

# The Role of Shallow Processing in Agreement Attraction

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## Abstract

We report the results of two speeded acceptability judgment experiments in Turkish. We hypothesized an alternative explanation for agreement attraction effects in Turkish that is based on shallow processing. Our findings contradict our hypothesized form-driven processing strategy and support an account of agreement attraction based on the use of abstract linguistic features, rather than mere form.

## Introduction

### Experiment 1

In Experiment 1, we tested whether speakers of Turkish make fewer agreement attraction errors when the local ambiguity in the head noun is resolved. Specifically, we tried to replicate Lago et al. (2018) study. However, instead of using morphologically ambiguous head nouns, we used nouns ending in a vowel, thus resolving the ambiguity between the accusative and possessive.

### Participants

We recruited 118 undergraduate students to participate in Experiment 1 in exchange for course credit. All participants were native speakers of Turkish, with an average age of 20 (range: 18 – 32). Experiment were carried out following the Declaration of Helsinki and the regulations concerning ethics at research in Boğaziçi University. All participants provided informed consent prior to their participation.

### Materials

We used 40 sets of sentences like ((1)), in which we manipulated (i) the number of the attractor noun, and (ii) the number agreement on the verb. Plural number and plural agreement were both marked with the affix *-ler/-lar*, while singular number and singular agreement were marked with its absence. We have used the experimental items in Lago et al. (2018) as a base. All sentences started with a complex subject NP like ‘*the manager’s cook*’ (*yöneticinin aşçısı*), in which the possessor, which functioned as the attractor, carried genitive case, and the head noun carried possessive case. Because the head noun was singular in all conditions,

sentences with plural verb agreement were ungrammatical. Moreover, as in the original study, the properties of the nouns in the complex subject NP and the relation between these nouns held constant in our replication. The distribution of the verb types followed the same pattern as in Lago et al. (2018), namely twenty unergatives, eighteen unaccusatives, and two optionally transitive verbs. Both in Lago et al. (2018) and in our replication, pre-verbal adverbials consisting of 2-3 words (15 characters on average) are used. Unlike the Lago et al. (2018) sentences, our head nouns were vowel-ending, and therefore not ambiguous between accusative case, for which the case suffix is *-yI*, and possessive case, for which the suffix is *-sI*.

- (1) a. PLURAL ATTRACTOR, UNGRAMMATICAL (PLURAL VERB)  
 \*[Yönetici-ler-in **aşçı-sı**] mutfak-ta sürekli **zıpla-dı-lar**.  
 manager-PL-GEN cook-POSS kitchen-LOC non-stop jump-PST-PL.  
*'The cooks of the manager were jumping in the kitchen non-stop.'*
- b. PLURAL ATTRACTOR, GRAMMATICAL (SINGULAR VERB)  
 [Yönetici-ler-in **aşçı-sı**] mutfak-ta sürekli **zıpla-dı**.  
 manager-PL-GEN cook-POSS kitchen-LOC non-stop jump-PST.  
*'The cooks of the manager was jumping in the kitchen non-stop.'*
- c. SINGULAR ATTRACTOR, UNGRAMMATICAL (PLURAL VERB)  
 \*[Yönetici-nin **aşçı-sı**] mutfak-ta sürekli **zıpla-dı-lar**.  
 manager-GEN cook-POSS kitchen-LOC non-stop jump-PST-PL.  
*'The cook of the manager were jumping in the kitchen non-stop.'*
- d. SINGULAR ATTRACTOR, GRAMMATICAL (SINGULAR VERB)  
 [Yönetici-nin **aşçı-sı**] mutfak-ta sürekli **zıpla-dı**.  
 manager-GEN cook-POSS kitchen-LOC non-stop jump-PST.  
*'The cook of the manager was jumping in the kitchen non-stop.'*

We intermixed our experimental sentences with 40 filler sentences of two types, as illustrated in ((2)). To compensate for the fact that among experimental sentences, all ungrammatical sentences ended in a plural-agreeing verb, while all grammatical sentences ended in a singular-agreeing verb, we included 20 grammatical sentences with plural verbs, and 20 ungrammatical sentences with singular agreement. This was done in order to discourage participants from using a strategy based on verb number. Filler items followed a similar template in which sentence again started with a complex genitive-possessive noun phrase. However, in filler items, they were the controller of an embedded clause which serves as an adverbial. In grammatical fillers, we have made use of pro-dropped subject strategy in Turkish; thus, it enabled us to use plural verb without having ungrammatical sentences as in ((2-a)). The object *tutarsızlık* is a bare nominal preceding a light verb construction. Differently in ungrammatical fillers, bare nominal did not precede a light verb construction, but an adverb and a verb. Since Turkish only allows bare nominals right next to the

verb, sentences were deemed ungrammatical when the participants read the verb.

- (2) a. GRAMMATICAL FILLER (PLURAL VERB)  
 [Sosyolog-un **öğrenci-si**] konuş-unca tutarsızlık açığ-a  
 sociolog-GEN student-POSS speak-NMLZ inconsistency open-DAT  
**çıkar-dı-lar.**  
 deduct-PST-PL.  
*‘When the student of the sociologist spoke, they revealed an inconsistency.’*
- b. UNGRAMMATICAL FILLER (SINGULAR VERB)  
 \*[Dansöz-ün **koca-sı**] var-ınca kapı sakince aç-tı.  
 dancer-GEN husband-POSS arrive-NMLZ door slowly open-PST.  
*Intended: ‘When the husband of the dancer came, the door opened slowly.’*

## Procedure

The experiment was run online, using the web-based platform Ibex Farm (<http://spellout.net/ibexfarm/>). Each experimental session took approximately 25 minutes to complete. Prior to the start of the experiment, participants provided demographic information, as well as informed consent to participate in the experiment. They read the instructions, and were given 9 practice trials before the experiment began. Each trial began with a blank screen for 600 ms, followed by a word-by-word RSVP presentation of the sentence in the center of the screen, followed by an acceptability judgment. Sentences were presented word-by-word in 30pt font size, and at a rate of 400 ms per word. Between each word, participants saw a blank screen for 100 ms. Participants pressed the key ‘P’ for ‘acceptable’ and ‘Q’ for ‘unacceptable’. They were instructed to provide an acceptability rating before the 5,000 ms deadline. During the experiment, they were reminded to respond faster if they responded too slowly.

Participants saw 40 experimental and 40 filler sentences. Experimental sentences were distributed among four different lists according to a Latin-square design. Every participant saw one version of the experiment with a specific list and one item per condition.

## Analysis

Since our aim was to test whether the morphological ambiguity present in the Lago et al. (2018) items affected the presence or magnitude of the agreement attraction effect, statistically, we needed to test for the presence of an interaction between (i) the presence of the morphological ambiguity on the head noun, and (ii) the agreement attraction effect. In order to do so, we decided to analyze the data from the present experiment together with Lago et al.’s data, using experiment as an additional factor in the analysis.

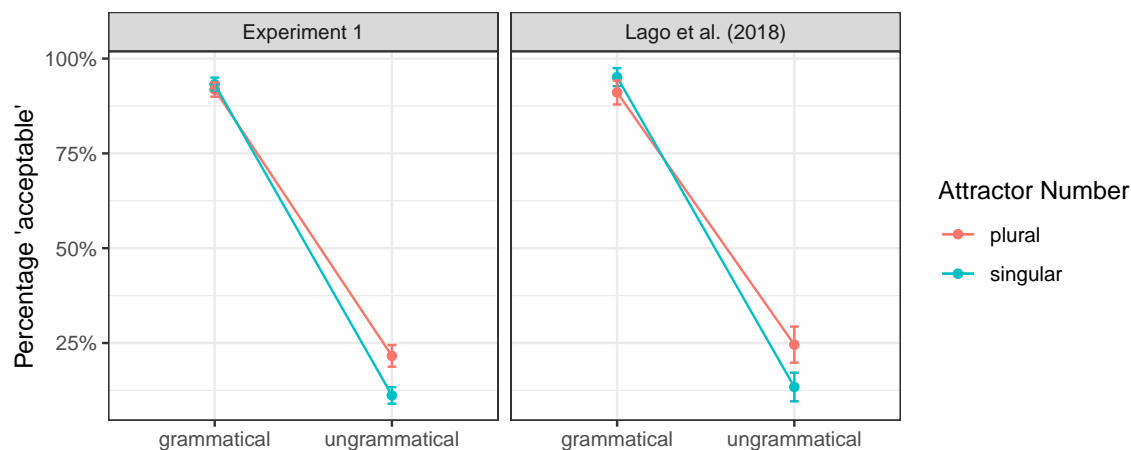
Prior to analysis we removed the data for all participants who failed to show

sufficient sensitivity to the effect of grammaticality in singular attractor conditions, i.e., when no agreement attraction was expected. Specifically, we removed all participants for whom the difference in the percentage of ‘yes’ responses between the grammatical condition (1-d) and the ungrammatical condition (1-c) was below the threshold of 25 percentage points. As a result, we excluded 10 participants from experiment 1, and one participant from the Lago et al. experiment.

We used the R packages *brms* (Bürkner, 2018) and *rstan* (Stan Development Team, 2019) to fit Bayesian hierarchical models (e.g., Gelman & Hill, 2007). We analyzed only experimental sentences, and used (i) grammaticality of the sentence, (ii) attractor number, and (iii) presence of morphological ambiguity (i.e., experiment), as well as all their interactions as predictors. Moreover, we used by-participant and by-item intercepts and slopes for all predictors. Data for experiment 1, along with our analysis scripts can be found in [https://github.com/utkuturk/replication\\_lagoetal2018](https://github.com/utkuturk/replication_lagoetal2018).

## Results

Figure 1 shows the average proportions of ‘acceptable’ responses by experimental condition for both the original experiment in Lago et al. (2018) and our replication with unambiguous possessive marking. It shows that ungrammatical sentences with plural attractors are rated as acceptable more often ( $M = 0.22$ ,  $SE = 0.01$ ) than their counterparts with singular attractors ( $M = 0.11$ ,  $SE = 0.01$ ). The magnitude of the effect (0.10) was in line with the findings reported in Lago et al. (2018), where the difference was 0.11. Accuracy rates for grammatical conditions were nearly equal ( $M = 0.93$  and  $0.92$ ,  $SE = 0.01$  and  $0.01$ , for singular and plural attractors respectively).



*Figure 1.* Average percentages of ‘acceptable’ responses in Experiment 1 and Lago et al. (2018). Within-subject 95% confidence intervals in brackets Cousineau (2005); Morey (2008).

A Bayesian GLM assuming a Bernoulli distribution with a probit-link function was fit to participants' 'acceptable' responses. The model's estimates and 95% credible intervals are shown in Figure 2. The main effect of *ungrammaticality* ( $\hat{\beta} = -3.09$ ;  $CI = [-3.34; -2.85]$ ;  $P(\beta < 0) > .999$ ) indicates that, on average, participants were quite good at distinguishing between grammatical and ungrammatical sentences. Meanwhile, the positive interaction between *ungrammaticality* and *attractor number* ( $\hat{\beta} = 0.72$ ;  $CI = [0.41; 1.02]$ ;  $P(\beta < 0) < .001$ ) indicated a larger effect of attractor number in ungrammatical conditions, and thus a number agreement attraction effect. Importantly, there was no evidence for a three-way interaction between *the presence of ambiguity*, *ungrammaticality* and *attractor number* ( $\hat{\beta} = 0.31$ ;  $CI = [-0.21; 0.83]$ ;  $P(\beta < 0) = .12$ ).

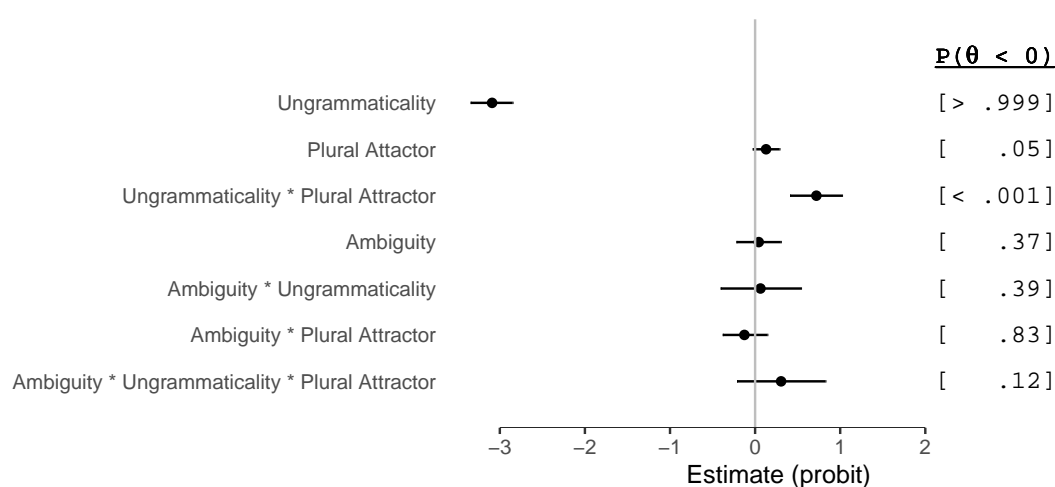


Figure 2. Estimates and 95% credible intervals for the regression coefficients for Experiment 1.

## Discussion

In Experiment 1, we have found number attraction effects in Turkish using genitive possessive structures, as it is also attested in Lago et al. (2018). To account for their findings, Lago et al. (2018) assume a cue-based memory retrieval mechanism. That is, they assume that upon reaching the verb, the parser attempts to retrieve its agreement controller (the subject) using a cue-based retrieval mechanism (Jäger, Engelmann, & Vasisht, 2017; Lewis & Vasisht, 2005). The assumption is that in sentences such as (1), features such as case and number information are used to identify the agreement controller in memory. In ungrammatical sentences, when the verb bears plural agreement, no NP in memory will match both retrieval cues. However, in ungrammatical plural attractor conditions, the attractor matches one of the cues, which can lead to its erroneous retrieval on some occasions. This cannot happen in ungrammatical singular

attractor conditions. This difference in the probability of erroneous retrievals is presumably what surfaced as a number agreement attraction effect, as observed in Lago et al. (2018), and our Experiment 1.

In their work, Lago et al. (2018) argue that the agreement attraction in genitive-possessive structures in Turkish is due to the use of genitive case as a marker of embedded subjects in Turkish, i.e. differential subject marking (DSM) properties of Turkish (Kornfilt, 2009). They argue that the genitive case in Turkish may not provide strong cue against subjecthood due to DSM while it does in English. Following this logic, we hypothesized that the other phenomenon that gives a strong clue against the subject should inhibit the illusionary dependencies as argued in Nicol, Barss, and Barker (2016). One such phenomenon was present in the experimental items used in Lago et al. (2018): the morpho-phonologic ambiguity between the accusative and the possessive case. Since they use only consonant ending heads, the marking on the head is ambiguous between the accusative and the possessive marking. Following their argumentation, participants may search for other agreement controllers than the possessive marked heads when they are engaged in shallow processing and erroneously assign head as genitive marked distractor.

Nevertheless, we found that when the possessive marker is disambiguated agreement attraction does not diminish in effect size. As seen in Figure 2, we successfully replicated the findings of Lago et al. (2018) with disambiguated head nouns. Thus, we conclude that the morpho-phonological possessive-accusative ambiguity plays no role in number attraction in Turkish.

However, there is an alternative explanation that has yet to be ruled out: task-specific strategies. We hypothesized that readers may engage in an even shallower process in the evaluation of the sentences such as (3) in which readers decide on the acceptability of the sentence with a faulty state of memory. In our model, we claim that after they read the sentence readers may end up with insufficient information to reliably judge the sentence. Upon such cases, readers may end up using extremely shallow processing methods such as matching the agreement-wise unrelated but form-wise related elements. We present our hypothesized decision tree in Figure 3

The aim of our second experiment was to test whether agreement attraction in Turkish may be an instance of a *form-driven processing strategy*. Assuming that readers sometimes engage in shallow processing, they may end up with insufficient information to reliably classify a sentence as (un)acceptable. In such cases, participants may choose to classify sentences with plural-agreement-bearing verbs as acceptable if they have a memory of a nominal plural morpheme in the sentence. Such a response strategy would lead to a larger number of ‘acceptable’ responses in ungrammatical plural attractor conditions than in ungrammatical singular attractor conditions.

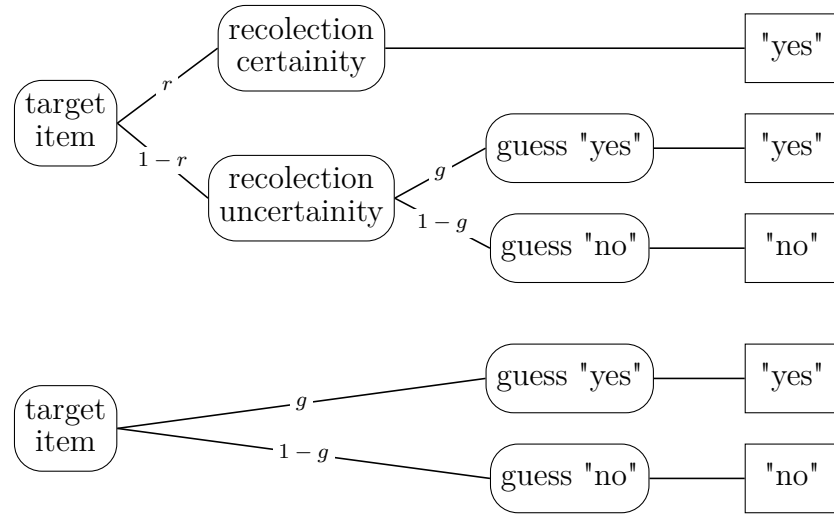


Figure 3. Proposed multinomial processing tree of how people judge sentences in an agreement attraction task

## Experiment 2

In Experiment 2, we wanted to rule out the possibility of *form-driven processing strategy*, namely participants deciding on the acceptability of a sentence using a memory of plural morpheme in the sentence when they do not have sufficient information to rate sentences (un)acceptable.

### Participants

We recruited 79 undergraduate students to participate in Experiment 2 in exchange for course credit. All participants were native speakers of Turkish, with an average age of 21 (range: 18 - 31). Experiment were carried out following the Declaration of Helsinki and the regulations concerning ethics at research in Boğaziçi University. All participants provided informed consent prior to their participation.

### Materials

We used 40 sets of sentences like ((3)), in which we manipulated (i) the number of the attractor, and (ii) the number agreement on the verb. Unlike Experiment 1, we used the verb of a nominalized relative clause (i.e. *tuttukları*) as an attractor instead of a genitive marked noun. We took advantage of syncretism between Turkish nominal and verbal plural marker. Both of these morphemes spells-out as *-lar*, which enables us to check whether agreement attraction in Turkish can be explained by an extremely shallow dependency parsing based on the forms of morphemes rather than linguistic features.

All sentences started with a complex subject NP like ‘*the cook that they hired*’ (*tuttukları aşçı*), in which the verb of the relative clause functioned as the attractor. Because the head noun was singular in all conditions, sentences with plural verb agreement were ungrammatical. We have used the same verbs, and have not

changed the distribution of verb types. We also utilized the same or similar adverbials in length. Relative clauses we used in this experiment are all object relative clauses, and they are all marked with canonical *-dIK* nominalizer. Since Turkish is a pro-drop language, we also dropped the subject within the embedded clause, thus ending up with a one-word object relative clause whose head is the controller of the number agreement on the matrix verb. One example set of experimental items can be seen in (3).

- (3) a. PLURAL ATTRACTOR, UNGRAMMATICAL (PLURAL VERB)  
 \*[Tut-tuk-lar-ı **aşçı**] mutfak-ta sürekli **zıpla-dı-lar**.  
 hire-NMLZ-PL-POSS cook kitchen-LOC non-stop jump-PST-PL.  
*‘The cook that they hired were jumping in the kitchen non-stop.’*
- b. PLURAL ATTRACTOR, GRAMMATICAL (SINGULAR VERB)  
 [Tut-tuk-lar-ı **aşçı**] mutfak-ta sürekli **zıpla-dı**.  
 hire-NMLZ-PL-POSS cook kitchen-LOC non-stop jump-PST.  
*‘The cook that they hired was jumping in the kitchen non-stop.’*
- c. SINGULAR ATTRACTOR, UNGRAMMATICAL (PLURAL VERB)  
 \*[Tut-tuğ-u **aşçı**] mutfak-ta sürekli **zıpla-dı-lar**.  
 hire-NMLZ-POSS cook kitchen-LOC non-stop jump-PST-PL.  
*‘The cook that they hired were jumping in the kitchen non-stop.’*
- d. SINGULAR ATTRACTOR, GRAMMATICAL (SINGULAR VERB)  
 [Tut-tuğ-u **aşçı**] mutfak-ta sürekli **zıpla-fı**.  
 hire-NMLZ-POSS cook kitchen-LOC non-stop jump-PST.  
*‘The cook that they hired was jumping in the kitchen non-stop.’*

In addition to the experimental items, we used 40 filler sentences of two types, both of which starts with an object relative clause, as illustrated in ((4)). Similar to Experiment 1, our filler items included 20 grammatical sentences with an overtly plural marked verbs, and 20 ungrammatical sentences with no overt plural marking, thus singular. This was done in order to discourage participants from using a strategy based on verb number. In all of our filler sentences, the dependency between the first complex NP subject modified with an object relative clause and its verb resolved in an adverbial embedded sentence. In grammatical fillers, we have used intransitive verbs with a pro-dropped subject as in ((4-a)). In ungrammatical fillers, we created the ungrammaticality by placing an adverbial between the bare nominal object and the verb as in ((4-b)).

- (4) a. GRAMMATICAL FILLER (PLURAL VERB)  
 Oku-t-tuk-lar-ı öğrenci başarılı ol-unca mutlu ol-du-lar.  
 read-CAUS-NMLZ-PL-POSS student successful be-NMLZ happy be-PST-PL.  
*‘When the student they sponsored become successful, they became*



- happy.’
- b. *Ungrammatical Filler (Singular Verb)*
- \*Kandır-diğ-1     adam öde-me-yince     bulaşık saatlerce yıka-dı.  
 trick-NMLZ-POSS man     pay-NEG-NMLZ dish     for.hours clean-PST.  
 Intended: ‘When the man he tricked did not pay, he cleaned dishes for hours.’

## Procedure

The experiment was run online, using the web-based platform Ibex Farm (<http://spellout.net/ibexfarm/>). For each participant, experiment took approximately 25 minutes to complete. Participants were asked to provide information regarding their native language and age. They were also asked for their consent to participate in the experiment. Prior to experimental items, participants read the instructions, and were given 9 practice items with feedback on their accuracy. Each trial began with a blank screen for 600 ms, followed by a word-by-word RSVP presentation of the sentence in the center of the screen, followed by an acceptability judgment. Sentences were presented in 30pt font size, and at a rate of 400 ms per word. Between each word, participants saw a blank screen for 100 ms. Participants pressed the key ‘P’ for ‘*acceptable*’ and ‘Q’ for ‘*unacceptable*’. Within instructions, they were told to provide an acceptability rating before 5,000 ms deadline. During the experiment, they were reminded to respond faster if they did not respond within 5,000 ms.

Participants saw 40 experimental and 40 filler sentences. Experimental sentences were distributed among four different lists according to a Latin-square design. Every participant saw one version of the experiment with a specific list and one item per condition.

## Analysis

In our analysis, we used the items from Experiment 1, as well as the items from Experiment 2. This decision was made to answer our hypothesis that whether or not participants use the form of the plural suffix rather than the linguistic features. A presence of interaction between the attractor type (*nominal* vs. *verbal*) and the agreement attraction effect would indicate that people use the linguistic features rather than the form of the plural suffix.

Similar to Experiment 1, we removed the data for all participants who did not exceed the threshold of 25 percentage points in ‘yes’ responses between the grammatical condition and the ungrammatical condition with singular attractors. As a result, we excluded one participant from the Experiment 2, and 10 participant from the Experiment 1.

We used R packages *brms* (Bürkner, 2018) and *rstan* (Stan Development Team, 2019) to fit Bayesian hierarchical models (e.g., Gelman & Hill, 2007). We analyzed only experimental sentences, and used (i) grammaticality of the sentence,

(ii) attractor number, and (iii) type of the plural suffix (i.e., experiment), as well as their interactions as predictors. Moreover, we used by-participant and by-item intercepts and slopes for all predictors. Data for Experiment 2, along with our analysis scripts can be found in

[https://github.com/utkuturk/orc-attractor\\_numberattraction](https://github.com/utkuturk/orc-attractor_numberattraction).

## Results

Figure 4 shows the average proportions of 'acceptable' responses by experimental conditions for Experiment 2. It shows that ungrammatical sentences with plural attractors are rated as acceptable ( $M = 0.05$ ,  $SE = 0.01$ ) as their counterparts with singular attractors ( $M = 0.06$ ,  $SE = 0.01$ ). The lack of effect ( $-0.01$ ) compared to the magnitude of the effect in Experiment 1 (0.10) indicates that the verbal plural morpheme does not trigger an illusionary agreement. Accuracy rates for grammatical conditions were nearly equal ( $M = 0.91$  and  $0.94$ ,  $SE = 0.01$  and  $0.01$ , for singular and plural attractors respectively).

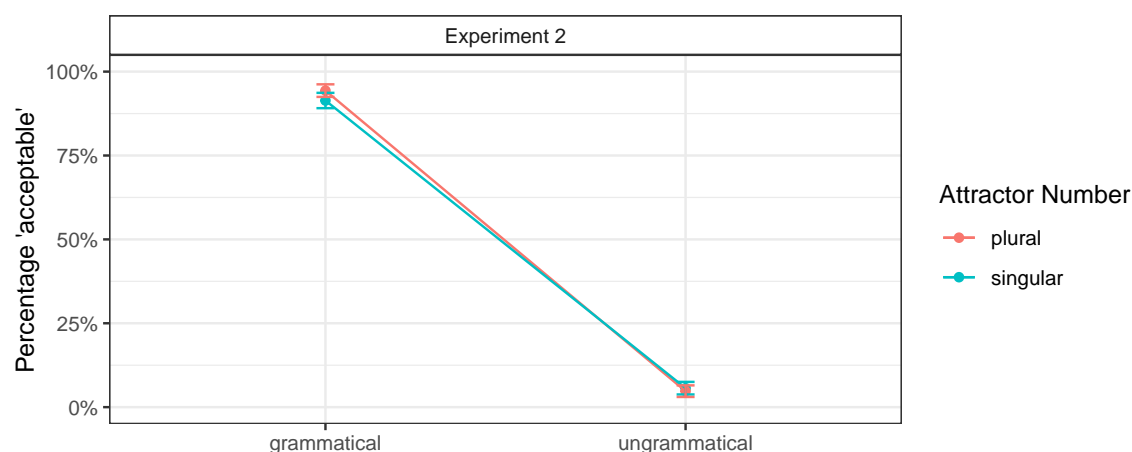


Figure 4. Estimates and 95% credible intervals for the regression coefficients for Experiment 1 and Experiment 2. Within-subject 95% confidence intervals in brackets Cousineau (2005); Morey (2008).

A Bayesian GLM assuming a Bernoulli distribution with a probit-link function was fit to participants' 'acceptable' responses. The model's estimates and 95% credible intervals are shown in Figure 5. The main effect of *ungrammaticality* ( $\hat{\beta} = -3.41$ ;  $CI = [-3.63; -3.19]$ ;  $P(\beta < 0) > .999$ ) indicates that, on average, participants were quite good at distinguishing between grammatical and ungrammatical sentences. Meanwhile, there was no evidence for an interaction between *ungrammaticality* and *attractor number* ( $\hat{\beta} = -0.03$ ;  $CI = [-0.33; 0.25]$ ;  $P(\beta < 0) = .58$ ), indicating a similar effect of attractor number in ungrammatical conditions compared to grammatical conditions, and thus no number agreement attraction effect. Importantly, the negative effect between *the presence of the verbal*

*plural*, *ungrammaticality* and *attractor number* ( $\hat{\beta} = -1.07$ ;  $CI = [-1.53; -0.61]$ ;  $P(\beta < 0) > .999$ ) indicated that the plural morpheme on the verb of the object relative clause lowered the agreement attraction effects.

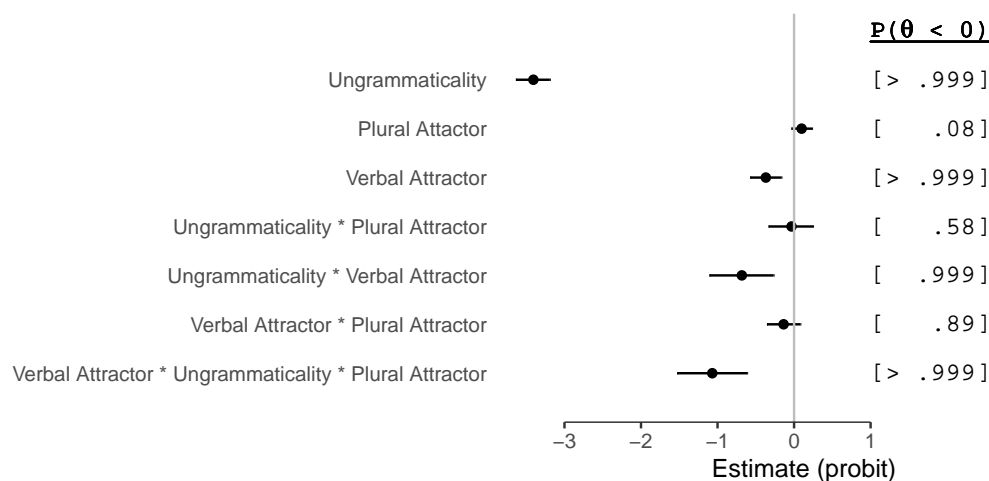


Figure 5. Estimates and 95% credible intervals for the regression coefficients for Experiment 2

## Discussion

In Experiment 2, we could not find any effect of agreement attraction in the acceptability ratings of ungrammatical conditions with a verbal plural attractor. However, number agreement attractions were observed when the attractors were nominal. Even though the forms of the two plural morphemes are the same form-wise, there is a distinct difference between the results of two experiments. One of the indications of zero-effect with verbal plural morpheme is that readers do not make decisions solely based on the form of the elements. This finding contradicts our hypothesized form-driven processing strategy and supports an account of agreement attraction based on the use of abstract linguistic features, rather than mere form.

However, results may be more telling with regards to the other theories of agreement attraction. These results seem unexpected within the cue-based retrieval mechanisms. Even though the root of the attractor is verbal, the morpheme is the same with the third person plural possessive marker since the relative clauses in Turkish are always nominalized and the subject is marked with the genitive case. The findings of this experiment indicate towards more fine-grained features needs to be utilized. One other possible explanation within the cue-based retrieval models can be formed around the status of agreement markers. One can say that the agreement process is completed in the verbal *-lAr*; in other words, it is not the triggering morpheme but the probe of the agreement. This difference would mean that verbal *-lAr* should not start any search for dependency resolution. In contrast to verbal *-lAr*, the plural morpheme on the genitive is supposed to be triggering

part of the agreement, not the probe. However, in Turkish embedded clauses, where genitive subjects can be seen, the number agreement works differently than the matrix level agreement. When the genitive subject of an embedded clause is marked with plural it is ungrammatical to have plural marking on the verb. This prohibition in return means that the genitive subjects should not create an expectation for a plural marked verb, which was believed to be the reason for the agreement attraction in Lago et al. (2018).

As for the marking and morphing theories, the results of Experiment 2 are completely expected and mitigated by the syntactic depth effects. Due to the genitive possessor's limited inner complexity compared to that of relative clause modifiers, marking and morphing theories would expect higher contribution from the genitive attractors to the final representation of number information.

### **General Discussion**

## References

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