, M. F. (1996). Subject-verb agreement in Spanish and English: Differences in the role of conceptual constraints. *Cognition*, 61(3), 261–298.
- Wagers, M. W., Lau, E. F., & Phillips, C. (2009). Agreement attraction in comprehension: Representations and processes. *Journal of Memory and Language*, 61(2), 206–237.

Appendix A. Target Items for Experiments 1 & 2

- (1) (The realization) that the doctor(s) studied long and hard was/were a major relief to the nervous patients.
- (2) (The story) that the zookeeper(s) closed too early yesterday was/were an annoying thing to the elderly visitors
- (3) (The reminder) that the janitor(s) cleaned up almost everything was/were a nice

- relief for the event organizers.
- (4) (The report) that the scientist(s) published over and over was very good news for the granting agency.
 - (5) (The fact) that the musician(s) sang beautifully and passionately was/were so extremely impressive for the excited audience.
 - (6) (The rumor) that the philosopher(s) argued loudly and unceasingly was/were a terrible annoyance to their wives.
 - (7) (The report) that the anglers fished until early dawn was/were an encouraging sign for the meat markets.
 - (8) (The belief) that the occultist(s) meditated outside at midnight was/were a good omen for the mystical order.
 - (9) (The story) that the adventurer(s) traveled far and wide was/were exhilarating and thrilling for the young movie-goer.
 - (10) (The decision) that the tourist(s) rested after much traveling was/were a good idea by the travel agency.
 - (11) (The rumor) that the environmentalist(s) protested while getting sunburnt was/were actually very amusing to the oil mogul.
 - (12) (The realization) that the ballerina(s) practiced day and night was/were a sincere inspiration to the little girl.
 - (13) (The discovery) that the student(s) reviewed daily before class was/were a true delight to the tired professor.
 - (14) (The revelation) that the cop(s) patrolled basically until dawn was/were a shock to their concerned spouses.
 - (15) (The thought) that the clown(s) laughed colorfully and boisterously was/were actually deeply unnerving to the meek child.
 - (16) (The fact) that the athlete(s) worked out almost daily was/were obviously very impressive to the excited spectator.
 - (17) (The revelation) that the priest(s) prayed fervently and passionately was/were not very interesting to the critical atheist.
 - (18) (The discovery) that the inventor(s) worked Saturday and Sunday was a bit worrisome to the concerned clients.
 - (19) (The observation) that the musician(s) played loudly and excited was/were really exciting to everyone in the audience.
 - (20) (The observation) that the student(s) snored loudly and obnoxiously was/were extremely annoying to the aggravated kindergarten teacher.
 - (21) (The fact) that the linguist(s) spoke with total confidence was/were enough to fool all the conference attendees.
 - (22) (The news) that the archaeologist(s) dug just about everywhere was/were a bit troubling to the park preservationists.
 - (23) (The realization) that the engineer(s) broke just about everything was/were upsetting to the astronauts on their team.
 - (24) (The news) that the politician debated on and on was/were starting to get exhausting for almost everyone else.
 - (25) (The fact) that the baker(s) prepared the entire morning was/were considered very notable by the food critic.
 - (26) (The finding) that the virus(es) spread erratically and slowly was/were highly intriguing to the biology graduate student.
 - (27) (The finding) that the cloud(s) drifted to and fro was/were fascinating to the young budding amateur meteorologist.
 - (28) (The realization) (The realization) that the neuroscientist(s) knew not an iota

- was/were enough to make the patient absolutely terrified.
- (29) (The fact) that the jogger(s) stretched for thirty minutes was/were absolutely critical for the brand new world records.
- (30) (The news) that the author(s) write passionately and eloquently was/were noted at the very prestigious literary awards ceremony.
- (31) (The fact) that the kid(s) played until almost night was/were why everyone was late in the morning.
- (32) (The news) that the activist(s) demonstrated all day long was/were barely noticed by the corrupt corporate executives.