Does case marking affect agreement attraction in comprehension?

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Abstract

Previous studies have suggested that distinctive case marking on noun phrases reduces attraction effects in production, i.e., the tendency to produce a verb that agrees with a nonsubject noun. An important open question is whether attraction effects are modulated by case information in sentence comprehension. To address this question, we conducted three attraction experiments in Armenian, a language with a rich and productive case system. The experiments showed clear attraction effects, and they also revealed an overall role of case marking such that participants showed faster response and reading times when the nouns in the sentence had different case. However, we found little indication that distinctive case marking modulated attraction effects. We present a theoretical proposal of how case and number information may be used differentially during agreement licensing in comprehension. More generally, this work sheds light on the nature of the retrieval cues deployed when completing morphosyntactic dependencies.

Keywords: subject-verb agreement, attraction, case, Eastern Armenian, cue-based retrieval, comprehension

Introduction

Consider sentence (1).

- (1) *The key to the cabinets are rusty.*

This sentence is ungrammatical because the subject head *key* does not agree with the copula verb *are* in number. Now compare this sentence with (2).

- (2) *The key to the cabinet are rusty.*

Sentence (2) is also ungrammatical and for the same reason as (1). But interestingly, speakers are more likely to wrongly produce a sentence like (1) than (2). Such *agreement attraction errors* have been widely attested in production (Bock & Cutting, 1992; Bock & Eberhard, 1993; Bock & Miller, 1991; Vigliocco, Butterworth, & Semenza, 1995) and in comprehension (Dillon, Mishler, Sloggett, & Phillips, 2013; Lago, Shalom, Sigman, Lau, & Phillips, 2015; Nicol, Forster, & Veres, 1997; Pearlmutter, Garnsey, & Bock, 1999; Wagers, Lau, & Phillips, 2009). In comprehension, reading studies typically find faster processing times after the verb in (1) versus (2); in grammaticality judgment tasks, (1) is incorrectly judged to be grammatical more often than (2).

Attraction errors in production have been explained in terms of encoding-based accounts. One prominent example is the Marking and Morphing account according to which attraction effects are due to ambiguous encoding of a subject phrase's number (Bock, Eberhard, Cutting, Meyer, & Schriefers, 2001; Eberhard, Cutting, & Bock, 2005). Under this account, number is a continuum; as a consequence, singular is at one end of the continuum and plural is at the other end, a subject phrase with a singular head but a plural modifier noun as in (1) may be evaluated as being somewhat plural (i.e., having a number that falls somewhere between the two ends of the continuum). This ultimately may lead to erroneous production of a plural verb. The mechanism responsible for this is the spreading of the activation of the feature "plural" from the modifier noun (i.e., the attractor) to the root node of the subject phrase. The likelihood of misrepresenting a singular subject phrase as plural is determined by the number of sources of plurality within the sentence (e.g. the number of plural modifiers) as well as their syntactic proximity to the root node of the subject phrase.

Importantly, a recent implementation of Marking and Morphing has applied the model to comprehension, more specifically to grammaticality judgment tasks (Hammerly, Staub, & Dillon, 2019), combining the continuous number valuation procedure from Marking and Morphing with evidence accumulation processes from the Drift Diffusion Model (Ratcliff, 1978). According to this implementation, when a subject phrase's number is unambiguous (i.e., the head and attractor are both singular), a decision about the grammaticality status of a sentence is reached fast and accurately. But when the subject phrase's number is ambiguous in the presence of a plural attractor, the drift rate of evidence accumulation in favor of a particular decision is slowed. This results in slower response times and sometimes in wrong decisions and leads to attraction errors (i.e., sentences with ungrammatical plural verbs are judged as grammatical).

Alternatively, attraction may arise as a by-product of the cue-based memory retrieval mechanism assumed in the Lewis and Vasisht (2005) model to account for the licensing of long-distance dependencies in comprehension. Under this account, attraction effects result from incorrect retrieval of the subject head due to interference at a point when the head needs to be re-accessed for number licensing (i.e., at the verb *are* in the examples above). The cue-based retrieval model assumes that sentence constituents are represented in declarative memory as chunks containing feature values that encode a constituent's syntactic position and its morphosyntactic features (number, gender, etc.). To license linguistic dependencies, previously encoded chunks need to be retrieved from memory through cues that are matched against the feature values of these chunks.

The retrieval latency and the probability of successful retrieval depend on how many of a chunk’s features match the retrieval cues. For example, in the sentences above, the copula verb *are* seeks a subject with a plural feature to license its number. In (1) this memory search yields two partial matches: The chunk corresponding to the subject head *key* matches the syntactic cue {+subject}, but the chunk corresponding to the attractor *cabinets* matches the number cue {+plural}. Due to this partial match, the two chunks enter a so-called race for retrieval, and whichever chunk is accessed faster in a particular trial becomes the “winner” and gets retrieved. On trials in which the attractor *cabinets* is misretrieved, comprehenders can (mistakenly) license the ungrammatical plural verb, and an illusion of grammaticality is created. Thus, the speedup typically observed in (1) relative to (2) is the result of this race process. By contrast, in (2), no such race is initiated due to the lack of a number-matching chunk. The relative speedup in (1) versus (2) has been referred to as *facilitatory interference*. Here, the term *facilitatory* does not necessarily imply that processing is easier; rather, this refers to the observed speedup. Another type of interference that the cue-based retrieval model predicts in agreement configurations is *inhibitory interference* (this is discussed below).

Critically, if errors in the identification of the subject head lead to agreement attraction, then attraction should be reduced when the nouns in the subject phrase bear features that help the parser identify the subject head. Specifically, fewer agreement attraction errors should be observed in languages with overt case marking on noun phrases (NPs) because in such languages case information plays a pivotal role in encoding subjecthood (Bader & Lamers, 2009; Comrie, 1989). For example, in languages with a nominative-accusative case distinction, nominative case usually denotes subjecthood because grammatical subjects in transitive and intransitive sentences are marked with nominative morphology and control verb agreement in contrast to objects, which are clearly identified with accusative case.

But does distinctive case marking on NPs really help comprehenders avoid attraction in sentences like (1)? This question has not been sufficiently investigated in comprehension studies, nor has it been clearly answered in production. One reason for this lack of clarity is that production studies have sometimes used paradigms in which case information was confounded with other variables. Another reason is that although most production studies have reported reduced attraction rates in the presence of distinctive case morphology, some studies have found the opposite pattern (Franck, Lassi, Frauenfelder, & Rizzi, 2006; Franck, Soare, Frauenfelder, & Rizzi, 2010). The current study revisits this open question regarding the role of distinctive case marking in attraction. We use a language with a productive case system, Eastern Armenian (henceforth Armenian), to determine whether nominal case marking modulates the magnitude of attraction effects. This question was investigated using a forced-choice sentence completion task (Experiment 1) and self-paced reading tasks (Experiments 2 and 3). Before presenting these experiments, we review previous work on this topic. Then, we motivate why case information may exert an influence in comprehension, and we describe the design and hypotheses of our study.

Previous work on case and agreement attraction

Evidence that grammatical case modulates agreement attraction mainly comes from production studies, which have yielded a mixed picture.¹ For example, Nicol and Antón-Méndez (2009) conducted an English study in which participants were instructed to complete sentence preambles with a verb. The materials were complex subjects with singular heads and prepositional phrase (PP) modifiers. The modifiers varied in number (singular vs. plural) and word category such that they were either non-case marked NPs (*the bill from the accountant/accountants*) or accusative-marked pronouns (*the bill from him/them*). Attraction rates were 13.9% for full NPs and 5.9% for pronouns; thus, the interaction between word category and number was 8%, with a 95% confidence interval of [0.7, 15.3]. This was taken as evidence that overtly accusative-marked modifiers reduced attraction rates. However, this manipulation may have conflated word category (full NP vs. pronoun) with overt case marking, as the case-marked attractors were also always pronouns. Thus, it is unclear which of these variables modulated attraction rates.

Hartsuiker, Antón-Méndez, and van Zee (2001) examined object attraction in a sentence completion task in Dutch. Participants saw incomplete sentences with an attractor that was the grammatical object of the verb. The object was either a full NP, which had been encountered in a preceding context, or it was a pronoun, which co-referred with that previously-encountered NP. The objects varied in number and, depending on the antecedent features, also in animacy. Half of the objects were inanimate and half were animate. Crucially, the inanimate plural pronoun *ze* was ambiguous between nominative and accusative case, whereas its animate counterpart *hen* was unambiguously accusative. The numerical patterns suggested that overt case marking led participants to make fewer attraction errors: Whereas the inanimate and case-ambiguous pronoun *ze* induced as many erroneous plural verbs as the inanimate full NP (5.6% each), the animate and accusative case-marked pronoun *hen* did not produce many errors relative to the animate full NP (0.7% vs. 9.7%). However, this study only reported a significant effect in the by-items but not the by-subjects ANOVA. Thus, apart from the fact that the word category/case marking confound remains unaddressed in this study, it is unclear whether its results provide convincing evidence for a reduction of agreement attraction specifically due to case marking.

The two studies reviewed above showed suggestive numerical patterns that unambiguous case marking on the attractor nouns might lead to reduced attraction. However, these studies conflated case marking with word category partly because in the languages tested, English and Dutch, case morphology is mostly restricted to the pronominal system. By contrast, languages like German have a case system that involves overt morphological marking on noun phrases. Hartsuiker, Schriefers, Bock, and Kikstra (2003) exploited this property of German and performed a sentence-completion task, which provided evidence that distinctive case information may reduce attraction even when word category information is controlled for. The authors used complex subjects with PP modifiers that varied in the modifier's number and the preposition introducing it: The determiner after the preposition

¹In this summary of the literature, we endeavor to provide a numerical estimate for each effect that we discuss along with its 95% confidence interval if enough information was available from the published paper to derive this information.

had a form that was either ambiguous between accusative and nominative case (e.g., *die Stellungnahme gegen die_{ACC/NOM} Demonstration/gegen die_{ACC/NOM} Demonstrationen* ‘the position against the demonstration/the demonstrations’) or it was unambiguously dative (*die Stellungnahme zu der_{DAT} Demonstration/zu den_{DAT} Demonstrationen* ‘the position on the demonstration/the demonstrations’). They found patterns consistent with the proposal that unambiguous case marking reduces attraction: The case ambiguous local noun in the PP modifier elicited on average 6.8% CI:[-0.6, 14.2] more attraction errors compared with the unambiguous conditions.

Additionally, a series of three studies (a production and two comprehension studies) by Slioussar (2018) showed a close relationship between case ambiguity and attraction in Russian. All three experiments used the same materials (i.e., sentences containing subjects with PP modifiers) and involved the same factor manipulations: subject head and attractor number (singular/plural), attractor case manipulated between items (accusative/genitive), and verb grammaticality (grammatical/ungrammatical). In the production study, participants saw inflected verbs and complex subjects in a rapid serial presentation. Their task was to produce complete sentences by combining these constituents. Since half of the trials contained ungrammatical verbs incompatible with their subject heads, participants were instructed to change the verb number when necessary to produce grammatical sentences. The comprehension studies consisted of a grammaticality judgment task and a self-paced reading task.

None of the experiments yielded effects with plural heads, but in sentences with singular heads, attractor case and number interacted in all three experiments. For example, in the production study and the grammaticality judgment study, more erroneous responses were elicited by the type of attractors whose form coincided with nominative plural; these were the plural attractors in the accusative conditions (*the highway across the field_{ACC.SG/NOM.SG}/fields_{ACC.PL/NOM.PL}*) and, by contrast, the singular attractors in the genitive conditions (*the room for party_{GEN.SG/NOM.PL}/parties_{GEN.PL}*). Similarly, in the reading task, the error-related slowdown was reduced in ungrammatical sentences when the attractor was plural in accusative conditions and when the attractor was singular in the genitive conditions. One issue with these data is that it is again difficult to draw unequivocal conclusions about the role of case because the case ambiguous experimental items were lexically different from the case unambiguous items such that case differences may have been confounded with semantic differences between the nouns in the subject phrase (Gillespie & Pearlmutter, 2011, 2013).

Finally, previous work includes two production studies in French the results of which are noteworthy because they deviated from the experiments in English, Dutch, German, and Russian mentioned above (Franck et al., 2006, 2010). Franck and colleagues showed that distinctive case marking may sometimes result in *increased* rather than *reduced* attraction. In one of these studies (Franck et al., 2006), the authors manipulated attractor nouns for number and syntactic status such that they were either case-marked pronominal objects (*le professeur le/les* ‘the professor it/them’) or case-unmarked subject modifiers (*le professeur de l’élève/des élèves* ‘the professor of the student/students’). The numerical patterns suggested that attraction rates were about 4.9% CI:[-2.3, 12.1] higher with case-marked object clitics

than with case-unmarked subject modifiers.

Franck and colleagues reported similar findings in a study that examined whether in-situ direct objects induced as much attraction as moved direct objects (Franck et al., 2010, Experiment 2). Depending on their syntactic position, objects were either pre-verbal pronominal clitics or post-verbal full NPs. Again, object clitics that were unambiguously accusative elicited 7% CI:[1.4, 12.6] more attraction errors than full NPs. In an additional experiment, the authors compared attraction rates between (a) accusative clitics and dative clitics, and (b) accusative clitics and case unmarked PP modifiers (Franck et al., 2010, Experiment 3). Mean attraction rates were 5% for dative clitics, 6.3% for case-unmarked PP modifiers, and 10.1% for accusative clitics. Therefore, dative-marked clitics and case-unmarked PP modifiers showed lower attraction rates than accusative clitics: -5.1% CI:[1.6, -11.8] and -3.8% CI:[1.6, -9.2], respectively.

To summarize, previous studies in English, Dutch, and German on the effect of case marking on attraction have not furnished clear evidence, but they do show suggestive numerical patterns that are consistent with the idea that distinctive case marking reduces attraction rates. By contrast, data from French show the opposite pattern. Although the reasons for the crosslinguistic contrast are presently unclear, it is possible that specific properties of French, rather than case per se, could be responsible for the stronger attraction rates with accusative clitics. For example, the past participle in French relative clauses requires agreement with the direct object when it precedes the participle. This could have biased participants to erroneously compute agreement with pre-verbal accusative clitics, which had the role of direct objects, but not with dative clitics or subject modifiers.

The current study contributes to previous work by asking: Does case modulate agreement attraction in comprehension? Under the cue-based retrieval account, which is the theoretical framework adopted in this study, case information could be an important cue for sentence processing, as case marking allows comprehenders to identify the grammatical roles of nouns and assign them thematic roles. Due to this, comprehenders are likely to use case information during incremental comprehension to inform their interpretation of the sentence.

A role of case in attraction effects in comprehension?

There is ample evidence that case information is used to assign grammatical and thematic roles during sentence processing (Chow, Nevins, & Carreiras, 2018; Henry, Hopp, & Jackson, 2017; Hyönä & Hujanen, 1997; Kamide, Altmann, & Haywood, 2003a; Kamide, Scheepers, & Altmann, 2003b; Knoeferle, Crocker, Scheepers, & Pickering, 2005; Traxler & Pickering, 1996; Yamashita, 1997). For instance, studies using the visual world paradigm in German have demonstrated that participants combine the case of sentence-initial NPs with the meaning of verbs to predict upcoming arguments: Given the nominative-marked NP *the hare* and the verb *eats*, participants predictively look at a picture of cabbage, thus showing evidence of having assigned an agent role to *the hare* and used it to predict an upcoming edible object. Conversely, when *the hare* is accusative-marked, participants mostly look at a picture of a fox, thus suggesting that the accusative case allowed them to interpret *the hare* as the theme of the verb and predictively look at the upcoming agent (see also Henry

et al., 2017; Kamide et al., 2003b; Knoeferle et al., 2005). More strikingly, similar effects have been reported in verb-final languages like Japanese in which sentences can contain three noun phrases (a subject, a direct object, and an indirect object) prior to the verb: In these configurations, it has been found that Japanese comprehenders use the case of the first and second NPs to predict the argument role of the third NP, predictively shifting their gaze towards it before the occurrence of the verb (Kamide et al., 2003a; Yamashita, 1997). The active use of case is also attested in languages with poor case morphology, such as English, in which case-marked pronouns have been shown to help speakers avoid garden paths (Traxler & Pickering, 1996).

Due to the relevance of case marking in assigning grammatical and thematic roles, we hypothesized that case information may affect the computation of subject-verb agreement in reading comprehension. Specifically, case information may be used as a cue for resolving subject-verb agreement according to cue-based retrieval models. As summarized above, the cue-based retrieval model of Lewis and Vasishth (2005) assumes that memory search triggers retrieval of co-dependents in order to complete a dependency (Engelmann, Jäger, & Vasishth, 2019; Jäger, Engelmann, & Vasishth, 2017; Vasishth, Nicenboim, Engelmann, & Burchert, 2019). Case information may play a role during this process because it may be used as an additional cue to identify the subject of the verb. Consider a situation in which a sentence has multiple nominative NPs. An example from German is: *Das Kindermädchen_{NOM} denkt, dass der Junge_{NOM} den Spiegel zerbrach* ‘The nanny thinks that the boy broke the mirror.’ Here, if case cues are used during retrieval at the verb *broke*, then the nominative cue will match two noun phrases, leading to lower accuracy in retrieving the correct noun compared with a baseline condition in which the local subject is the unique noun with nominative case marking. In the experiments presented here, we investigate whether case overlap leads to increased difficulty in comprehension.

The present study

The current study examined subject-verb agreement in Armenian, which is a pro-drop subject-object-verb (SOV) language with a productive case system. Nominative case is morphologically unmarked and is usually used for grammatical subjects. Non-nominative cases are usually used for grammatical (in)direct objects. Importantly, definite animate subject nouns do not exhibit syncretism of case markers (Dum-Tragut, 2009); syncretism is a situation where one form corresponds to two or more case functions. We exploited these properties to construct our experimental materials. In our design, sentence-initial NPs were modified by an object relative clause (RC), and they were either nominative or accusative marked:

- (3a) The painter(s)_{NOM} [_{RC} that the sculptor_{NOM} ignored]...
 (3b) The painter(s)_{ACC} [_{RC} that the sculptor_{NOM} ignored]...

In contrast to most previous work, which largely focused on attractors within prepositional phrases, in our design the attractor *the painter* was the head of an object RC. Our question of interest concerned whether the attractor would interfere with the agreement relationship between *sculptor* and *ignored* within the RC. This type of configuration has been found to yield attraction effects in previous work on English and Spanish (Dillon et al., 2013; Lago et al., 2015; Staub, 2009; Wagers et al., 2009), and so our research questions were

whether these effects would be replicated in Armenian and whether they would be modulated by the case of the attractor noun. In (3a) the attractor noun was nominative-marked, and the sentence continuation after the RC provided information consistent with the attractor NP (*the painter*) having a subject role in the main clause (e.g., *has been ostracized from the art community*).

Critically, the pro-drop status of Armenian also allowed us to construct versions like (3b) in which the attractor was accusative-marked. In these versions, the sentence continuation after the RC was similar to (3a) with the exception that the verb appeared in the active voice (i.e. *ostracized* rather than *has been ostracized*). This resulted in a sentence in which the attractor was the object of the main clause (rather than the subject), whereas the pronominal subject of the main clause was tacit (i.e. *The painter [that the sculptor ignored] ostracized (they) from the art community*). A tacit subject can be grammatically licensed in Armenian through the inflectional morphology of its verb (Dum-Tragut, 2009: 123). In order to interpret a tacit subject, its referent needs to have been established in the discourse so that it can be recovered using the number and person features of the verb. Indeed, avoiding the expression of previously introduced referents is extremely common in Armenian, and sentences with tacit pronominal subjects are considered the unmarked form (Dum-Tragut, 2009: 555). Furthermore, the tacit subjects in our materials always consisted of third person plural pronouns (“they”), and thus they constituted cases of impersonal constructions in which the doer of the action is either unknown, irrelevant, or is understood from sentence context, similarly to passives (Dum-Tragut, 2009: 417).

We conducted three experiments in Armenian: a forced-choice task and two self-paced reading (SPR) studies. In the forced-choice task (Experiment 1), participants only saw the materials up to the RC subject *sculptor*, and they had to decide between the singular and plural continuations of the sentence. In the self-paced reading tasks (Experiments 2 and 3), participants read entire sentences for comprehension. Experiment 1 had two goals. One goal was to establish whether attraction occurred at all in Armenian. The second goal was to establish whether case marking on the attractor affected the selection of verb number in a paradigm similar to those used by previous production studies. The goals of Experiments 2 and 3 were to determine whether attraction occurred during reading comprehension (Experiments 2 and 3) and whether case marking modulated attraction strength (Experiment 3).

Experiment 1

Experiment 1 investigated attraction errors using a forced-choice paradigm introduced by Staub (2009, 2010). This is a task that has aspects of both production and comprehension: Participants read a sentence preamble and have to select a suitable verb continuation from a set of two options. Like spoken production paradigms, the forced-choice task allows us to examine participants’ verb choices and assess the circumstances under which errors are made. But in addition, the forced-choice task allows us to record participants’ response times, providing a measure of latency that reflects decision time.

Our research question was whether we would observe agreement attraction in Armenian and whether it would be modulated by the case marking of the attractor noun. Our

predictions regarding response accuracy were as follows. If the plural number on the attractor leads to a greater proportion of erroneous verb choices, this would confirm that attraction occurs in Armenian. Furthermore, if different case marking on the attractor and subject noun reduces the proportion of erroneous verb choices, then this would show that case marking reduces attraction effects.

Regarding the prediction for response times, previous work by Staub (2009, 2010) has established that response times for correct verb choices are longer in the presence of a plural attractor. Hammerly et al. (2019) show that this pattern can be explained in terms of the Marking and Morphing model, assuming that a more ambiguous number marking on the subject phrase slows down correct verb-choice decisions in the forced-choice task.

What patterns of retrieval times would the cue-based retrieval model predict? If we assume that a retrieval occurs after a verb choice is made (presumably to check that the correct verb form has been selected), then cue-based retrieval would predict faster retrieval times with plural attractors; this is the opposite of the pattern found by Staub (2009, 2010). However, it is questionable whether retrieval occurs in the course of the forced-choice task. The response times measured in this task involve the prediction of a verb form based on the sentence fragment, recognition of the two verb forms displayed on the screen, accessing both verb forms from long-term memory, and a decision process to select one of these forms as the appropriate continuation of the sentence preamble. Since the trial ends as soon as the participant makes a verb choice, the response time most likely reflects this decision process rather than any subsequent retrieval process.

Participants

One hundred and eighty-nine participants were recruited online via email and social networking sites. Data from 14 participants were excluded: Five participants missed the response deadline in all trials, four participants reported uncorrected vision, three participants reported a speech impairment, one participant reported a native language other than Armenian, and another one had a filler accuracy below 70%. The remaining 175 participants (mean age 29 years, age range 18–40 years, 149 females, 164 right-handed) had normal or corrected-to-normal vision. They were self-reported native speakers of Armenian. They all had finished secondary school when the experiment took place. In addition, the majority (164 participants) had completed or were still pursuing higher education. Once testing was complete, a raffle was held, and three randomly selected participants received monetary compensation in Armenian Drams, equivalent to 20 Euros each.

Materials

An example set of the experimental items is given in Table 1. The items consisted of 48 sentence fragments containing object-extracted relative clauses (ORCs), such as *the painter that the sculptor...* In what follows, we refer to the noun that was the subject of the RC verb as *the target* (e.g. *the sculptor*) and to the noun that was the RC head as *the attractor* (e.g. *the painter*). The target noun was always the controller of verb agreement. The attractor noun was followed by the relative pronoun *that*, which was always accusative marked. Participants' task was to read a sentence fragment and continue it with one of two

alternative verb forms (e.g., ignored_{SG} vs. ignored_{PL}). In the experimental items, the singular RC verb form was always the correct response, providing a grammatical continuation. The RC verbs were lexical verbs in the aorist form, which is a synthetic tense-aspect combination (one word inflected for person and number) that indicates a witnessed event completed in the past.

There were 72 fillers, which consisted of 24 sentence fragments in each of the following categories: subject-extracted relative clauses, object-extracted relative clauses, and (in)direct object sentences. Each of these fragments were varied in length and complexity, but the number marking of the nouns within each fragment was held constant (either all singular or all plural) to avoid attraction errors in the fillers. The fillers were constructed such that across the experiment half of the items had a target singular response, and the other half had a target plural response.

All items were distributed across four lists such that each participant saw all fillers but only one version of each experimental item. The order of fillers and experimental items was randomized for each participant. The full set of materials and data for this and for all following experiments are available here: <https://osf.io/ye98q/>.

Table 1

*Sample experimental stimuli for Experiment 1. For this set of items, the two response options were the singular and plural forms of the verb **ignore** (i.e., arhamarh-ec' 'ignore-AOR.3.SG' and arhamarh-ec'-in 'ignore-AOR.3-PL', respectively). SG = singular, PL = plural, NOM = nominative, ACC = accusative, DEF = definite, AOR = aorist.*

case match, singular attractor	Nkarič-Ø-ë, Painter-SG.NOM-DEF	or-i-n that-SG.ACC-DEF	k'andakagorç-Ø-ë sculptor-SG.NOM-DEF
case match, plural attractor	Nkarič- ner -ë, Painter-PL.NOM-DEF	or-one' that-PL.ACC	k'andakagorç-Ø-ë sculptor-SG.NOM-DEF
case mismatch, singular attractor	Nkarč-i-n, Painter-SG.ACC-DEF	or-i-n that-SG.ACC-DEF	k'andakagorç-Ø-ë sculptor-SG.NOM-DEF
case mismatch, plural attractor	Nkarič- ner -i-n, Painter-PL-ACC-DEF	or-one' that-PL.ACC	k'andakagorç-Ø-ë sculptor-SG.NOM-DEF
<i>'The painter(s) that the sculptor...'</i>			

Procedure

Participants first gave informed consent and provided demographic information. Afterwards, they read the instructions that emphasized the importance of fast and accurate responses. Each session started with a practice phase that included seven filler-like fragments, followed by the actual experiment. The sentence fragments were presented word by word in the center of the screen, using the web-based platform Ibex Farm (<http://spellout.net/ibexfarm>). Each word was displayed for 500ms, on a grey background in 18pt Helvetica font. Each fragment was followed by a response screen, prompting participants to continue the fragment by choosing between the singular and plural forms of the verb. Key assignments were counterbalanced across participants such that 89 participants pressed the *F* key for singular and the *J* key for plural, whereas 86 participants used the reverse key configuration. Feedback was provided only for practice trials. If participants failed to give a response within the 3000ms deadline, the trial timed out, and a message appeared that read *Time has expired*. An experimental session lasted approximately 20 minutes.

Analysis

We analyzed response accuracy and response times for correctly answered trials. Prior to the analysis, 1.5% of the experimental trials were discarded because in these trials participants had either missed the response deadline or had provided a response in less than 200ms. These cutoffs follow those used by Staub (2010). Response times were log-transformed following the Box-Cox procedure (Box & Cox, 1964) to account for the skewness inherent to response time data.

We fit a Bayesian linear mixed model (Bayesian LMM) with a Gaussian link function to the response time data and a Bayesian linear mixed model with a Binomial link function to the accuracy data in the R programming environment (R Core Team, 2018), using the package *brms* (Bürkner, 2017). The experimental factors *attractor number* (singular/plural) and *case* (match/mismatch) as well as their interaction were entered into the models as fixed effects. The factors were sum-coded: Singular was coded as -1 and plural as 1. Case match was coded as -1 and mismatch as 1. Participants and items were entered into the models as random effects. All models had a full variance-covariance matrix specification for participants and items.

We used so-called mildly informative priors, which allow a wide range of parameter values a priori. The prior for the intercept was a normal distribution with a mean of 0 and a standard deviation (SD) of 10. This means we could be 68% certain that the intercept would fall between -10 and 10 on log-odds or log scale (this approximates an interval ranging from 0 to 100% for accuracy measures and from 0ms to 22sec for time measures). The priors for slopes (i.e., the effects of interest, including interactions) were set to be a standard normal distribution with a mean of 0 and an SD of 1. Given our sum-coded factors, this means that if the intercept (i.e., grand mean) in accuracy data were, say, 1.4 on log-odds scale ($\approx 80\%$), we could be 68% certain that the effect of interest would be less than -0.76 ($\approx 32\%$). Similarly, if the intercept value in time measures were, say, 7 ($\approx 1097\text{ms}$), we could be 68% sure that the effect of interest would be less than 7.855 ($\approx 2578\text{ms}$).² The prior distribution

²In order to calculate effect size we need to take intercept into account: $\text{inv.logit}(1.4+1) - \text{inv.logit}(1.4-1)$

of all standard deviations was a half-normal (truncated at 0) with a mean of 0 and a SD of 1. Finally, a so-called LKJ prior (Stan Development Team, 2017) was used for the correlation matrix for the random effects. The prior can regularize the distributions of the correlation parameters such that extreme values like +1 and -1 are less likely a priori. For a detailed tutorial on fitting linear mixed models in a psycholinguistic setting, see Sorensen, Hohenstein, and Vasissth (2016). The same priors were used across the experiments. For each model, four sampling chains were run, each with 2000 iterations. Of the 2000 iterations, the initial 1000 were warm-up iterations. Thus, there were a total of 4000 sampling iterations available for analysis.

The Bayesian model output provides a posterior distribution of likely values for a parameter given the data and the model. We report the estimate of the posterior mean with its 95% credible interval (CrI), which denotes the range of values within which we can be 95% certain that the true effect falls. Finally, the analyses were performed on log odds for the accuracy data and on log milliseconds for the response time data, but we report the back-transformed model estimates as percentages and milliseconds for ease of interpretation.

Results

Response accuracy. Accuracy was high in the filler items (mean = 91.4%, SE = 0.3%), suggesting that participants were able to perform accurately under time pressure. In the experimental items, participants made 587 agreement errors (7% of all responses). 76% of the agreement errors were in conditions with a plural attractor and 24% in conditions with a singular attractor. The mean percentages of correct responses in each of the four conditions are illustrated in Figure 1A (see also Table A1 in the Appendix).

The estimate of the main effect of case was zero 0% CrI: [-0.8, 0.8]. The number effect was -4.6% CrI: [-6.3, -3.1], suggesting fewer agreement errors in the singular than in the plural attractor conditions. The interaction between case and attractor number was 0.6% CrI: [-0.2, 1.4] (Figure 2A).³ This effect suggests that plural attractors elicited slightly more agreement errors in case-match than -mismatch conditions. Follow-up nested comparisons revealed that the attractor number effect was -5.1% CrI: [-7.5, -3.1] in case-match conditions and -3.8% CrI: [-5.6, -2.4] in case-mismatch conditions.

Response times. Mean response times of correctly-answered trials in each of the four conditions are shown in Figure 1B. The main effect of case was -22ms CrI: [-36, -7], with faster responses in the case-mismatch than -match conditions. The number effect was 96ms CrI: [75, 117], suggesting longer response times in plural than in singular attractor conditions. Notice that the main effect of case was small as compared with the attractor number effect (almost one-fourth of the number effect), and that it was mainly restricted to conditions with plural attractors. The interaction between case and number was -13ms CrI: [-29, 3]. This effect suggests that plural attractors elicited longer response times in case-match than -mismatch conditions (Figure 2B). In a nested comparison, the attractor number effect was 109ms CrI: [80, 139] in case-match conditions, and 84ms CrI: [59, 109] in case-mismatch conditions.

and $\exp(7 + 1) - \exp(7 - 1)$.

³For this and for all following studies, additional analyses on raw reading times yielded qualitatively similar results for interaction effects (Balota, Aschenbrenner, & Yap, 2013).

Figure 1. Mean accuracy and response times of correctly-answered trials in Experiment 1. Error bars show the standard error of the means.

Figure 2. Posterior probability distributions of effects in Experiment 1. The distributions display the posterior probability of different effect sizes, with solid vertical lines corresponding to posterior means and shaded areas to 95% credible intervals. The dashed vertical lines correspond to an effect size of zero.

Discussion

Experiment 1 found attractor number effects in participants' accuracy and response times: Participants made more agreement errors and showed longer latencies for correct responses when a plural rather than singular attractor was present. With regard to case effects, a different picture emerged in the accuracy and response time data. The accuracy results provided no indication of a main effect of case and an extremely small estimate of the effect of case on attractor number, which ranged from -0.2% to 1.4%, with a mean estimate of 0.6%. This suggests that the influence of distinctive case marking on participants' verb choices in these data may be very limited.

By contrast, the response time results provided clear indication of a main effect of case: Consistent with facilitated processing, participants showed faster response times when the two nouns had different case marking. We also saw an interaction between case and attractor number that showed that the disruptive influence of plural attractors on response times was reduced when the two nouns had different case marking relative to when they had the same case marking. This effect is consistent with a role of case information in agreement computations, suggesting that participants may have had an easier time choosing the correct verb form when the attractor noun had a non-subject-like case, thus aiding the identification of the true subject head.⁴ The fact that case effects on attraction emerged more readily in response time measures motivated the following SPR studies, which had reading times as their main dependent variable.

Experiment 2

Experiment 2 sought to establish whether plural attractors affected reading comprehension in Armenian. We manipulated the presence of a plural attractor in grammatical and ungrammatical sentences. For ungrammatical sentences, we hypothesized that if Armenian comprehenders experience attraction in reading comprehension, they should show facilitated processing due to the presence of a plural attractor, consistent with facilitatory interference effects proposed by cue-based retrieval (e.g. Dillon et al., 2013; Lago et al., 2015; Wagers et al., 2009). For grammatical sentences, previous studies have reported mixed findings. Whereas some studies have failed to observe any effects, others have occasionally found longer reading times at the verb due to plural attractors (see Hammerly et al., 2019; Jäger

⁴A reviewer pointed out a potential problem with this interpretation, namely that the case match and mismatch manipulation involved different syntactic structures. In the case-match conditions, the attractor was the subject of the main clause verb, whereas it was the object in the case mismatch conditions. It is possible that the match condition was harder because the structure was lower in frequency, more infelicitous, or more difficult to comprehend. To address this hypothesis, we performed a supplementary analysis in Experiment 3, which used the same items as Experiment 1. Specifically, we analyzed participants' reading times prior to the RC verb to examine whether there was evidence of more comprehension difficulty in the case-match conditions. This was not the case: The pattern at the attractor noun (the first word of the sentence) showed longer reading times in the mismatch than match conditions (95ms CrI:[73, 119]). The size of the effect decreased at the following relative pronoun (15ms CrI:[6, 25]) and did not persist at the RC subject, the region immediately before the RC verb. Thus, we found no indication that the match structures were harder to process than the mismatch structures prior to the verb. Rather, the increased difficulty in the mismatch conditions is consistent with prior work showing an object-initial dispreference, even in languages with freer word order than English (Haupt, Schlesewsky, Roehm, Friederici, & Bornkessel-Schlesewsky, 2008; Schlesewsky, Fanselow, Kliegl, & Krems, 2000).

et al., 2017). Only one study has reported longer reading times with singular attractors than plural ones (Nicenboim, Vasisht, Engelmann, & Suckow, 2018), consistent with the inhibitory interference predicted by the cue-based retrieval model of Lewis and Vasisht (2005). The model predicts this pattern because it assumes that the overlap in singular number between the target and attractor should render the verb number cue ineffective in uniquely identifying the target noun, leading to slower retrieval of the target from memory.

For Armenian, our predictions were as follows: If attractor number interferes with reading comprehension, we expected to observe facilitatory interference in ungrammatical sentences, resulting in faster reading times after the RC verb in sentences with a plural attractor. Additionally, interference effects may be observed in grammatical sentences; here, cue-based retrieval predicts inhibitory interference from singular attractors. However, given that such interference effects have only rarely been observed in previous work, the chances of detecting any interference in the grammatical conditions seemed a priori low. Nevertheless, it is important to include the grammatical conditions in the experiment in order to balance the overall proportion of grammatical to ungrammatical verbs.

Participants

Forty-eight participants (mean age 23 years, age range 18–34 years, 28 females, 47 right-handed) were recruited in the cities of Artashat and Yerevan, Armenia. One participant had mild uncorrected near-sightedness that reportedly did not cause discomfort when viewing a computer screen; the rest had normal or corrected-to-normal vision. All were native speakers of Armenian. The majority (44 participants) had already finished or were still pursuing higher education. Each participant gave informed consent and received monetary compensation in Armenian Drams in the equivalent of 6 Euros.

Materials

Thirty-six sentence sets were randomly selected from Experiment 1 and adapted for this experiment (see Table 2 for an example set). The sets were arranged in a 2×2 repeated measures design with *number interference* (no-interference/interference) and *grammaticality* (grammatical/ungrammatical) as factors. The attractor and RC verb differed in number in the no-interference conditions, whereas they matched in the interference conditions: That is, in grammatical sentences with interference, the attractor and RC verb were both singular; in ungrammatical sentences with interference, they were both plural. Case was held constant to first address whether interference was observed at all in Armenian: Both the attractor and target noun bore nominative case. In grammatical conditions, the target noun and RC verb agreed in number (i.e., both were singular), whereas in ungrammatical conditions, the target noun was singular and the RC verb was plural. Because of the plural marking, the RC verb in ungrammatical sentences was two characters longer than in grammatical sentences. Since facilitatory interference tends to emerge one or two words downstream from the critical region (Jäger et al., 2017), the critical RC verb was always followed by a two-word adverbial phrase that acted as a spillover region for measurement.

Participants read sentences in a non-cumulative self-paced reading paradigm, and they answered yes/no comprehension questions. As in previous studies, comprehension

questions targeted relationships other than the agreement between the subject and RC verb. These questions were intended to retain participants' attention and discourage them from developing a reading strategy. For example, the question for the item set in Table 2 was *Was it during the exhibition that the painter(s) was/were ignored?* (correct answer: *yes*).

The experimental items were complemented with 84 grammatical fillers. 72 fillers were adapted from Experiment 1, and 12 fillers were newly constructed. All items were distributed across four lists such that each list included all fillers but only one version of each experimental item. The percentage of ungrammatical sentences per list was 15%. The presentation of experimental and filler items was pseudo-randomized on a by-participant basis such that no two experimental items were adjacent.

Table 2

Sample experimental stimuli for Experiment 2. Note that the term “interference” applies to sentences with singular attractors in grammatical sentences but plural attractors in ungrammatical sentences. In other words, an interference configuration arises when the attractor and relative-clause verb number match. Gram = grammatical, ungram = ungrammatical, SG = singular, PL = plural, NOM = nominative, ACC = accusative, DEF = definite, AOR = aorist.

gram, no-interference	Nkarič-ner-ë, Painter-PL.NOM-DEF	or-onc' that-PL.ACC	k'andakagorç-Ø-ë sculptor-SG.NOM-DEF	arhamarh-ec'... ignore-AOR.3SG...
gram, interference	Nkarič-Ø-ë, Painter-SG.NOM-DEF	or-i-n that-SG.ACC-DEF	k'andakagorç-Ø-ë sculptor-SG.NOM-DEF	arhamarh-ec'... ignore-AOR.3SG...
ungram, no-interference	Nkarič-Ø-ë, Painter-SG.NOM-DEF	or-i-n that-SG.ACC-DEF	k'andakagorç-Ø-ë sculptor-SG.NOM-DEF	arhamarh-ec'-in... ignore-AOR-3PL...
ungram, interference	Nkarič- ner -ë, Painter-PL.NOM-DEF	or-onc' that-PL.ACC	k'andakagorç-Ø-ë sculptor-SG.NOM-DEF	arhamarh-ec'-in... ignore-AOR-3PL...
	...c'owc'ahandesi ...exhibition	ënt'ac'k'owm, during	vagowc' mekowsac'vel long been ostracized	ē/en arvestagetneri is/are artists' šrjanakic'. circle
‘The painter(s) that the sculptor ignored during the exhibition has/have long been ostracized from the art community.’				

Procedure

After providing informed consent and demographic information, participants were instructed to read the sentences at a natural pace and answer the questions as fast and accurately as possible. They were not informed about the existence of ungrammatical sentences. Each session started with six practice trials.

Sentences were presented on a laptop computer using the Linger software (<http://tedlab.mit.edu/~dr/Linger/>). They were displayed word-by-word in a centered self-paced reading paradigm. The words were presented in black with a 28pt size on a gray background in Sylfaen font, which supports Armenian characters. Each trial began with a fixation cross in the middle of the screen, and participants were required to press the space bar to initiate the sentence. Each subsequent button press replaced the current word with the following one, and the reading times between two successive button presses were recorded. Each sentence was followed by a comprehension question. To give a *yes* or *no* answer, participants were prompted to press the *F* or *J* key respectively. Half of the questions had a *yes* answer, and the other half had a *no* answer. Feedback was provided only for practice trials. There were two mandatory breaks occurring after each block of 40 items. An experimental session lasted approximately 45 minutes.

Analysis

We analyzed reading times at the RC verb (critical region) and at the following word (post-critical region), which is the region in which attraction effects have been most often found in previous self-paced reading studies (Lago et al., 2015; Pearlmutter et al., 1999; Wagers et al., 2009). Prior to the analysis, RTs below 200ms and above 8000ms were excluded, resulting in the overall loss of 0.3% of observations. We used a higher upper threshold than previous self-paced reading studies because reading times in Armenian were longer than those observed in previous work, likely due to the use of a non-latin script or the increased morphological complexity of Armenian words. Qualitatively similar results were obtained with a lower threshold of 6000ms.

We carried out two analyses. First, we fit a model examining main effects and interactions, with the fixed effects of *number interference* (no-interference/interference), *grammaticality* (grammatical/ungrammatical), and their interaction. No-interference conditions were coded as -1 and interference conditions as 1. Grammatical conditions were coded as 1 and ungrammatical ones as -1. Caution should be applied in the interpretation of the grammaticality effect: Because the RC verb varied in number between grammatical and ungrammatical sentences (the RC verb was plural and, therefore, two characters longer in ungrammatical than grammatical sentences), an effect of grammaticality could be in part due to word-length or number complexity. However, the grammaticality effect is not of interest here; the comparisons of primary interest were within grammatical and ungrammatical sentences in which the verb length and number were identical. The second model involved nested comparisons for grammatical and ungrammatical sentences separately, comparing the no-interference conditions (coded as -1) with the interference conditions (coded as 1).

Results

Question-response accuracy was high in the fillers (mean = 90.1%, SE = 0.5%) and in the critical items (mean = 86.1%, SE = 0.8%). Accuracy rates in the critical items were comparable across conditions (see Table A1 in the Appendix). By-region reading times are presented in Figure 3.

Figure 3. Panel A shows region-by-region mean reading times in Experiment 2, whereas panel B provides a closeup look at mean reading times in the regions of interest. Interference conditions involve a singular attractor noun in grammatical sentences and a plural attractor noun in ungrammatical sentences. Error bars show the standard error of the means.

Critical region. In the analysis of main effects and interactions, the estimate of

the main effect of grammaticality was -291ms CrI: [-397, -195], with shorter reading times in grammatical than ungrammatical conditions. The rest of the estimated effects were uninformative, with credible intervals spanning a broad range of values below and above zero (Figures 4A and C). Specifically, the main effect of interference was 7ms CrI: [-48, 62], and the interference-grammaticality interaction was 19ms CrI: [-35, 74]. In nested comparisons, the interference effect was 26ms CrI: [-44, 98] in grammatical and -11ms CrI: [-91, 67] in ungrammatical sentences.

Post-critical region. In the analysis of main effects and interactions, the main effect of grammaticality was -37ms CrI: [-72, -4], with shorter reading times in grammatical than ungrammatical conditions. The main effect of interference was -19ms CrI: [-51, 14]. This estimate was uninformative given the credible interval with broad range of values on either side of zero. The interaction between interference and grammaticality was 33ms CrI: [1, 66], suggesting that number-matching attractors affected the processing of grammatical and ungrammatical sentences differently (Figure 4B).

The nested analysis revealed that the number interference effect was 14ms CrI: [-30, 58] in grammatical and -51ms CrI: [-100, -2] in ungrammatical sentences. This suggests that attractors that matched the number of the verb led to longer reading times in grammatical sentences and, conversely, to shorter reading times in ungrammatical sentences, as predicted by the Lewis and Vasishth cue-based retrieval model (Engelmann et al., 2019; Vasishth et al., 2019). However, whereas in ungrammatical conditions the interference effect was numerically consistent with the model's prediction, in grammatical sentences the credible interval for the interference effect spanned widely across positive and negative numbers (Figure 4D).

Discussion

Experiment 2 established the presence of number interference effects during reading comprehension in Armenian. Crucially, the interference effect differed between grammatical and ungrammatical sentences, as supported by an interaction between interference and grammaticality in the post-critical region. Nested comparisons revealed that in ungrammatical sentences, attractors that matched the number of the verb elicited shorter reading times; in grammatical sentences, there was no clear indication of an effect. Therefore, these patterns were consistent with facilitatory interference (in ungrammatical sentences) but not with inhibitory interference (in grammatical sentences), yielding only partial support for the predictions of the Lewis and Vasishth cue-based retrieval model.

In comparison with previous studies, the estimated interference effect in the post-critical region was of larger magnitude and had a wider credible interval (i.e., -51ms CrI: [-100, -2]) than the estimate derived from the meta-analysis by Jäger et al. (2017) (i.e., -22ms CrI: [-36, -9]). This was presumably due to the smaller sample size of our study relative to this meta-analysis, which synthesized findings from eleven published studies and likely yielded more precise estimates. Nevertheless, our results support the existence of facilitatory interference in ungrammatical sentences in Armenian and provide the first demonstration of number interference in this language. Next, we turn to the role of case in modulating interference effects.

Figure 4. Posterior probability distributions of effects in Experiment 2. The distributions display the posterior probability of different effect sizes, with solid vertical lines corresponding to posterior means and shaded areas to 95% credible intervals. The dashed vertical lines correspond to an effect size of zero.

Experiment 3

Experiment 3 was designed to test whether distinctive case marking would reduce interference effects. The same sentences as in Experiment 2 were used but with the added manipulation of case marking on the attractor nouns. We hypothesized that if case was a retrieval cue in the comprehension of subject-verb agreement, we should observe increased interference in conditions where the attractor and target matched in case compared with the conditions where the two nouns mismatched in case. Thus, the effect of interest was the interaction between interference and case. For ungrammatical sentences, we expected distinctive case marking (i.e., case mismatch) to facilitate the retrieval of the grammatically licit target noun, reducing facilitatory interference as compared with the conditions in which the attractor and the subject head matched in case. By contrast, we did not expect a role of case in grammatical sentences, as Experiment 2 failed to find interference effects.

Participants

One hundred and twenty participants were recruited in the cities of Artashat and Yerevan, Armenia. Three participants were excluded because Russian was their primary language, resulting in 117 participants (mean age 22 years, age range 18–39 years, 84 females, 110 right-handed). 11 participants had mild uncorrected near-sightedness, but they reported feeling comfortable when viewing a computer screen; the rest had normal or corrected-to-normal vision. All were native speakers of Armenian. The majority (112 participants) had completed or were still pursuing a degree in higher education. Participants gave informed consent and received monetary compensation in Armenian Drams, equivalent to 6 Euros each.

Materials

The experimental items consisted of 48 sentence sets that were arranged in a $2 \times 2 \times 2$ repeated measures design, crossing the factors *grammaticality* (grammatical/ungrammatical), *number interference* (no-interference/interference), and *case* (match/mismatch). Thus, in addition to including the case match conditions tested in Experiment 2, Experiment 3 included case mismatch conditions in which the target noun was nominative, but the attractor was accusative marked because it was the object (rather than the subject) of the main clause verb (which had a null subject). Of the 48 sets, 36 sets were the same as in Experiment 2. In addition, 12 sentence sets were adapted from Experiment 1. An example item in the case-mismatch conditions is presented in Table 3. This, together with the example item set in the case-match conditions in Table 2, constitute the complete set of eight experimental conditions tested in Experiment 3.

The items were distributed across eight lists in a Latin Square design. Each participant received one list such that they saw only one version of each experimental item and six items per condition. 112 grammatical fillers were created and added to each list, resulting in 15% of the items being ungrammatical. The fillers varied in length and syntactic structure, including simple passives, sentences with or without (in)direct objects, ellipsis, indirect speech, coordinate clauses, and subordinate adverbial clauses. The presentation of experimental and

filler items was pseudo-randomized on a by-participant basis such that no two experimental items were adjacent.

Table 3

Sample experimental item in four case-mismatch conditions for Experiment 3. The complete set of conditions also included the four case-match conditions presented in Table 2. As in Experiment 2, the term “interference” applies to sentences with singular attractors in grammatical sentences but plural attractors in ungrammatical sentences. Gram = grammatical, ungram = ungrammatical, SG = singular, PL = plural, NOM = nominative, ACC = accusative, DEF = definite, AOR = aorist.

gram, no-interference	Nkarič-ner-i-n, Painter-PL-ACC-DEF	or-onc’ that-PL.ACC	k’andakagorç-Ø-ë sculptor-SG.NOM-DEF	arhamarh-ec’... ignore-AOR.3SG...
gram, interference	Nkarč-i-n, Painter-SG.ACC-DEF	or-i-n that-SG.ACC-DEF	k’andakagorç-Ø-ë sculptor-SG.NOM-DEF	arhamarh-ec’... ignore-AOR.3SG...
ungram, no-interference	Nkarč-i-n, Painter-SG.ACC-DEF	or-i-n that-SG.ACC-DEF	k’andakagorç-Ø-ë sculptor-SG.NOM-DEF	arhamarh-ec’-in... ignore-AOR-3PL...
ungram, interference	Nkarič- ner -i-n, Painter-PL-ACC-DEF	or-onc’ that-PL.ACC	k’andakagorç-Ø-ë sculptor-SG.NOM-DEF	arhamarh-ec’-in... ignore-AOR-3PL...
<p>...c’owc’ahandesi ënt’ac’k’owm, vağowc’ mekowsac’rel en arvestagetneri šrjanakic’ ...exhibition during long ostracized (they) are artists’ circle.</p> <p><i>‘They have long ostracized from the art community the painter(s) that the sculptor ignored during the exhibition.’</i></p>				

Procedure and analysis

The same procedure was used as in Experiment 2. We analyzed reading times at the RC verb (critical region) and at the word immediately following it (post-critical region). We applied the same trimming procedure as described in Experiment 2, which led to the overall loss of 0.5% of trials. Qualitatively similar results were obtained with a lower cut-off value of 6000ms. As in Experiment 2, two analyses were carried out. First, we tested for the main effects of *grammaticality* (grammatical/ungrammatical), *number interference* (no-interference/interference), *case* (match/mismatch), and their interaction. Then, we performed nested comparisons to look into the effects of number interference (no-interference/interference), case (match/mismatch), and their interaction in grammatical and ungrammatical sentences separately. All fixed effects were sum coded such that ungrammatical conditions were coded as -1 and grammatical ones as 1; no-interference was coded as -1 and interference as 1; case match was coded as -1 and mismatch as 1.

Results

Question-response accuracy was high in the fillers (mean = 94.1%, SE = 0.2%) and in the experimental items (mean = 87.2%, SE = 0.4%). Accuracy rates in the critical items were comparable across conditions (see Table A1 in the Appendix). By-region reading times in grammatical and ungrammatical sentences are presented in Figures 5 and 6, respectively. In the text, we report effects that either showed convincing patterns or were of theoretical importance. All other effects spanning a range of values on either side of zero are deemed as inconclusive and reported in Table 4.

Critical region. In the analysis of main effects and interactions, the main effect of grammaticality was -209ms CrI: [-251, -169], with shorter reading times in grammatical than in ungrammatical conditions. The interaction between interference and grammaticality was -30ms CrI: [-54, -5], suggesting that interference affected grammatical and ungrammatical sentences differently. The main effect of case was -19ms CrI: [-45, 6], with shorter reading times in case-mismatch than case-match conditions. (Figure 7A).

In the nested analysis, in grammatical sentences the interference effect was -22ms CrI: [-55, 11], and in ungrammatical sentences the interference effect was 36ms CrI: [-2, 75]. Thus, a speedup was observed in grammatical sentences and a slowdown in ungrammatical sentences. The sign of the effects (that is, facilitation in grammatical and inhibition in ungrammatical sentences) was surprising and the opposite of what cue-based retrieval predicts. The main effect of case was largely inconclusive in grammatical sentences -4ms CrI: [-36, 28] but not in ungrammatical sentences -34ms CrI: [-74, 4], suggesting that the main effect of case was driven by ungrammatical sentences (Figures 7B and C).

As noted above, interference in grammatical and ungrammatical sentences yielded effects with unexpected directions. However, a closer look at the data suggests that spillover effects from previous regions could have potentially contaminated the results at the critical RC verb. All three regions prior to the RC verb were read more slowly in conditions with sentence-initial plural attractors (i.e., RC heads) than with singular attractors. This was also confirmed statistically: The number effect was 150ms CrI: [118, 184] in the RC head region, 13ms CrI: [3, 24] in the RC pronoun region, and 42ms CrI: [23, 61] in the RC subject region.

Figure 5. Panel A shows region-by-region mean reading times in grammatical sentences in Experiment 3, whereas panel B provides a closeup look at mean reading times in the regions of interest. No-interference conditions involve a plural attractor noun, whereas interference conditions involve a singular attractor noun. Error bars show the standard error of the means.

Figure 6. Panel A shows region-by-region mean reading times in ungrammatical sentences in Experiment 3, whereas panel B provides a closeup look at mean reading times in the regions of interest. No-interference conditions involve a singular attractor noun, whereas interference conditions involve a plural attractor noun. Error bars show the standard error of the means.

This number effect originating at plural attractors was presumably due to plural complexity or word length. Whatever the reason may be, the spillover seemed to be the cause that in interference conditions there was a relative speedup in grammatical and a slowdown in ungrammatical sentences. To test this hypothesis, we built a model with nested comparisons for grammatical and ungrammatical sentences, and we included the centered reading times of the preceding word as a covariate. This model reduced the estimated mean effect sizes, shifting posterior distributions to more positive values in grammatical and negative values in ungrammatical sentences, thus rendering the estimates inconclusive: -15ms CrI: [-52, 20] in grammatical sentences and 24ms CrI: [-14, 62] in ungrammatical sentences. Furthermore, when the reading times of the preceding region were taken into consideration, the main effect of case in ungrammatical sentences was strengthened, with an estimated mean of -41ms and a 95% credible interval of [-79, -3].

Table 4

Statistical results in Experiment 3. Effects are described in terms of their posterior mean in milliseconds and 95% credible interval [CrI].

	Critical region	Post-critical region
<i>Main effects and interactions</i>		
grammaticality	-209 [-251, -169]	-71 [-94, -47]
interference	7 [-18, 32]	-8 [-25, 8]
case	-19 [-45, 6]	-12 [-28, 4]
interference $\times$ grammaticality	-30 [-54, -5]	12 [-4, 29]
case $\times$ grammaticality	15 [-9, 39]	-4 [-20, 13]
case $\times$ interference	6 [-19, 29]	-10 [-26, 6]
case $\times$ interference $\times$ grammaticality	-9 [-32, 15]	-8 [-23, 7]
<i>Nested comparisons</i>		
grammatical: interference	-22 [-55, 11]	4 [-19, 27]
grammatical: case	-4 [-36, 28]	-16 [-39, 8]
grammatical: case $\times$ interference	-3 [-35, 31]	-18 [-42, 6]
ungrammatical: interference	36 [-2, 75]	-21 [-46, 3]
ungrammatical: case	-34 [-74, 4]	-9 [-31, 14]
ungrammatical: case $\times$ interference	15 [-19, 48]	-2 [-24, 20]

Post-critical region. In the analysis involving main effects and interactions, the effect of grammaticality was -71ms CrI: [-94, -47], suggesting that reading times were shorter in grammatical than in ungrammatical conditions. There was some indication of a main effect of case with an estimate of -12ms CrI: [-28, 4], suggesting that case mismatch elicited shorter reading times than case match. There was also some indication of an interaction between grammaticality and interference with an estimate of 12ms CrI: [-4, 29], suggesting that interference affected grammatical and ungrammatical sentences differently (Figure 8A).

In the nested analysis, in grammatical sentences the effect of case was -16ms CrI: [-39, 8], and in ungrammatical sentences the effect of case was -9ms CrI: [-31, 14]. The interference

Figure 7. Posterior probability distributions of effects in the critical region in Experiment 3. The distributions display the posterior probability of different effect sizes, with solid vertical lines corresponding to posterior means and shaded areas to 95% credible intervals. The dashed vertical lines correspond to an effect size of zero.

Figure 8. Posterior probability distributions of effects in the post-critical region in Experiment 3. The distributions display the posterior probability of different effect sizes, with solid vertical lines corresponding to posterior means and shaded areas to 95% credible intervals. The dashed vertical lines correspond to an effect size of zero.

effect was inconclusive in grammatical sentences, with an estimate of 4ms CrI:[-19, 27], and it was -21ms CrI:[-46, 3] in ungrammatical sentences, suggesting that plural attractors elicited shorter reading times than singular attractors in ungrammatical sentences. As to the interaction between interference and case, there was an indication of an interaction in grammatical sentences -18 ms CrI:[-42, 6], but the effect was close to zero in ungrammatical sentences, with an estimate of -2ms CrI:[-24, 20] (Figures 8B and C). To interpret the interaction in grammatical sentences, we performed nested comparisons to evaluate how interference affected each level of the *attractor case* factor. These comparisons yielded estimates which were inconclusive but which pointed to slower reading times for interference conditions when the two nouns overlapped in case, 22ms CrI:[-14, 57], but faster reading times when they did not, -15ms CrI:[-47, 17].

Discussion

Experiment 3 addressed whether distinctive case marking modulated interference effects by manipulating whether the attractor noun had the same or a different case than the target noun. With regard to interference effects, the critical RC verb revealed no facilitatory interference in ungrammatical sentences when the plural feature on the attractor noun matched that of the verb. Instead, the critical RC verb was read more slowly (rather than faster) when a plural attractor was present. A similar slowdown with plural attractors was observed in grammatical sentences. These unexpected effects could be spurious, reflecting the processing slowdown that originated at sentence-initial plural attractors and spilled over into subsequent regions. But even after we ran a supplementary analysis accounting for the spillover effect, the pattern remained the same, although the estimates were smaller in magnitude and were rendered largely inconclusive. Thus, we interpret the data in the critical region as showing no conclusive interference effects.

In the post-critical region, in ungrammatical sentences we observed a small facilitatory interference effect. This estimated mean effect was half the size of the effect in Experiment 2 (-21ms CrI:[-46, 3] vs. the Experiment 2 estimate, -51ms CrI:[-100, -2]). The Experiment 3 estimate might be more accurate than the Experiment 2 estimate: First, the wider interval in Experiment 2 suggests a Type M error (overestimation of the effect magnitude; Gelman & Carlin, 2014; Vasishth, Mertzen, Jäger, & Gelman, 2018). Secondly, facilitatory interference effect in Experiment 3 is similar to the estimate derived from the meta-analysis by Jäger et al. (2017) (-21ms CrI:[-46, 3] vs. -22ms CrI:[-36, -9], respectively). This estimate was computed using data from previously published articles and therefore serves as the best available estimate to date of the underlying true effect.

Also in the post-critical region, there was some indication of a crossover interaction between case and interference, but this effect was restricted to grammatical sentences: There was a processing slowdown in the interference conditions when the two nouns bore the same case compared with when the nouns bore distinctive case. Although this pattern of processing difficulty in case-match configurations (i.e., with feature-overlapping nouns) is consistent with the predictions of a retrieval account, none of the nested comparisons within each level of case revealed conclusive effects of interference. Therefore, we feel it is not justified to claim that there is any interference effect in case-match or -mismatch conditions

within the grammatical conditions; further work is needed to assess the reliability of the observed case-interference interaction.

To summarize, the present data do not allow us to draw definitive conclusions because all in all case manipulation in Experiment 3 did not lead to a reliable or systematic modulation of interference effects in the comprehension of subject-verb agreement. For one thing, there was only a trend toward the interaction effect in grammatical sentences, and follow-up nested comparisons to evaluate the interference effect at each level of the *attractor case* factor also produced inconclusive results. A further study with even a bigger sample size would be informative. With greater sample size credible intervals get smaller and are less likely to include a zero when an effect is present. For another thing, we did not find the analogous interaction effect in ungrammatical sentences. Put differently, there was no suggestion of a case modulation in the ungrammatical sentences, which was the primary object of interest given that these were the conditions that yielded reliable interference effects. By contrast, Experiment 3 showed more consistent main effects of case, reflecting faster processing in case-mismatch than case-match conditions, independently of attractor number. These effects emerged in both grammatical and ungrammatical sentences but at different points in the sentence: at the RC verb in ungrammatical sentences and in the post-critical region in grammatical sentences. These patterns are discussed below.

General discussion

Summary of findings

This study investigated agreement attraction in Armenian object relative clauses using a verb selection task (Experiment 1) and two self-paced reading tasks (Experiments 2 and 3). We investigated two questions: (a) Does attraction occur in Armenian? (b) Is attraction modulated by the presence of distinctive case marking on the attractor and target nouns? Our predictions were based on the cue-based retrieval model as implemented in Lewis and Vasishth (2005) and Engelmann et al. (2019), which predicts attraction effects (commonly referred to as *facilitatory interference*) when the plural attractor noun matches the number retrieval cue of the ungrammatical verb. We hypothesized that attractors with non-subject-like case marking (e.g. accusative case) should be misretrieved less often than attractors with subject-like case marking (e.g. nominative case), thus leading to smaller attraction effects. Such an interaction effect between case and attraction would support the claim that case information is used as a retrieval cue during subject-verb number agreement.

The three experiments showed patterns consistent with agreement attraction, extending previous findings to Eastern Armenian. In the forced-choice task, response accuracy was reduced and response times for correct verb choices were longer in conditions with plural as compared with singular attractors. In the two self-paced reading tasks, facilitatory interference in ungrammatical conditions was observed only in the post-critical region: Plural attractors, which matched the number of ungrammatical verbs, elicited shorter reading times after the verb compared with singular attractors. By contrast, the results in grammatical conditions did not show reliable inhibitory interference effects, consistent with many previous findings in other languages (Jäger et al., 2017).

With regard to the question of whether case marking modulated attraction effects, the

experiments did not clearly support this hypothesis. In the forced-choice task, participants' response times did indeed show an interaction between case marking and attractor number, but their response accuracies did not, as the mean estimate of the interaction effect was 0.6% with a range distributed between 0% and 1%. To follow up on the response time patterns, we conducted a self-paced reading study to examine participants' reading times (Experiment 3). Although the ungrammatical conditions showed the expected facilitatory effect after the RC verb, the modulation of this effect due to case was negligible, with a mean of -2ms and a range of estimates between -24 and 20, consistent with either a positive or a negative influence of distinctive case on attraction.

It is important to point out that the lack of a case modulation on attraction effects is unlikely to have resulted from participants' failure to process case information per se because there were main effects of case in time measures across experiments. In the forced-choice task, participants showed faster response times when the case marking on the two nouns was distinct. Furthermore, distinctive case marking elicited faster reading times at the critical RC verb and the following word in Experiment 3. This facilitatory effect of case was observed both in grammatical sentences (where inhibitory interference effects were absent) and ungrammatical sentences (where facilitatory interference effects were present). Taken together, the consistency and ubiquity of main effects of case suggest that participants effectively used case information during processing: The critical contrast is that the case effect did not interact with the attraction effect.

Given our findings, the outstanding question is why distinctive case marking might not modulate agreement attraction in comprehension. In what follows, we describe how this result could be accommodated under the two main frameworks proposed for agreement attraction: the Marking and Morphing model (Bock et al., 2001; Eberhard et al., 2005; Hammerly et al., 2019) and the cue-based retrieval model of Lewis and Vasishth (2005). Our discussion is not aimed at favoring one model over the other: At present, we think that more empirical work would be needed to expand the empirical base to arbitrate between the models. Our goal in the following sections is to articulate possible avenues to build this empirical base.

Case-number dissociations under Marking and Morphing

The lack of a modulation of attraction effects by case information is naturally expected under Marking and Morphing, which would not have predicted such an interaction effect in either production or comprehension. This is because this model does not have a mechanism for case information to influence the factors that contribute to the number valuation of the subject phrase. Specifically, attraction emerges according to Marking and Morphing through the spreading of activation of the attractor noun's plural feature, which makes singular subjects seem more plural. In the model, the main factor that determines spreading activation is syntactic distance: Deeply embedded plural attractors have less weight in the valuation of the number of the subject phrase, consistent with the idea that with larger distance, spreading activation declines as it takes more time to reach the root node, reducing the likelihood of feature percolation (Franck, Vigliocco, & Nicol, 2002).

Furthermore, the observation in Experiment 1 that selecting a correct verb form takes

longer in conditions with plural attractors also finds a natural explanation in Marking and Morphing. Because the presence of plural attractors makes the number of the subject phrase ambiguous between singular and plural, agreement decisions are expected to become harder and, therefore, take longer (Hammerly et al., 2019). Thus, unlike the cue-based retrieval account, Marking and Morphing can explain the response time patterns in the forced-choice task.

However, one caveat about Marking and Morphing is that it fails to account for the lack of effects in grammatical sentences in our reading comprehension studies and in previous work on attraction (Jäger et al., 2017). A key prediction of the model is that attraction from plural attractors should also occur in grammatical sentences because spreading activation of plural morphology is not contingent on the grammaticality of the verb. Attraction in grammatical sentences is expected to go in the reverse direction: A somewhat plural subject phrase should slow the processing of the grammatical singular verb, creating an *illusion of ungrammaticality*.

A recent implementation of Marking and Morphing has offered an alternative explanation for the lack of effects in grammatical sentences, which suggests that Marking and Morphing may be a plausible mechanism for attraction effects in comprehension (Hammerly et al., 2019). Specifically, Hammerly and colleagues have suggested that the lack of attraction effects in grammatical sentences may actually be an artifact created by participants' response bias, as participants may be prone, in general, to perceiving sentences as grammatical (perhaps due to their high frequency of occurrence in day-to-day input). Hammerly and colleagues conducted three acceptability judgment tasks and showed that when response bias was neutralized (e.g., by cautioning participants that they would see ungrammatical sentences), attraction effects (i.e., illusion of ungrammaticality) appeared in grammatical sentences, consistent with the predictions of Marking and Morphing. This proposal is promising and offers an interesting direction for future research, but to extend its generalizability it needs to be able to explain the observed behavior in other paradigms and configurations that have been explored in attraction research.

A final caveat about Marking and Morphing is that it is unclear how it would account for attraction effects in configurations like the object relative clauses used in the current study. This is because the implementation of this model is best suited to capture attraction effects with intervening attractors (i.e., NPs inside prepositional modifiers), which are part of the subject phrase whose number needs to be evaluated. In our configurations, the attractor NP was not part of the subject phrase, and thus it is unclear why it should have affected its number valuation. There are at least two different ways for Marking and Morphing to address this issue. One alternative would be to propose that attraction in intervening and non-intervening constructions arises due to different mechanisms (for empirical support, see Staub, 2009, 2010). Alternatively, to capture our attraction effects, the current computational implementation of Marking and Morphing would have to be modified to allow number features to percolate from any NP in the sentence and to weight this process according to both syntactic distance and clause membership. It remains to be seen whether these adaptations can be pursued while still providing a good fit to the attraction data obtained in intervening configurations, and while accounting for the structural distance

effects found in production studies, one of the key motivations for feature percolation models to begin with (Bock & Cutting, 1992; Eberhard et al., 2005; Franck et al., 2002).

Case-number dissociations under cue-based retrieval

The absence of a case modulation on attraction effects is unexpected under the cue-based retrieval account described in the Introduction. Could the absence of an interaction between case and agreement attraction still be consistent with the cue-based retrieval account? We offer two possible ways in which this could be the case. Each explanation offers a different implementation of the proposal that case and number information are differentially used during comprehension. The first explanation, which is closely related to a proposal by Wagers et al. (2009), is as follows. It is generally assumed in psycholinguistics that left-corner parsing drives incremental processing (Crocker, 1999; Gibson, 1991; Resnik, 1992), and that overt case marking drives predictions about the syntactic frame of an upcoming verb (Chow et al., 2018; Henry et al., 2017; Husain, Vasishth, & Srinivasan, 2014; Hyönä & Hujanen, 1997; Kamide et al., 2003a, 2003b; Knoeferle et al., 2005; Traxler & Pickering, 1996; Yamashita, 1997). In our materials, after encountering the main clause noun (i.e., the attractor), the relative pronoun, and the relative clause subject, the parsing system will predict an upcoming relative clause verb phrase (VP) and a main clause verb with certain features. Case marking will play a role only at this predictive stage and will serve to determine the feature structure of the predicted VP. Determining this predicted feature structure will involve co-indexing the subject and the object with the subcategorization frame of the verb and fixing the thematic roles to the most likely values, with the nominative noun phrase being marked as the agent and the accusative noun phrase as the patient (Figure 9).

Importantly, the feature structure is defeasible at this point: Once the verb is encountered, any information that contradicts the predicted feature structure will require an edit to this structure such that the number marking is changed to plural (because the encountered verb has plural morphology). This will be the case in the ungrammatical conditions of Experiment 3 in which the plural number of the encountered verb will contradict its predicted singular value. After editing the number feature of the verb, the parser will trigger a search in memory for a noun phrase with a plural feature, as originally proposed by Wagers et al. (2009). Critically, the predicted argument structure and thematic roles of the VP will not be edited, as these were not in conflict with the input. Therefore, the claim here is that case marking only plays a role during the prediction stage in determining the feature specifications on the predicted VP.

One question arises with this account: If case marking plays no role in retrieval processes, why do we see a main effect of case at the relative clause verb? One explanation could be encoding interference (Nairne, 1990; Oberauer & Kliegl, 2006): Similarly case marked nouns may be more difficult to keep distinct in memory. Another possible explanation for the main effect of case marking is that when the two nouns are similarly marked (both nouns are nominative marked), it may be more difficult to resolve the case mismatch between the relative clause pronoun (which is always accusative case marked) and the first noun (the subject of the main clause). Both these views imply that the main effect of case observed at the relative clause verb is a spillover from events occurring earlier in the sentence. One

Figure 9. The left and right panels show participants' parse before and after encountering the RC verb. Prior to the RC verb, the case marking on the nouns predicts the verb's feature structure, including the syntactic and thematic role of its arguments (predicted chunks are in gray). After an ungrammatical RC verb is encountered, participants should detect the mismatch between the predicted and the actual number feature of the verb. To address this mismatch, a number edit is required (see the number feature shown in red in the right-hand side plot). This will trigger a search in memory for a noun with the relevant feature. Critically, because case marking does not need to be edited when the verb is encountered, case features will play no role in the retrieval. The figure is by Vasisht, Avetisyan, and Lago and is available under a CC-BY4.0 license from <https://doi.org/10.6084/m9.figshare.11440854.v1>.

prediction of these accounts is that increasing the distance between the second noun and the verb should reduce the main effect of case—this should be investigated in a future study.

Another way to capture the dissociation between case and number information would be to propose that two distinct types of retrievals occur at the verb. One of the memory retrievals may be triggered in order to assign a thematic interpretation to the sentence. This should involve linking the verb to the NP arguments and assigning each argument a thematic role. In addition, a separate retrieval may be triggered to license the morphological features of the verb, such as number and person. Under these assumptions, case information would be used as a cue for determining thematic roles, but it may not be used—or it may have reduced influence—in the retrieval responsible for number licensing (for previous proposals of differential cue weighting see Dillon et al., 2013; Kush & Phillips, 2014; Parker, Shvartsman, & Van Dyke, 2017; Van Dyke & McElree, 2011). Therefore, under this account the retrieval

involving thematic role resolution would lead to a main effect of case, and the retrieval involving number licensing would show an agreement attraction effect, with no interaction between them, as we observed in Experiment 3.

In Experiment 3, the thematic role assignment and licensing of number features both occurred at the relative clause verb and cannot be separated out. However, one could experimentally investigate whether these two classes of retrieval can be observed at different stages. Consider the sentence: *Most rooms in the warehouse are misused*. Here, the auxiliary verb *are* encodes limited semantic information and does not assign thematic roles (Pollock, 1989). By contrast, the participle *misused* carries the lexico-semantic content of the VP. Under the account proposed above, the auxiliary verb should trigger a number agreement-driven dependency completion, whereas the participle should trigger a different dependency relation, leading to thematic role assignment. If evidence can be found for these two classes of dependency completion, this would provide independent support for the proposal that two distinct classes of retrievals may be occurring.

Finally, some limitations of the current study should be acknowledged. First, one could argue that the current experiments simply lacked the statistical power needed to detect effects of case modulation on attraction. We cannot rule out this concern. In lieu of a power analysis, we aimed for as large a number of participants (175 in Experiment 1 and 117 in Experiment 3) as logistically and financially feasible in order to maximize our chances of observing the effects of interest, although it is possible that an even larger number of participants would have been necessary. A second concern is related to the nature of our materials: The relative clauses were introduced by a relative pronoun, which was always accusative marked, regardless of the case of the attractor noun. If the retrieval triggered by the RC verb targeted solely the RC subject and the accusative pronoun (rather than the attractor noun), then the case manipulation on the attractor noun should have been ineffective, as this noun would have not been considered at retrieval. To address this concern, further work using different grammatical constructions will be very informative.

Conclusion

This study tested the existence of agreement attraction effects and their interaction with overt case marking in the comprehension of subject-verb agreement in Eastern Armenian, a previously unstudied language. We found that manipulations of number and case independently affected processing measures, but they did not consistently interact. This finding supports an encoding-based model of attraction—Marking and Morphing, but a remaining challenge for this model is to explain why attraction was elicited by an element located outside of the subject phrase. By contrast, this finding is surprising under the cue-based retrieval account, which predicts that case information should influence retrieval errors. Our findings can be accommodated by this latter model if additional assumptions are made about how case and number information dissociate during agreement dependency formation. Specifically, we proposed that the assignment of thematic roles, for which case information is crucial, may be implemented predictively and may not be affected by number retrieval operations. Alternatively, thematic and number licensing may be implemented by two separate retrieval operations. These suggestions, together with our empirical findings, contribute to a deeper understanding of the influence of grammatical cues in cue-based

memory retrieval and articulate two processing accounts that could be investigated in future empirical work.

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Appendix

Table A1

Mean accuracy rates and response/reading times (RT) in each experiment. Standard errors (SE) of the means are in square brackets (expt. = experiment).

		Accuracy rate [SE] %	RT [SE] ms		
				Region	
				critical	post-critical
Expt. 1	case match, singular attractor	97.1 [0.4]	1064 [9]		
	case match, plural attractor	88.4 [0.7]	1175 [11]		
	case mismatch, singular attractor	96.2 [0.4]	1053 [9]		
	case mismatch, plural attractor	90.1 [0.7]	1136 [10]		
Expt. 2	grammatical, no-interference	86.3 [1.7]	1096 [36]	971 [28]	
	grammatical, interference	86.1 [1.7]	1147 [40]	989 [29]	
	ungrammatical, no-interference	88.0 [1.6]	1540 [53]	1050 [32]	
	ungrammatical, interference	84.0 [1.8]	1525 [54]	963 [23]	
Expt. 3	grammatical, case-match, no-interference	88.0 [1.2]	1016 [30]	880 [22]	
	grammatical, case-match, interference	88.6 [1.2]	1021 [32]	916 [24]	
	grammatical, case mismatch, no-interference	86.5 [1.3]	1015 [30]	883 [22]	
	grammatical, case mismatch, interference	87.2 [1.3]	978 [27]	865 [21]	
	ungrammatical, case match, no-interference	87.2 [1.3]	1279 [33]	977 [24]	
	ungrammatical, case match, interference	87.3 [1.3]	1344 [40]	947 [21]	
	ungrammatical, case mismatch, no-interference	87.2 [1.3]	1229 [35]	972 [25]	
	ungrammatical, case mismatch, interference	85.8 [1.3]	1330 [42]	944 [23]	

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