

Transitivity and non-uniform subjecthood in agreement attraction

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Abstract

Research on human language converges on a view in which a grammatical “subject” is the most saliently encoded entity in mental representation. However, subjecthood is not a syntactically uniform phenomenon. Notably, many languages encode morphological distinctions between subjects of transitive verbs (i.e., verbs which require an object) and subjects of intransitive verbs. We ask how this typological pattern manifests in a language like English (which does *not* morphologically signal it) by examining the “distinctiveness” of transitive versus intransitive subjects in memory during online sentence processing. We conducted a self-paced reading experiment which tested for “attraction” effects (Dillon et al., 2013; Wagers et al., 2009) in the processing of subject-verb number agreement. We find that *transitive* subjects trigger attraction effects, but that these effects are mitigated for *intransitive* subject attractors (independently of the number of other noun phrases present in the intervening clause). We interpret this as indicating that transitive subjects are less distinctive and therefore less representationally salient than intransitive subjects: This is because a transitive subject must compete with another clause-mate *core* argument (i.e., a direct object), which draws on resources from the same pool of memory resources. On the other hand, an intransitive subject minimally only competes with a *non-core* argument (i.e., an oblique noun phrase); this consumes fewer memory resources, leaving the subject to enjoy greater spoils.

Keywords: subjecthood, transitivity, distinctiveness, attraction effects, filler-gap dependencies

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Introduction

One of the most ubiquitous concepts in the study of natural language is the notion of the “subject” of a sentence. Subjecthood is widely discussed across several sub-domains of linguistic research, including formal and functional syntax, sentence processing, sentence production, and cross-linguistic typology. This body of literature converges on an empirically-grounded generalization in which the subject is the most salient and prominent noun phrase in a sentence. Semantically, subjects are usually a thematic agent, initiator, or experiencer of an event; for example, in the sentence “The coach trains the athlete”, we understand the subject as being the “the coach”, which is the agent of the training event. In languages such as English, subjects typically exhibit a set of core structural and morphological properties (Aldridge, 2004; Dixon, 1979; Ershova, 2023; Keenan, 1976; McCloskey, 1997; Tolan & Heller, 2022, among many others). As recently discussed at length by Tolan & Heller (2022: 161), a subject is usually the noun phrase (NP) that triggers verb agreement (e.g., as in English 3rd person singular “-s”) and generally functions as the “pivot” of a sentence in formal syntactic operations such as raising, control, coordination, and cross-clausal movement. In generative syntactic literature, the subject of a clause is characterized as the NP which occupies the inflectional/sentential specifier position, a position which is *always* projected regardless the other syntactic elements in the sentence (Chomsky, 1995; Dianne & Bobaljik, 1993; McCloskey, 1997, a.o.). Meanwhile, other NPs such as objects, are not always present (e.g., a sentence like “The coach sleeps” has no object) – a matter which we will return to shortly.

In parallel with formal syntactic theories, subjecthood plays a central role in language production and comprehension. In sentence production studies, for example, the subject of a sentence has been found to be more likely than other kind of NP to be re-mentioned in subsequent discourse and/or realized in pronominal form (Ariel, 1990; Arnold, 2010; Bosch et al., 2007; Chafe, 1976; Chambers & Smyth, 1998; Crawley et al., 1990; Gordon et al., 1993; Gundel, 2010; Gundel et al., 1993; Kaiser, 2011; Rohde & Kehler, 2014, among others). In terms of comprehension, long distance dependencies in constructions such as *wh* questions and relative clauses, as in the examples in (1), have widely been recognized as being easier to process when they pertain to a subject than when they pertain to an object (Clemens et al., 2015; Donkers et al., 2013; Ford, 1983; Gibson, 1998; Holmes & O'Regan, 1981; King & Just, 1991; Kwon et al., 2006; Nakamura & Miyamoto, 2013; Schriefers et al., 1995, among others). In (1a), “*who*” is the subject of the embedded verb “*trained*”, whereas in (1b), “*who*” is the object (known as the “*subject advantage*”).

- (1) a. *Subject Relative Clause*: The coach [who __ trained the athlete] worked meticulously.
b. *Object Relative Clause*: The athlete [who the coach trained __] worked meticulously.

Interestingly, this facet of sentence processing is mirrored in cross-linguistic typological patterns. Based on cross-linguistic survey of relative clauses across forty-nine languages, Keenan & Comrie (1977) propose an implicational universal known as the “*Accessibility Hierarchy*”. This holds that the subject is the most easily relativizable noun. If a given language permits object relative clauses, it is predicted to also permit subject relative clauses also, but not vice-versa.

- (2) The Accessibility Hierarchy (Keenan and Comrie, 1977: 66)

Subject > Direct object > Indirect object > Oblique > [...]

In response to these and to other related observations, theoretical models of language use commonly posit that the subject is the most prominent, or “accessible” referential entity in human mental representation – more accessible than any of the other kinds of nouns in (2) – whereas other kinds of entities (e.g., those encoded as objects) are less accessible by comparison (Ariel, 1988, 1990; Arnold, 2001; Chafe, 1976; Gordon et al., 1993; Grosz et al., 1995; Gundel, 2010; Gundel et al., 1993; Engelmann et al., 2019; Franck & Wagers, 2020; McElree & Wagers, 2009; Parker & An, 2018; Van Dyke & McElree, 2011). Arnold (2010: 188) characterizes accessibility in psychological process as “the property of information that makes it easier to access, independent of ambiguity considerations”. In terms of commonly studied psycholinguistic processes such as incremental sentence comprehension, the storage and retrieval of information about these highly accessible elements – namely, subjects – requires comparably less effort than for less accessible ones such as objects. This results in reduced processing burden for (more accessible) subjects as compared with (less accessible) objects, an outcome reflected in widely studied phenomena such as the “subject advantage” in processing relative clauses.

Despite its theoretical importance, however, “subjecthood” does not appear to behave universally as a homogenous category of human language. Looking beyond English, many languages encode distinctions between subjects of transitive verbs (i.e., verbs which also have an object) versus subjects of *intransitive* verb (i.e., those with no object) in their morphosyntactic systems. This distinction is heavily apparent in languages with morphological “case” marking. In a subset of these languages, subjects of transitive verbs *only* appear with some morphological marker (e.g., a grammatical suffix, or “case marker”). These are widely known as “ergative-absolutive” (ERG-ABS) languages (approximately 25% of the world’s languages; Dixon, 1979). Importantly, subjects of *intransitive* verbs do not appear with this same morphological marker that transitive ones do. This contrasts with the more widely-known “Nominative-Accusative” (NOM-ACC) languages such as English, where subjects of both transitive and intransitive verbs take nominative case (as per the English pronouns *I, he, she, they, and we*), and

objects of transitive verbs are marked as accusative (corresponding to English *me, him, her, them, and us*). The difference between ERG-ABS and NOM-ACC languages is illustrated in Table 1.

Table 1 Marking of subjects and objects in NOM-ACC languages (left) and ERG-ABS languages (right)

	Nominative-Accusative		Ergative-Absolutive	
TRANSITIVE	Subject	Object	Subject	Object
	<NOM>	<ACC>	<ERG>	<ABS>
INTRANSITIVE	Subject		Subject	
	<NOM>		<ABS>	

The non-uniform realization of grammatical subjects in ERG-ABS languages has raised the question of whether “subject” is even a primitive category of human language at all. In both early and contemporary syntactic literature, from Chomsky’s foundational works (1965, 1981, 1982) to recent contributions by Ershova (2023), the answer is a definitive “no”: Rather, subjecthood is a label invented by linguists to refer to an NP which exhibits a constellation of properties, such as (i) being the thematic “agent” of a sentence, (ii) having no dedicated morphological case marker, and (iii) being the pivotal NP for formal syntactic operations like verb agreement. For languages like English, the label has proven to be a useful one, because of these characteristics all apply to the *same* NP across-the-board. But for ERG-ABS languages, some *subset* of the properties applies to the subject of a transitive verb (i.e., the ergative NP) and the others apply to the subject of an intransitive verb and to the object of a transitive verb (i.e., the absolutive NP). The means that, although both ERG and ABS nouns have some “subject”-like properties, neither can be exhaustively characterized as the “subject”, making the label redundant.

This outcome therefore raises a host of questions for psycholinguistic theories which make reference broadly to the notion of “subject”. If “subject” is truly a redundant label, what underlying

primitive should it be replaced by? In the current paper, we investigate one characteristic domain of inquiry where the label “subject” has been overwhelmingly important for theoretical models: Memory. Here, the “subject” (broadly construed) is regarded as more easily stored and retrieved than NPs in other positions (e.g., object position) during sentence comprehension (Lin, 2018; Mak et al., 2006; O’Grady, 2011). In the current study, we address a hugely under-explored question: Is the processing ease associated with the “subject” different according to verb *transitivity*? Insofar as cross-linguistic diversity – in particular, the abundance of ERG-ABS languages – might provide any insight into memory-based comprehension mechanisms, we expect some types of “subjects” to have higher salience than others. In the next section, we introduce the relevant empirical phenomena and theoretical framework which allow for operationalizing this research question.

From typology to memory: Distinctiveness, subjecthood, and agreement

In the modeling memory systems, “salience” or “accessibility” is commonly characterized in terms of the notion of “distinctiveness”. Distinctiveness is the property of a storage unit (e.g., a referential entity like an NP) which allows for its features to be individuated from those belonging to other units; for example, other NPs in the same sentence (Hunt, 2003, 2013; Smith, 2011). Subsequently, the success of retrieving such a unit from memory during sentence processing depends at least partially on how distinctively that unit was originally encoded. Due to the high level of salience among nominal referents, grammatical subjects enjoy a high probability of being successfully maintained and subsequently retrieved; higher, indeed, than any other kind of NP such as an object.

In investigating the non-homogeneity of subjecthood in memory, we examine how distinctiveness of transitive subjects might differ from that of intransitive subjects. Therefore, we ask whether distinctiveness is *absolute* (i.e., what matters in a memory system is simply the property of “subject” alone) or rather, *relative* to a key property of verbs that conditions case marking in ergative-

absolute languages: transitivity. Returning to the English examples in (1), we ask how distinctiveness of subject of a verb like “train” might vary as a function of its argument structure: Importantly, “train” can be used in English *both* transitively, as in (3a) or intransitively, as in (3b).

(3) Transitive versus intransitive “train”

a. *Transitive*: **The coach** trains the athlete.

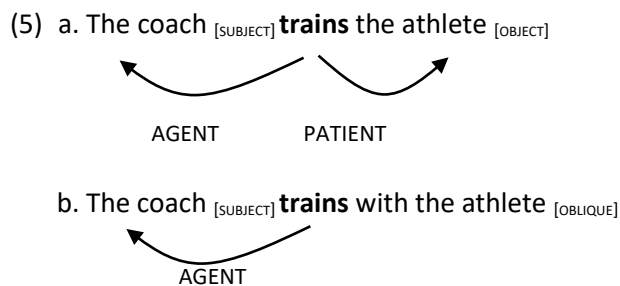
b. *Intransitive*: **The coach** trains.

On the one hand, one might expect that the memory system would represent “the coach” with the same degree of distinctiveness, regardless of whether it appears in a transitive frame like (3a) or an intransitive one like (3b): English does not distinguish between transitive and intransitive subjects via any morphosyntactic mechanisms. Quite the contrary, English syntax treats transitive and intransitive subjects alike: Both exhibit the formal syntactic properties that characterize a “subject” (Keenan, 1976; Dixon, 1979; McCloskey, 1997; Aldridge, 2004; Tolan & Heller, 2022; Ershova, 2023). For example, both control subject-verb agreement (i.e., trigger third person singular -s on the verb in 3), and both can undergo fundamental formal syntactic operations such as raising and movement. On the other hand, however, there is an obvious difference between (3a) and (3b) which one might well expect to impact a memory-based notion like distinctiveness: In the transitive frame in (3a), there is a second nominal (i.e., the object “the athlete”), which must also be encoded in memory in order for the sentence to be interpreted correctly. In (3b), meanwhile, there is no such competing nominal. However, verb transitivity is *not* ultimately determined purely by the number of nominals in any given configuration. Importantly, an intransitive verb like “train” in (3b) may also appear together with second, non-subject nominal like “the athlete”, as in (3a). Here, however, the second nominal must be introduced by a preposition (e.g., “with”) and subsequently does not behave as a direct object (i.e., like “the athlete in

3a), insofar as it is unable to be targeted in syntactic operations such as passivization. Despite the presence of a second noun phrase, therefore, the verb “train” in (4) is still intransitive.

(4) The coach trains with the athletes.

In syntactic terms, the contrast between (3a) and (4) amounts to a distinction between NPs whose thematic role is dependent on, or “assigned by”, the verb itself. In (3a), the transitive variant of the verb “train” assigns *two* thematic roles – one to the subject “the coach”, which is interpreted as an agent, and one to its object complement “the athlete”, interpreted as a patient. The subject and object are therefore characterized as *core arguments*. This is schematized in (5a). Conversely, in (4), intransitive “train” assigns only *one* thematic role: agent, to the NP in the subject position (and thus, this subject is a core argument). The second NP in (4), “the athletes”, is a complement not of the “train” but of the preposition “with”, upon which it is both structurally and interpretatively dependent. Therefore, “the athletes” in (4) is a *non-core argument*, otherwise known as a “oblique” NP, as in (5b).



Examining sentence pairs like in (5) allows us to ask whether distinctiveness of a subject is truly uniform (i.e., sensitive to grammatical function and/or structural position alone), while also controlling for the number of NPs present in each configuration (i.e., consistently two). This is the outcome most straightforwardly predicted by existing models of linguistic mental representation which are based around accessibility hierarchies as in (2). In view of the different cross-linguistic behaviors of subjects conditioned by transitivity, however, it stands to reason that subject distinctiveness is not homogenous.

Rather, we would expect that it is sensitive to the status of other NPs (e.g., “the athlete” in 6a as compared with 5b), as a function of the argument structure of the selecting verb in the sentence.

Interference effects as a testing ground

We put the hypothesis that subject distinctiveness is not homogenous to the test, by turning to a well-studied phenomenon which has generated a lot of discussion in psycholinguistic literature: a facilitatory interference effect, so-called *agreement attraction*. Agreement attraction is a well-known piece of evidence for a cue-based retrieval mechanism (Lewis et al., 2006; Lewis & Vasishth, 2005; McElree, 2000; McElree et al., 2003; Van Dyke & McElree, 2011). Under the retrieval mechanism, lexical items are stored in memory and identified with their own features, which include lexical and morphological information as well as syntactic and semantic information (e.g., number, definiteness, gender, etc.), when items are first encountered. At the retrieval site, features that matches the retrieval cues of a target item is assumed to be retrieved in parallel. The syntactically illicit but feature-matching elements (hereafter, attractor), therefore, may interfere the retrieval process of a target item. Agreement attraction may occur when the attractor gives rise to processing facilitation in ungrammatical sentences, resulting in a temporary illusion of grammaticality (Ness & Meltzer-Asscher, 2017, 2019; ; Nicol et al., 1997; Pearlmutter, 2000; Van Dyke, 2007; Van Dyke & Lewis, 2003; Van Dyke & McElree, 2011; Van Dyke & McElree, 2006; Nicol et al., 1997; Pearlmutter, 2000; Nicol et al., 1997; Pearlmutter, 2000).

(6) a. *The key to the cabinets **are** rusty. [attraction effects]

b. *The key to the cabinet **are** rusty.

For example, the sentence in (6a) is ultimately ill-formed because the singular subject NP “the key to the cabinets” triggers mismatching plural verb agreement (“are”) instead of singular (“is”). However, the fact that the attractor (i.e., “the cabinets”) matches the plural number feature of the main verb makes

the sentence are temporarily perceived as being at least partially well-formed, even though this noun does not actually control verb agreement itself. This plural feature of an attractor in (6a) matches the retrieval cue of the plural verb, and thus, the attractor leads to processing facilitation at the verb where the target subject must be retrieved to resolve number agreements, compared to the sentence (6b) in which no feature-matching attractor exists. A large body of studies on subject-verb agreement has attested that structurally illicit attractors such as “the cabinets” in (6a) give rise to facilitatory attraction effects in online sentence processing (Dillon et al., 2013; Franck et al., 2002; 2006, 2010, 2015; Hammerly et al., 2019; Parker, 2017; Parker & An, 2018; Pearlmutter, Garnsey, & Bock, 1999; Sturt & Kwon, 2017; Tucker, Idrissi, & Almeida, 2015; Van Dyke & McElree, 2011; Wagers et al., 2009) as well as agreement errors in sentence production (J. K. Bock & Cutting, 1992; J. K. Bock & Eberhard, 1993; K. Bock & Eberhard, 1993; K. Bock & Miller, 1991).

Our primary reason for looking at agreement attraction effects as a means of investigating the question of subject distinctiveness is as follows: the verb must retrieve a target subject to form number agreement between them. It has been widely observed that the dynamics of retrieval are sensitive to the distinctiveness of an attractor. That is, not *all* kinds of NPs trigger attraction effects, but rather, only those that have *not* been (sufficiently) distinctively encoded in memory, prior to the critical verb then being encountered or to the loss of the distinctiveness at retrieval¹ (Cunnings & Sturt, 2018; Engelmann et al., 2015; Parker & An, 2018; Patil et al., 2016; Van Dyke & McElree, 2011). This scenario presents a means to ask whether different kinds of subjects are indeed represented with different degrees of distinctiveness; namely, do subject attractors trigger different levels of agreement attraction according to the *transitivity* of their selecting verb? We examine this by returning to the pair of sentences in (6).

¹ In models of sentence processing, interference of an attractor can occur when it is encoded, so-called *encoding interference* (Barker et al., 2001; Hofmeister & Vasishth, 2014; Kush et al., 2015; Nairne, 1990; Oberauer & Lange, 2008; Villata et al., 2018), and then can affect retrieval (Laurinavichyute et al., 2017). For instance, if two NP items share overlapping features, the distinctiveness of these items in memory is reduced.

Importantly, displacing the second NP (“the athlete”) to form a relative clause allows us to create a minimal construction pair like in (7). Here, in both (7a) and (7b), the attractor (i.e., “the coach(es)”) is always in subject position, but the embedded verbs differ in transitivity. Consequently, the status of the second NP goes from being a core argument/direct object (7a), to a non-core argument/adjunct (7b).

(7) a. *Transitive subject attractor:*

*The athlete who the coach(es) trained **were** well-prepared.

b. *Intransitive subject attractor:*

*The athlete who the coach(es) trained with **were** well-prepared.

We therefore ask in the current study whether the distinctiveness of a subject (e.g., “the coach(es)”) differs as a function of verb transitivity, whereby the relevant non-subject clause-mate NP (e.g., “the athlete”) is either a direct object/core argument (7a) or oblique/non-core one (7b). To do so, we examine how the processing of subject-verb agreement (e.g., at “were” in 8) is affected by the subject attractor in each case. Before doing so, we briefly overview the relevant background regarding existing literature on agreement attraction.

Background on Interference Effects

Theories of agreement attraction effects in sentence processing draw heavily on the notion of “distinctiveness” in accounting for why such effects arise. To date, research on this topic has focused on the grammatical status of the attractor NP in a given configuration, whether it is a subject NP (“subject attractor”), object NP (“object attractor”) or non-core NP (“oblique attractor”). There is consensus that not all NPs behave alike as attractors – some kinds of NPs trigger attraction effects, whereas others do not. Importantly, whether an NP triggers interferences largely depends on how “distinctively” that NP is

represented and/or well-maintained in memory storage. This theoretical picture has been largely motivated by observations that attractors in *direct object position* and attractors in *oblique (adjunct) position* do not lead to the same profile of interference effects in processing agreement. Prior studies did not observe interference effects for direct object attractors, but found an effect for oblique attractors (Van Dyke, 2007; Van Dyke & McElree, 2011; Parker & An, 2018). Van Dyke & McElree (2011) and Parker & An (2018) attribute the difference between oblique NPs (which trigger interference effects) and object NPs (which do not) as being due to their differing levels of distinctiveness, or salience, in memory, as follows: NPs that are *more* distinctive (e.g., object NPs) are *less* susceptible as triggers for interferences, whereas NPs which are less distinctive (e.g., oblique NPs) are more susceptible to trigger such an effect. This is because their features are *not* represented as maximally distinct from those of other NPs; most relevantly, from the NP which is the *true* controller of the agreement (i.e., the matrix subject). On the other hand, NPs that are more distinctly encoded can produce a more salient *mismatch* with verb and are therefore less prone to causing interference effects. Concerning the contrast between direct object attractors and oblique PP attractors, Van Dyke & McElree (2011) reasoned that core arguments like direct objects (as well as subjects) provide more salient featural cues than oblique adjuncts PPs, because, as arguments of a verb, they are more prominent when computing the propositional content of a sentence. In contrast, oblique PPs are less prominent than core arguments because the theta roles of the NPs in these constructions are not directly assigned by the main verb but by the preposition itself (e.g., “with”), and thus, they argued to be less important in building a mental representation (Bresnan, 2001; Frazier & Clifton, 1996). This line of theory is indeed in line with the Accessibility Hierarchy (e.g., Keenan & Comrie, 1977): Recall that direct objects indeed outrank oblique nominals (as in 2).

In short, the likelihood of an NP triggering interferences is inversely aligned with its distinctiveness: The absence of interference effects indicates *more* distinctiveness, whereas the

presence of them indicates *less* distinctiveness of the NP. As discussed by Van Dyke & McElree (2011), it should naturally follow that an NP in a subject position, such as “the motion”/ “the witness” in (8), should *not* trigger interference: If NPs in direct object position are encoded distinctly enough so as not to, then subjects – which are, after all, even *more* distinctly encoded than objects – also should not.

(8) *Subject attractor*: The attorney who the judge realized had declared that

the motion/the witness was inappropriate compromised.

(Van Dyke & McElree, 2011)

However, Van Dyke & McElree in fact found a clear interference effect for subjects but not for direct objects. This was manifest from attractor-verb plausibility matches as induced by animacy (i.e., “witness” can plausibly “compromise”, whereas “motion” cannot) in (8). To account for this effect, the authors proposed that not *all* core arguments are prominent enough to be resistant to interference effects. The grammatical function of subject attractors, unlike object attractors, *matches* with that of the main subject, which is the *true* controller of agreement (recall that both objects and obliques *mismatch*); this effect was termed by Van Dyke & McElree as ‘syntactic gating’. Van Dyke & McElree’s proposal is consistent with a recent finding by Bhatia & Dillon (2022) for Hindi-Urdu, an ergative-absolutive language in which only absolutive NPs (i.e., direct objects and intransitive subjects) can control verb agreement (i.e., ergative transitive subjects cannot). In forced-choice completion tasks, Bhatia & Dillon found that only NPs which control agreement in Hindi-Urdu (i.e., absolutive ones) cause interference.

On the other hand, Parker & An (2018)’s self-paced reading task yielded a different outcome with regards to subject NPs. Their experiment 2 examined sentences with an intervening NP in subject position, as in (13), looking at both grammatical and ungrammatical agreement forms.

(9) The celebrity who **the journalist(s)** insulted certainly {was/*were} upset about the claims.

(Parker & An, 2018)

Parker & An found only a main effect of grammaticality, where sentences with ungrammatical plural verbs (“were”) were read slower than grammatical singular ones (“was”), but no number mismatch effect. On the surface, Parker & An’s (2018) finding is inconsistent with that of Van Dyke & McElree (2011), a point which Parker & An indeed bring to attention in their Discussion section. As these authors noted, Van Dyke & McElree manipulated attractor *animacy* whereas Parker & An manipulated attractor *number*, and it may be that subject-verb number agreement retrieval cues for animacy are weighted differently to those for number.

Lastly, Arnett & Wagers (2017) examined interference effects triggered by subjects (e.g., “the monster” in 10) that have different structural attributes and/or different abstract (i.e., non-morphologically overt) case properties. They compared sentences with nominative-cased subjects of finite complement clauses (10a), with accusative-cased (a.k.a. “Exceptionally Case Marked”) subjects of nonfinite clauses (10b), and accusative objects of nonfinite object control clauses (10c). They found that interference effects triggered by nominative subjects (i.e., in 10a) led to a higher processing burden than accusative subjects (10b) or accusative object controllers (10c) at the matrix predicate “was insane”, indicating that the contrast between abstract nominative and accusative case impacts computation of matrix subject-verb agreement (between nominative-cased “the explorer” and “was insane”).

- (10) a. The explorer who believed [that **the monster**_{NOM} was prowling...] was insane...
- b. The explorer who believed [**the monster**_{ACC} to be prowling...] was insane...
- c. The explorer was persuaded **the monster**_{ACC} [*PRO* to prowl...] was insane...

(Arnett & Wagers, 2017)

With this picture of interference effects in mind, we investigate how verb argument structure impacts interference effects, re-examining the circumstances in which NPs in subject position give rise to attraction effects in the processing of verb agreement, with respect to a new factor: verb transitivity. We consider two types of subjects: subjects of transitive verbs (“transitive subjects”), such as in (11a),

and subjects of intransitive verbs (“intransitive subjects”), as in (11b). In asking whether grammatical “subjects” are uniform in distinctiveness, our design departs from that of previous studies on interference effects. Whereas prior work has focused on manipulating the grammatical function of the intervening NP (i.e., the “attractor”), we keep grammatical function consistent: The attractor is a subject in all conditions. Instead, we manipulate the status of the verb, as either transitive (11a) – wherein the second NP (i.e., the filler “who”) is a direct object (e.g., of “train”) – or intransitive (11b) – where “who” is a complement of a preposition (e.g., “with”).

(11) a. *Transitive subject attractor:* [= (7)]

*The athlete who the coach(es) trained **were** well-prepared.

b. *Intransitive subject attractor:*

*The athlete who the coach(es) trained with **were** well-prepared.

In operationalizing this paradigm, however, we note that, as well as differing in terms of the argument status of the *filler*, these two conditions also differ in terms of the agreement dependency *length* between the main subject and the verb with which the agreement dependency is formed: There is one additional word (i.e., the preposition “with” in 11b) in the oblique conditions, which is not present in the object conditions. This means that any difference between the object and oblique conditions could be attributed either to their differences in grammatical functions or simply to agreement dependency length. To accommodate this, we also include a third level, in which adverbial phrases (e.g., “on Sunday”) were included after the proposition in the intransitive condition, as in (12). In this condition, which we call “long agreement”, the dependency length between subject and verb was extended even further by the addition of extra adverbial material (underlined in 12); however, the transitivity of the verb is identical to the intransitive conditions.

(12) *Intransitive subject attractor; long agreement:*

*The athlete who the coach(es) trained with on Sunday **were** well-prepared.

Therefore, if the intransitive condition patterns together with the long condition in terms of any interference effects, then any difference between the crucial transitive condition and intransitive conditions (i.e., 11a vs 11b) can be attributed to transitivity, not to the dependency length.

Experiment

We conducted a self-paced reading experiment to diagnose distinctiveness of subjects by using agreement attraction effects as a testing ground. The current experiments focus on investigating how the distinctiveness of a subject differs across verb type by positing it as an NP attractor in a subject-verb agreement dependency configuration like in (11a) and (11b). In these sentences, the singular main subject (“*The athlete*”) is mismatched in number with the plural main verb (“*were*”). Following Parker & An’s (2018) design, the subject is modified by a relative clause which requires the formation of a filler-gap dependency between the relative pronoun (“*who*”) and the gap (after “*trained*”).

We note, however, that the sentences in (11a) and (11b) also vary in ways besides the critical manipulation of subject status. For example, the grammatical function of the *wh* filler at embedded dependency/gap site (i.e., inside the relative clause) necessarily differs between the transitive and intransitive conditions: the gap for the transitive condition is in direct object position, whereas for the intransitive condition, it is in oblique position. To ensure that any agreement attraction effects are tied to status of the *subject*, and not some other processing difference between transitive and intransitive sentence (e.g., resolution of a filler-gap dependency), we included a set of baseline conditions which were minimally different to (11a) and (11b) but which should *not* be expected to show attraction effects (that is, where the manipulation of number should *not* differ according to transitivity level). Following

previous literature on agreement attraction, we also examined the grammatical/well-formed counterparts of (11) and (12) with singular verb agreement, as in (13).

- (13) a. *Transitive*: ✓The athlete who the coach(es) trained **was** well-prepared.
b. *Intransitive*: ✓The athlete who the coach(es) trained with **was** well-prepared.
c. *Intransitive: long*: ✓The athlete who the coach(es) trained with on Sunday **was** well-prepared.

Notably, grammatical sentences typically do *not* exhibit agreement attraction, insofar as inverse *illusions of ill-formedness* arising from a mismatch between an attractor and the verb – such between plural “cabinets” and singular “is” as in (14) – do not generally arise. This contrast between the presence of facilitatory interference (i.e., agreement attraction) in ungrammatical sentences versus the absence of inhibitory interference in grammatical ones (the “grammaticality asymmetry”; Wagers et al., 2009), has recently been the topic of extensive discussion and investigation (Hammerly, Staub & Dillon, 2019, a.o.).

- (14)✓ The key to the cabinets is rusty.

For our present purposes, we expect that any differing number agreement effects according to transitivity level that are connected to subject status should emerge for ungrammatical sentences but not for grammatical ones – thus indicating that these are truly *attraction* effects attributable to (subject) attractor status, rather than other general processing costs (which we would expect to also emerge in grammatical conditions).

Our 2 x 3 x 2 design therefore manipulated three factors. The first was the number feature of the subject attractor (singular vs. plural; two levels). The second was the transitivity of the verb inside the relative clause modifying the matrix subject (transitive, as per 13a, intransitive, as per 13b, and intransitive with additional adverbial, as per 13c; three levels), created by modifying materials from

Parker & An (2018). These two factors were manipulated in a within-subjects design. The last factor was grammaticality, which was manipulated by the number feature of the agreeing main verb in a between-subjects design. The verb agreement was plural whereas the main subject was singular (and hence, there was a number mismatch) in ungrammatical sentences, while grammatical versions of the same sentences was with singular verb agreement, thus matching with the main subject (which was also singular); A sample itemset is shown in Table 2. The primary rationale for implementing a between-subjects design in our manipulation of grammaticality was the paucity of verbs, like “train”, that exhibit *both* transitive and intransitive forms, and the subsequent need to minimize the potential for participants to encounter identical lexical verb forms across items. However, we also used this manipulation as a means of safeguarding against potential mitigation of a grammaticality asymmetry (Hammerly et al., 2019), which we detail in the Methods section.

Table 2 A sample set of items for Experiment

Transitive verb condition

Grammatical, SG attractor

The athlete [who the coach trained ___] definitely was prepared for the championship game.

Grammatical, PL attractor

The athlete [who the coaches trained ___] definitely was prepared for the championship game.

Ungrammatical, SG attractor

The athlete [who the coach trained ___] definitely were prepared for the championship game.

Ungrammatical, PL attractor

The athlete [who the coaches trained ___] definitely were prepared for the championship game.

Intransitive verb condition

Grammatical, SG attractor

The athlete [who the coach trained with ___] definitely was prepared for the championship game.

Grammatical, PL attractor

The athlete [who the coaches trained with ___] definitely was prepared for the championship game.

Ungrammatical, SG attractor

The athlete [who the coach trained with ___] definitely were prepared for the championship game.

Ungrammatical, PL attractor

The athlete [who the coaches trained with ___] definitely were prepared for the championship game.

Intransitive verb: Long agreement condition

Grammatical, SG attractor

The athlete [who the coach trained with ___ on Sunday] definitely was prepared for the
championship game.

Grammatical, PL attractor

The athlete [who the coaches trained with ___ on Sunday] definitely was prepared for the
championship game.

Ungrammatical, SG attractor

The athlete [who the coach trained with ___ on Sunday] definitely were prepared for the
championship game.

Ungrammatical, PL attractor

The athlete [who the coaches trained with ___ on Sunday] definitely were prepared for the
championship game.

Method

Materials

18 sets of items were created and distributed across six lists in a Latin Square design in each of the two between-subjects blocks (ungrammatical agreement, grammatical agreement). These were coupled with 32 filler sentences of similar length to the items. 24 of them were cleft sentences as in (15a) and 8 of them consist of relative clauses as target items as in (15b). For the ungrammatical block, twelve of them were made ungrammatical via mismatched tense agreement, as in (15a), and the other twelve were grammatical (e.g., 15b).

(15) a. *It was the tailor who the customer gratefully thanks at the banquet.

b. The car that had been stolen by the criminal fortunately was found in an empty parking lot.

For the block of grammatical sentences, the fillers were identical to those used for the ungrammatical block, except that all were revised to make them fully grammatical (i.e., tense agreement was repaired). This was done to prevent diffusion of the grammaticality asymmetry (that is, failure of the baseline manipulation): Recent work by Hammerly et al. (2019) attributes the absence of attraction effects in grammatical sentence to *response bias*, whereby participants come to expect a certain token to be well-formed/grammatical, and therefore treat it as such. Subsequently, Hammerly et al. showed that mitigating response bias, through participant instructions and/or filler composition, weakened or alleviated the grammaticality asymmetry. To safeguard our grammatical baseline against this weakening, we give participants no reason to *expect* ungrammaticality by using grammatical fillers only (we also did not inform participants in this block that they should expect ungrammaticality).

Finally, comprehension questions appeared immediately after each item. For example, the question that followed the items shown in Table 2 was “What was the profession of the {{person/people}}”

who trained the athlete?”. Participants selected an answer from a multiple-choice set of three options. Identical comprehension questions were provided in both grammatical and ungrammatical blocks. Items were presented in a pseudo-randomized order, with no more than two critical items adjacent (and any two adjacent critical items were always of different conditions).

Participants

Participants were 250 native speakers of English who were recruited from Amazon’s Mechanical Turk web service. Half of participants were assigned to the ungrammatical block, and the other half of participants to the grammatical block. All participants provided informed consent and were compensated at a rate of \$10 per hour. All participants were included in the analysis because their performance accuracy across all comprehension questions (including fillers) was higher than 80%, indicating that they had paid attention to the task in hand, and all participants indicated that they were native speakers of English (payment was not contingent upon the response to this question, so there was no incentive to answer dishonestly).

Procedure

The task was a self-paced reading using a non-cumulative moving window display. The experiment used the online software platform Ixcel Farm (Drummond, 2018). Each word or phrase was presented in the middle of the screen. The crucial verb region and spillover regions were always displayed independently, and the display pattern was constant across the conditions of each item in the Latin Square design. Participants were asked to press the spacebar to see the next word or phrase. Once the last word or phrase of each sentence was presented, a comprehension question appeared separately as a full sentence. The multiple-choice answer set was given after the comprehension questions; no feedback was provided. Three practice trials were included at the beginning. Participants in the ungrammatical

block were informed that some of the sentences were not quite well-formed but that all were understandable. Participants in the grammatical block were given no such notice. The experiment lasted approximately 25 minutes.

Results

All participants were included in the data analysis because each had an accuracy rate of over 80%. We analyzed three regions of interest: the critical verb (critical region), and the two words following the verb (spillover regions 1 and 2, respectively). For each region, we analyzed the reading times by fitting a 3x2x2 mixed-effects linear regression with crossed random effects for participants and items (Baayen et al., 2008), using the *lme4* package (Bates, Maechler, Bolker, & Walker, 2015). Following Hammerly et al., (2019), we report statistical analyses of both log-transformed reading times (Box & Cox, 1964; Dillon et al., 2019; Nicenboim et al., 2018; Vasishth et al., 2013; Villata & Franck, 2020) and raw reading times (Parker & An, 2018). We used the maximal random effect structure justified by the experiment design that would allow for model convergence (Barr et al., 2013). *P* values were calculated via a Satterthwaite approximation, as computed using the *LmerTest* function (Kuznetsova et al., 2017).

The argument status of the subject (3 levels) was contrast-coded using centered Helmert contrasts. The first coefficient, TRANSITIVITY, contrasted transitive verb (coefficient: +2/3) with intransitive verb and intransitive verb-long agreement conditions, pooled (coefficient: -1/3 for intransitive verb conditions; -1/3 for intransitive verb-long agreement conditions). The second coefficient, LENGTH, contrasted intransitive verb conditions (coefficient: -1/2) with intransitive verb-long agreement conditions (coefficient: +1/2): this contrast asks the length effect in the two intransitive verb conditions (the transitive verb condition does not participate in this comparison; its coefficient is 0). Our second manipulation, the number feature of the attractor (“NUMBER”, 2 levels), was sum coded as +1/2 when the attractor was singular and -1/2 when it was plural. Finally, the third coefficient,

GRAMMATICALITY, contrasted ungrammatical sentences (coefficient: +1/2) with grammatical sentences (coefficient: -1/2).

The mean word-by-word reading time is plotted in Figures 1 (transitive verb conditions), 2 (intransitive verb conditions) and 3 (intransitive verb-long agreement conditions). We begin by examining the critical region (i.e., the copula verb “was/were”). Here, there was a main effect of *Transitivity*, such that the overall reading time for transitive verb conditions was longer than the other intransitive conditions (517ms vs 472ms; log-transformed RTs: $\beta=.03$, $SE<.01$, $t=4.5$, $p<.001$; raw RTs: $\beta=43.89$, $SE=17.78$, $t=2.46$, $p=.01$). No other main effects—*Length*, *Attractor Number*, and *Grammaticality*—were significant.

Importantly, we observed three-way interaction between *Transitivity x Attractor Number x Grammaticality* (log-transformed RTs: $\beta=.08$, $SE=.03$, $t=2.4$, $p=.01$; raw RTs: $\beta=141.83$, $SE=71.13$, $t=1.99$, $p=.04$). To examine the interaction, we conducted nested planned comparisons asking for each level of verb type (transitive verb, intransitive verb, intransitive verb: long agreement), whether there was an interaction of *Attractor Number* and *Grammaticality*. Our analysis revealed that this interaction was significant *only* in the transitive verb condition (both log-transformed and raw RTs: $t=2.31$, $p=.02$). There was no significant interaction for either the intransitive condition or the intransitive: long agreement condition (both log-transformed and raw RTs: $p >.87$). In short, we find evidence of subject agreement attraction effects when the verb is transitive, but *not* when it is intransitive.

We therefore focused on the transitive verb condition, asking about the effect of (un)grammaticality, corresponding to the boxed region in Figure 1. A second set of planned comparisons revealed that the effect of number was significant for *ungrammatical* sentences (log-transformed RTs: $\beta=.05$, $SE=.02$, $t=2.93$, $p=.003$; raw RTs: $\beta=128.65$, $SE=41.05$, $t=3.13$, $p=.001$): reading time was *faster* when the attractor was plural than when it was singular (i.e., an attraction effect). Critically, there was no sign of such an effect for *grammatical* sentences (both raw and log-transformed $ps >.72$).

This same difference duly showed no signs of significance in the intransitive verb condition (see box in see Figure 2) or in the intransitive verb: long agreement condition (see box in Figure 3). This indicates that the attraction effect of a *subject* attractor which is matched with an ungrammatical main verb (here: a plural attractor matched with plural agreement) obtains when the verb is transitive (independently from length), wherein the clause-mate *wh* filler is a direct object. Grammatical sentences did not show this effect.

At the Spillover 1 region, we found a main effect of *Length*. Here, the overall reading times were longer in the intransitive condition than the intransitive: long agreement condition (468ms vs 490ms; log-transformed RTs: $t=2.31, p=.02$; raw RTs: $t=2.12, p=.03$). Importantly, there were no interactions. The effect of *Length* was absent at the Spillover 2 region. Again, there were no interactions.

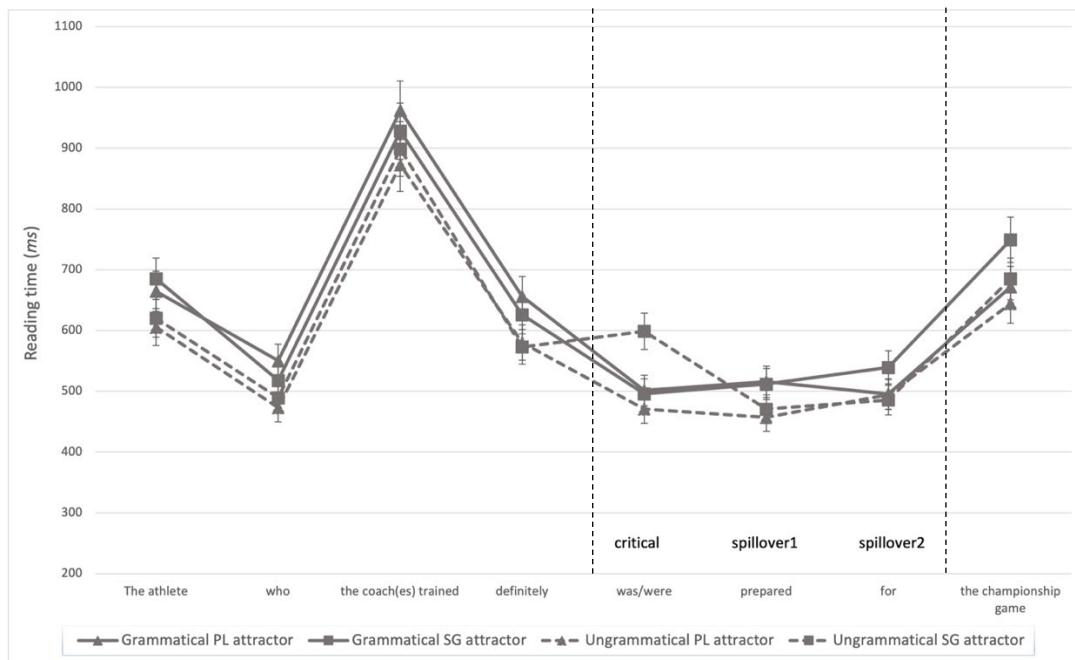


Fig. 1 Region-by-region reading times for the transitive verb conditions. Error bars indicate 95% Confidence intervals.

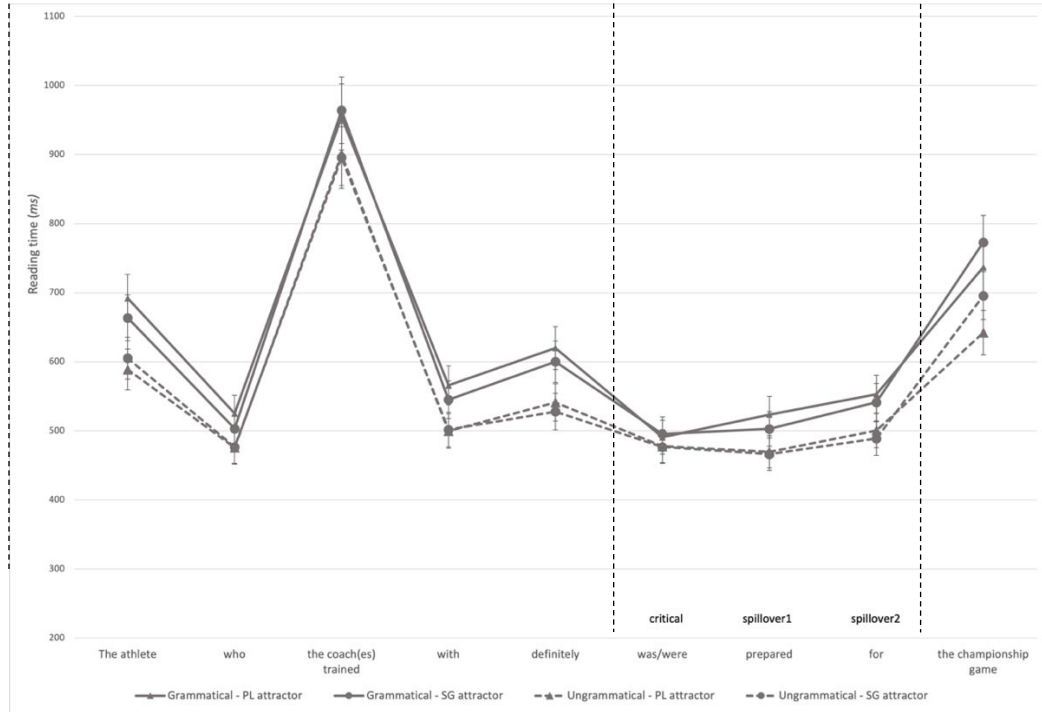


Fig. 2 Region-by-region reading times for the intransitive verb conditions. Error bars indicate 95% Confidence intervals.

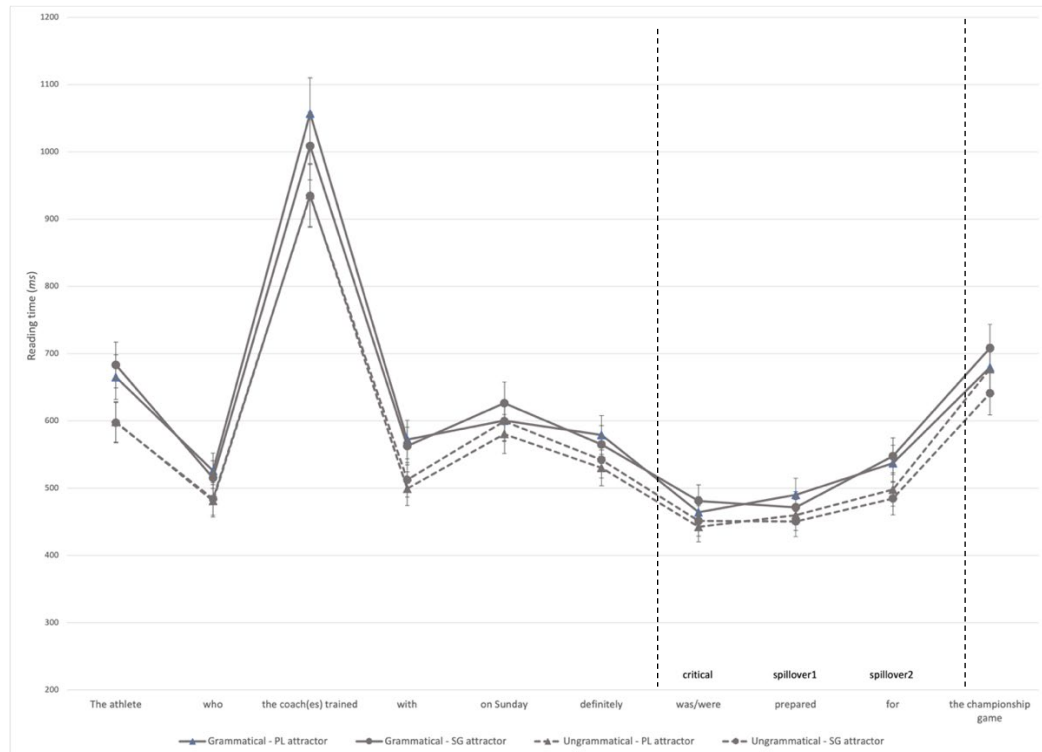


Fig. 3 Region-by-region reading times for the intransitive verb: long agreement conditions. Error bars indicate 95% Confidence intervals.

We note that, unlike in Parker & An (2018), we found no main effect of grammaticality at either the critical verb or the spillover regions. Rather, the reading times of grammatical sentences were in fact descriptively *longer* than those for ungrammatical sentences, although this did not comprise either a significant (or marginal) effect. In fact, RTs for the ungrammatical conditions were faster than those for grammatical conditions right from the very first presentation region (e.g., “The athlete” in Figures 1-3). We suspect that this might have been due to the between-subjects manipulation of grammaticality that we adopted (as opposed to within-subjects, as in Parker & An, 2018). As detailed in the Methods, participants in the ungrammatical block had been informed that sentences in some experimental trials were not fully grammatical (no such information was given to those in the grammatical block, where all trials indeed *were* grammatical sentences); this might have led to adoption of a shallower processing mode triggered by expectation of ungrammaticality, and thus overall faster reading times for ungrammatical block compared with grammatical one, across-the-board (Ferreira, Bailey & Ferraro, 2002). Indeed, filler sentences for the grammatical block were also read slower by comparison with those for the ungrammatical block, on average, both at the first reading presentation region (962ms vs. 560ms) and across all regions pooled (641ms vs. 571ms). In view of this, we base our forthcoming interpretation of our results upon how grammaticality interacts with transitivity and number, leaving the broader consideration of how grammaticality might impact subject attraction effects for future research.

Exploratory analysis: Adverb length.

Lastly, we consider a further aspect of our results. Our primary analyses revealed a 3-way interaction of transitivity level \times number \times grammaticality, in which subject attraction effects emerged only for ungrammatical transitive sentences. These effects were alleviated in the intransitive conditions and in the intransitive: long agreement conditions, in line with an interpretation of verb transitivity as being a critical factor in the encoding of subject NP, rather than length of the agreement dependency (i.e., the linear distance between the attractor and the critical verb). Here, however, we address an alternative explanation for this difference: it is possible that the presence of the preposition (e.g., *with*) in the intransitive condition (which differentiated it from the transitive condition) in fact facilitated an encoding of the intransitive subject which was *too good* for attraction effects to be detected. That is, the additional processing time provided by the extra length between the subject attractor and the critical verb might have sufficiently aided encoding of intransitive subjects, so as to mask attraction altogether. By comparison, no such additional time was available for the processing of the transitive counterparts.

To examine this possibility, we conducted an exploratory sub-analysis of our data. Here, we looked for effects of length differences among the set of adverbial phrases (e.g., *definitely*), which appeared immediately before the critical verb (*was/were*) in our materials. We reasoned that, if extra processing time allows for encoding sufficient to mask attraction, then attraction effects should be greater in magnitude for shorter adverbs as compared to longer adverbs (which yield slow reading times; Hofmeister, 2011; Hofmeister & Norcliffe, 2014). We divided our items into two groups: First, those with adverbs that were of 7 characters in length, or less (“short adverb”; *clearly, finally, likely, somehow*; total 6 items), and second, those with adverbs that were 9 characters or longer (“long adverb”; *certainly, obviously, evidently, undoubtedly, unsurprisingly, definitely, thankfully*; total 12 items). Across all experimental conditions, reading times for short adverbs (i.e., at the adverb/pre-critical region itself) were on average faster than those for long adverbs (552ms vs. 595ms; log-

transformed RTs: $t = -4.1, p < .0001$; raw RTs: $t = -3.8, p = .0001$), as expected. We then considered whether these length differences impacted attraction effects, by examining the transitive conditions which showed this effect and comparing reading times at the critical verb (i.e., *was/were*) for short adverb items vs. long adverb items, across conditions. Mean RTs are plotted in Figure 4. Descriptively, we find that the effect of attractor number in the ungrammatical conditions is impacted by adverb length; however, this patterned in the *opposite* direction to that which would be expected if extra processing time facilitated encoding (this comprised a marginal interaction of length x number x grammaticality for log-transformed RTs; $t = -1.844, p = .065$).

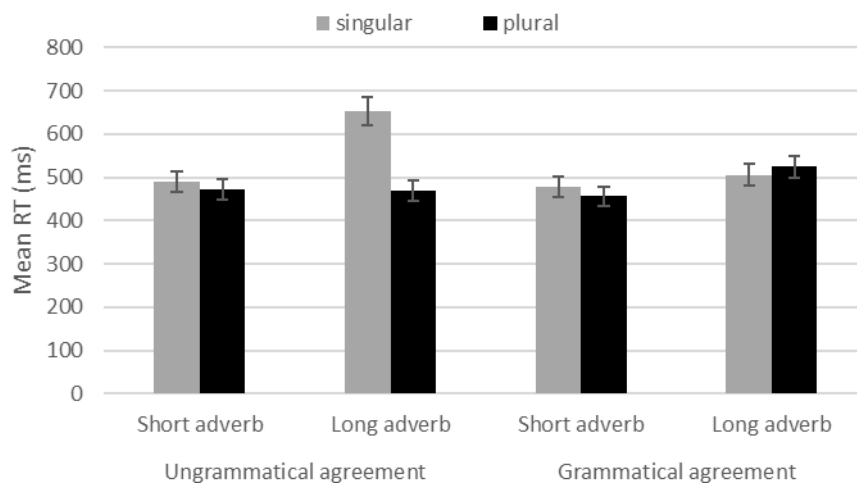


Fig. 4 Mean reading times for the transitive verb conditions at the critical region, for short versus long adverbs. Error bars indicate 95% Confidence intervals.

Importantly, it therefore seems unlikely that additional processing/encoding time provided by the presence of a preposition in the intransitive conditions could have facilitated encoding to the extent that attraction effects disappeared as result of length. On the contrary, we might expect this additional time to have *triggered* attraction effects in the intransitive conditions, rather than masked them.

Discussion

The results of this experiment provide evidence that subject attraction effects are susceptible to the distinctiveness of an attractor as a function of verb transitivity. Importantly, it occurs only when the relative clause is transitive, which importantly, means that the *wh*-filler is a core argument (i.e., the direct object) of the embedded verb in addition to the subject attractor. In the pair of ungrammatical transitive conditions, the attraction effect is observed at the main verb region, which is read faster when the attractor is plural, and therefore provides a viable match for the plural-marked verb. This same effect was, however, alleviated in the two *intransitive* condition pairs, where the *wh* filler was an oblique prepositional complement. Instead, our results generally support a view in which the distinctiveness of subjects is *not* invariant but is instead *relative* to the status of other clause-mate NPs (e.g., as core or non-core arguments). Importantly, existing theories of subject interference effects such as syntactic gating (e.g., Van Dyke & McElree, 2011) treat “subjecthood” as a monolithic category, which would thereby predict that agreement attraction effects should obtain consistently, regardless of verb transitivity.² Critically, this effect of attractor number occurred in ungrammatical sentences (i.e., the typical environment for attraction effects) but not in grammatical ones (where no such effects were expected to arise), thus providing support for the conclusion that the source of this attraction effect was indeed tied to the status of the attractor, rather than independent differences between processing of transitive versus intransitive sentences.

² One potential limitation of our design is a possible garden-path effect in intransitive conditions, because the verb and preposition were presented to participants separately. Therefore, it is possible that participants may have initially analyzed intransitive structures as being transitive, before the preposition was subsequently presented. However, since no interference effect was observed in intransitive structures (which we would expect if they had been treated as transitive), our results do not appear to wholly reflect such garden-path effects.

To account for our results, we adopt the following hypothesis: Once a grammatical subject has been encoded in working memory (i.e., upon being encountered by the parser), it is naturally susceptible to activation decay over time (Anderson & Lebiere, 1998; Anderson & Matessa, 1997; Gibson, 1998, 2000; Kempen & Vosse, 1989). Importantly, though, when a *second* NP must also be encoded, the level of distinctiveness of the already-encoded subject wanes, because memory resources which would otherwise maintain subject distinctiveness to a maximum level, must then be deployed in order to encode a second NP. Crucially, the level of encoding of this second (i.e., clause-mate) NP is *not* uniform between transitive and intransitive verbs: As is standardly posited both in theories of NP accessibility (Keenan & Comrie, 1977, 1979) and interference effects (Parker, 2017; Parker & An, 2018; Van Dyke & McElree, 2006, 2011), direct objects of transitive verbs (i.e., core arguments) get encoded more distinctly than prepositional objects of intransitive verbs (i.e., non-core arguments). The more distinctively this second NP must be encoded, the less distinctively maintained is the prior subject. In other words, the memory resources deployed to maintain distinctiveness of a subject NP must be shared when another core-argument (i.e., an object) must be encoded. The consequence of this is that subject agreement attraction effects obtained in our transitive conditions because, when the transitive verb (e.g., “train”) is encountered, the *wh* filler (“who”) gets encoded as a direct object (i.e., the person who was trained). Thus, we interpret these attraction effects as reflecting the *loss* of distinctiveness of subject attractors due to the encoding of a second core argument.

General Discussion

The goal of the current study was to explore whether subjects are invariantly distinctive units in the memory representations that get deployed during the processing of subject-verb agreement. To do so, we manipulated the transitivity of the verb of which the intervening NP is the subject (thus making it

either a transitive subject or an intransitive one). We then examined how the subject, as an attractor, modulates interferences in the subject-verb dependency formation. We found evidence that agreement-based attraction effects arise with subject attractors, but only when the verb is *transitive*, meaning that a second clause-mate core-argument NP (i.e., a direct object) must also be encoded. When the verb is *intransitive*, meaning that any other clause-mate NP is necessarily an oblique/prepositional *non-core* argument, these effects are weakened. With this in mind, we now return to our overarching question about the status/distinctiveness of “subjects” in memory by re-visiting the role of subjecthood in agreement attraction.

Transitivity and subjecthood in processing agreement.

First, we note that the results from our experiment are not immediately predicted by theories of interference effects which rely solely on the argument status of an attractor itself (e.g., Van Dyke & McElree, 2011), *without* some concomitant reference to the status of clause-mate nominals that are also present (i.e., direct objects or oblique prepositional complements). To account for interference effects triggered by subject NPs, Van Dyke & McElree (2011) proposed that subject attractors (which indeed *do* trigger interference effects) are unlike object attractors (which do not) because they are controllers of verb agreement (whereas objects are not; in English, verb agreement indeed cannot be controlled by any NP besides the grammatical subject). This means that they are not precluded from being retrieved as viable candidates for verb agreement. This state-of-affairs is consistent with recent results on agreement attraction in Hindi-Urdu (Bhatia & Dillon, 2022)– a language where both subjects and objects can control agreement depending on their morphological case – which reveal that attractor NPs only trigger interference effects if they themselves are agreement controllers. In English, however, subjects of *both* transitive and intransitive verbs are agreement controllers, yet we only found evidence for attraction effects with the former, suggesting that speakers of English rely on cues besides the

agreement controller status of an NP when processing agreement.

Bearing this in mind, we now lay out a schema in which both (i) an NP's status as an agreement controller (Van Dyke & McElree, 2011; Bhatia & Dillon, 2022) and (ii) its distinctiveness relative to any clause-mate NPs which must also be encoded in memory, are both relevant factors in determining whether subject interference effects arise in any given configuration. Here, we maintain that there are (at least) *two* circumstances under which an NP intervening between the matrix subject (i.e., the true agreement controller) and the verb can give rise to an interference effect. The first is by virtue of being syntactically licensed agreement controller in and of itself – for English, this means having the grammatical role of either transitive *or* intransitive subject (both types of subjects can control agreement). The second is by virtue of not being an agreement controller but of being insufficiently distinctively represented in memory; in other words, being a non-core argument subject as an oblique NP, which enjoys only low accessibility (Keenan & Comrie, 1977). As proposed by Van Dyke & McElree (2011), these kinds of attractors are not encoded well enough so as to be precluded from retrieval when the agreement target (i.e., the verb) is encountered. Therefore, they trigger interference effects.

Building on Van Dyke & McElree (2011), however, we maintain first, that these two factors in fact do not operate in isolation of each other, and second, that distinctiveness of an intervening NP ultimately reflects not only its level of representational encoding but is also impacted by the encoding level of any competing (e.g., clause-mate) NPs. Putting these premises together, we arrive at the following: **SUBJECTS OF TRANSITIVE VERBS** in English are agreement controllers therefore have the potential to trigger interference effects. Subsequently, they indeed succumb to this: Because their encoded mental representation is dampened when a second competing core argument position (i.e., the transitive direct object) is encountered and likewise encoded, they are ultimately *not* sufficiently distinct and cannot be precluded from retrieval when the verb is reached. Subjects of transitive verbs, therefore, are likely to trigger interference effects by virtue of being able to control agreement during the retrieval

of subjects to agree with. Looking beyond English, we note that Bhatia & Dillon (2022) recently observed the inverse for Hindi-Urdu, where (ergative-cased) transitive subjects do not control agreement but (absolutive-cased) transitive objects do. Accordingly, Bhatia & Dillon observed agreement attraction effects for Hindi-Urdu transitive objects but not subjects.

Meanwhile, **SUBJECTS OF INTRANSITIVE VERBS** are also agreement controllers in English, just like subjects of transitive verbs are. They therefore have potential to succumb to provoking interference effects. But, unlike subjects of transitive verbs, they do not. They are ultimately sufficiently distinct enough to be precluded from retrieval, and no interference effects arise. However, we would expect that intransitive subjects *would* succumb to attraction, if they *were* to appear in some other kind of configuration which precluded this kind of distinctive encoding. One possible setting which might meet the conditions for this is in an environment where two *subjects* must be simultaneously encoded. This would mean that effectively, neither is sufficiently distinctly encoded - because representational resources are shared between the two of them - and therefore *both* should be susceptible to attraction effects. One possible avenue to exploring this would involve looking at verbal agreement in an embedded relative clause and examining how manipulation of matrix subject number affect this (in other words, the inverse to the current study, where we manipulated number of the embedded subject and tested agreement effects at the matrix verb). Importantly, this configuration used by Wagers et al. (2009); an example from their study is given in (16).

(16) Matrix subject attractor (bolded) plus embedded subject attractor (underlined)

The musician(s) [who the reviewer(s) praise(s) so highly] will.....

(Wagers et al., 2009)

The authors found that matrix subjects like “the musician(s)” indeed *do* trigger attraction effects at embedded “praise(s)” in this setting, even though transitivity level of “the musician(s)” is not in fact discernable at this point in the sentence. Nonetheless, two subjects must be encoded: matrix subject

“the musician” and embedded subject “the reviewer”, and both are agreement controllers. Wagers et al. indeed found that manipulating the number of both the matrix and the embedded subject affected processing difficulty at the embedded verb, in line with the above-discussed state-of-affairs.

In short, the current study of verb transitivity highlights how two fundamental aspects of agreement processing – encoding and agreement control – effectively co-operate. This means that having the status of “subject” per se does not, in and of itself, predict whether agreement attraction effects will emerge. Instead, subject attraction depends on the syntactic environment in which a subject attractor is situated.

The status of “subject”

Finally, we return to considering the status of “subjecthood” as a category of human language in view of the above discussion. As mentioned in the Introduction, early and recent work in formal linguistics (Chomsky, 1965; a.o.) has advocated for a view in which the term “subject” is made redundant in linguistic description. This approach aligns neatly with cross-linguistic typology: As we discussed in the Introduction, “ergative-absolutive” languages, in which transitive subjects are case-marked differently from intransitive subjects, minimally provide evidence that agents of transitive verbs and solo arguments of intransitive verbs are not considered as equal. Even in nominative-accusative languages, dependencies involving intransitive verbs or movement of wh-phrases from intransitive verbs have been found to be more acceptable than dependencies involving transitive verbs or those from transitive verbs (Babyonyshev & Gibson, 1999; Jurka, 2013; Polinsky et al., 2013); similarly in infant language development, learners have been shown to produce solo arguments of intransitive verbs more readily than agents of transitive verbs (Akhtar & Tomasello, 1997; Theakston et al., 2001; Valian, 1986).

Fitting our experiment against this backdrop, we provide a new line of support for an increasingly prevalent view that models of language – and in more generally in our study, models of

memory – are optimally informed by considering a finer-grained notion of what it means for a noun to be a “subject”. A wholly radical approach would be to abandon the label entirely, and refer instead to “agent”, “patient” (i.e., the two arguments of a transitive verb)³ and “solo argument” (i.e., the single argument of an intransitive verb), as per typological tradition (e.g., Dixon, 1994). A middle ground might involve maintaining the label “subject”, as per tradition in psycholinguistic studies, but outlining or acknowledging what the linguistic behaviors are that underlie the term, given its murkiness as a linguistic universal, and as demonstrated in the present paper, its within-language (here: English) heterogeneity in memory-based comprehension processes. Whether and the extent to which different variants of “subjecthood” might also impact *production* (cf. Bock & Cutting, 1992) as well as comprehension remains an open line of inquiry.

Conclusion

In this paper, we have revisited a widespread characterization in linguistic and psycholinguistic literature, in which grammatical subjects are more prominent/accessible than other types of NPs (e.g., objects). We contrasted two types of “subjecthood” into in accordance with discussion throughout linguistic literature: We compared the distinctiveness of subjects of *transitive* verbs to those of *intransitive* verbs by looking at interference effects – commonly known as “attraction” effects – in the processing of verbal number agreement. We found that an attractor in the subject position of a relative

³ It is potentially also noteworthy that the set of verbs used in the current study had subjects which fulfilled the thematic role of *agent*. Subjects characterized by non-agent semantic roles such as *patient* or *experiencer* might indeed manifest distinct behaviors. If this is the case, one might expect patient subjects of unaccusative verbs (e.g., *fall*, *arrive*) to trigger dissimilar attraction profiles to agents subjects of unergative verbs (e.g., *dance*, *work*), and/or for subjects of psychological predicates (e.g., *love*, *see*) to pattern differently to those of action predicates (e.g., *chase*, *build*). Likewise, inanimate subjects of intransitive verbs which permit pseudo-passives (e.g., “*The couch was slept on*”) might behave differently from animate subjects of non-passivized counterparts (e.g., “*The child slept on the couch*”), especially given that animacy is understood as a central component of agency. We leave these considerations open for future research.

clause modifying the target subject indeed modulates the processing of number agreement, but only when the verb is transitive (and thus, the *wh* filler gets integrated as a direct object). When the verb was intransitive (and the *wh* filler is therefore an oblique prepositional complement), these attraction effects were mitigated. We situate these findings in a modulated theory of agreement attraction effects which takes into account both (i) the distinctiveness of an NP vis-à-vis that of other clause-mate NPs, and (ii) whether the attractor NP is a licit controller of verb agreement in a given language such as English (cf. Bhatia & Dillon, 2022). More broadly, our observations suggest that grammatical subjects are not uniform in terms of their representational prominence, with intransitive subjects being more prominent than transitive ones. Together with the typological profile of how subjects get realized across languages (Dixon, 1994; Du Bois, 1987), we maintain that these observations highlight the necessity of continued attention to fine-grained syntactic details such as verb transitivity across experimental manipulations, and of the benefit of maintaining back-and-forth discussions among research in cross-linguistic typology and research in language processing.

Declarations

Conflicts of interest

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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Ethics approval

This study was approved by the University of Delaware Internal Review Board (IRB).

Open Practices Statement

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