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SANTA CRUZ

**CONNECTIVITY AND CASE EFFECTS IN AGREEMENT ATTRACTION: THE CASE OF TURKISH**

A thesis submitted in partial satisfaction of the
requirements for the degree of

MASTER OF ARTS

in

LINGUISTICS

by

**Elifnur Ulusoy**

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## Abstract

Case and connectivity effects in agreement attraction: The case of Turkish

by

Elifnur Ulusoy

Agreement attraction is a phenomenon in language processing whereby ungrammatical sentences can be perceived as acceptable when there is an attractor noun phrase with matching features present. Theoretical accounts of this phenomenon propose explanations based on both syntactic and memory-based factors, and research in various languages has provided evidence supporting both views. While there is evidence that hierarchical relations between the agreement controller and the attractor can modulate attraction, it remains unclear which syntactic positions are accessible to the parser for retrieving an agreement controller. This study investigates agreement attraction in Turkish, an agglutinative language with flexible subject-object-verb (SOV) word order. Previous research on Turkish has focused on agreement errors where the attractor and controller share a common node in a containment relationship, such as possessive constructions. In contrast, this study explores constructions where the attractor and controller are separated by syntactic boundaries, intending to test whether the parser looks outside the syntactic domain of the verb for a feature-matching controller. The study presents three experiments using acceptability judgments and self-paced reading. The results suggest that

attraction effects can surface in Turkish even when the attractor and controller are syntactically separated. We additionally probe into the role of distinctive case-marking: and our initial findings show that dative-marked attractors fail to generate attraction effects, unlike nominative-marked attractors. This suggests that the case marking of the attractor might modulate agreement attraction in Turkish. We offer a bias analysis for our Experiments 1 and 2, providing insights into the discussion of the grammaticality asymmetry, finding no evidence for a correlation between the size of the asymmetry and the participant bias. We conclude by proposing an experiment to investigate the effects of semantic similarity.

*For my grandmothers, Sabiha & Müyesser*

# Chapter 1

# Introduction

Sentence comprehension is a rapid and complex process that involves numerous cognitive processes, such as the integration of semantic information, syntactic parsing, and morphological decomposition. To understand language in any modality, an incremental and rapid integration of new linguistic material, as well as the retrieval of and engagement with previously processed material from working memory, are necessary. A prominent example of this rapid retrieval and integration in sentence processing literature is long-distance dependencies, such as 1, where the noun phrase (NP) *the cat* must be maintained in working memory until it is integrated as the direct object of *like* (1):

(1)  **The cat** my siblings *like* is taking a nap on my bed.

Another prevalent long-distance dependency is subject-verb agreement, which

indicates the covariance of morphology on the verbal predicate with syntactic and/or semantic properties of the subject NP (Corbett, 2003). Languages differ in terms of which features of the subject are marked on the predicate. While Turkish generally exhibits person and number marking, as shown in (2), English only marks the third singular subject on the verb, as shown in (3).

(2)  a. Aday-lar       bu  haftasonu sınav-a      gir-ecek-ler.
     candidate-PL this weekend   exam-DAT enter-FUT-3PL
     'The candidates will take the exam this weekend.'

   b. Ben okul-a      yarın      gid-eceğ-im.
     I     school-DAT tomorrow go-FUT-1SG
     'I will go to school tomorrow.'

(3)  The dog barks loudly.

Speakers and listeners are highly skilled at carrying out these processes in milliseconds, retrieving the necessary information from working memory to form linguistic dependencies across long distances (Van Dyke & McElree, 2011). However, a growing body of literature suggests that interference can arise from structurally inaccessible items encoded in memory (Drenhaus, Frisch, Saddy, & Friederici, 2005; Wagers, Lau, & Phillips, 2009). These instances are known as linguistic illusions, where ungrammatical sentences are temporarily deemed acceptable in the early stages of processing. These illusions have the potential to provide insight into the nature of memory processes essential for dependency formation. One example of

these illusions is known as *agreement attraction*, which is the phenomenon where an agreement-bearing element, such as the verb, realizes agreement with a nearby, structurally inaccessible attractor (4b).

(4)  a.  The key to the cabinets is on the table.

  b.  The key to the cabinets are on the table.

Attested in both production and comprehension, agreement attraction is a prevalent illusion observed in colloquial speech and writing, as well as well-edited texts like the New York Times and presidential speeches (Wagers et al., 2009). It is widely suggested that agreement attraction effects are not simple instances of proximity concord (Quirk, Greenbaum, Leech, & Svartvik, 1972). Previous studies have shown that there are multiple factors influencing the presence and the degree of agreement errors. These factors include clause boundedness (Dillon, Mishler, Sloggett, & Phillips, 2013), the relative syntactic depth of the attractor relative to the agreement controller (Lago, Shalom, Sigman, Lau, & Phillips, 2015), the number features of the attractor (Badecker & Kuminiak, 2007), and case marking of the attractors (Avetisyan, Lago, & Vasishth, 2020). Early accounts of agreement attraction, such as the Feature Percolation (Bock & Miller, 1991) model, propose that the number feature incorrectly spreads upward in the hierarchical structure. A later model, Marking & Morphing (Eberhard, Cutting, & Bock, 2005), suggests that a continuum of plurality can lead the parser to generate a plural-marked verb.

Early studies in production support the idea that hierarchical relationships play a role in attraction (Bock & Cutting, 1992), which found that complex NPs with attractors situated in prepositional phrases (PPs) led to higher rates of attraction than attractors in relative clauses (RCs). It is important to note that both the Feature Percolation and Marking & Morphing accounts assume that the incorrect realization of agreement is caused by a faulty representation of the subject, which is influenced by the hierarchical relationships between the agreement controller and the attractor phrase. However, the cause of agreement errors is still debated in the literature. On the other hand, retrieval-based accounts of agreement attraction propose a different perspective. According to these accounts, these errors arise from the activation of multiple elements during the planning or comprehension of the verb. They propose that a content-addressable retrieval mechanism employed by the verb activates multiple elements in memory simultaneously, resulting in incorrect retrieval. This is particularly evident in cases of partial cue match, where an attractor with cues that match those of the verb is present (Wagers et al., 2009; Lewis, Vasishth, & Van Dyke, 2005). Other retrieval-based accounts present multiple factors to play a role in agreement errors. For instance, Gillespie and Pearlmutter (2013) provides a lack of evidence for the structural constraints in agreement attraction and suggests *co-planning* of the constituents to be the source of attraction effects. They show comparable effects across RC and PP constructions,

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suggesting that agreement computation lacks a hierarchical component. They propose the *scope of planning hypothesis* as an alternative to accounts of feature passing, arguing that the simultaneous planning of the arguments confounds the previous literature on the role of hierarchy in agreement attraction due to word order and semantic relatedness or similarity.

The present study aims to investigate the effects of syntactic connectivity between the attractor and the agreement controller in agreement attraction in Turkish. The role of syntactic connectivity is significant in hierarchy-based theories of agreement attraction, such as Feature Percolation. In these theories, shared nodes are essential for the percolation of the number feature, which can lead to agreement errors. In contrast, cue-based retrieval and scope of planning accounts do not rely on hierarchical modulation of agreement computation. The literature lacks consensus on the extent to which agreement dependency formation relies on structure, and the findings from different languages are conflicting. Moreover, previous studies often include confounding factors such as case-marking and semantic integration (Gillespie & Pearlmutter, 2011). By examining the Turkish language, which exhibits relatively free word order and distinct case marking, we can mitigate these confounds and gain further insights into the role of hierarchy in agreement computation. Our study aims to determine whether agreement attraction effects can be induced by a structurally inaccessible distractor located outside the clause

boundary of the agreement dependency and not contained by, or containing, the controller. This study has multiple objectives, including: (i) addressing the gap in the Turkish agreement attraction literature by examining constructions with syntactically disconnected attractors and agreement controllers, (ii) providing valuable insights into the influence of hierarchy in agreement attraction by utilizing Turkish, a language characterized by its free word order properties, and (iii) reevaluating the question of retrieval versus encoding interference while extending the findings of Wagers and colleagues on grammaticality asymmetry through a bias analysis. To accomplish our goals, we conduct three experiments and propose a fourth experiment. Experiments 1 and 2 assess attraction effects and utilize Detection Theory analysis to determine response bias. We employ the response bias to argue in favor of retrieval interference rather than encoding interference, as suggested by the grammaticality asymmetry reported by Wagers et al. (2009). Experiment 3 examines the effects of case marking on agreement attraction and investigates whether noun phrases marked with a case incompatible with subjecthood can lead to increased acceptability rates, akin to attractor noun phrases marked with a nominative case compatible with subjecthood. Our findings reveal the presence of agreement attraction in environments where the agreement controller and the attractor are syntactically disconnected, suggesting a lack of hierarchical modulation in the process of agreement computation. Additionally, our

study provides insights into the utilization of distinctive case marking in agreement computation.

# Chapter 2

# Background

## 2.1 Similarity-based interference in sentence processing

It is a well-established finding in cognitive science that working memory is vulnerable to overloads resulting from the encoding of multiple elements sharing similar features. This observation is supported by evidence from various domains, including sentence processing (Jäger, Benz, Roeser, Dillon, & Vasishth, 2017; Villata, Tabor, & Franck, 2018), visual processing (Conci, Münchau, Bloem, Thiel, & Kümmerer, 2006), item recognition (Nosofsky & Kantner, 2006), and numerical updating tasks (Pelegrina, Borella, Carretti, & Lechuga, 2012). During the retrieval process, items with features similar to the target can potentially interfere with the process due to overlapping features. This interference leads to the activation of other elements that match the same retrieval cues, resulting in spreading activation.

Such spreading activation can impede the retrieval process by increasing activation levels among elements similar to the target, leading to slower or less accurate retrieval. In sentence processing, a growing body of literature has investigated the effects of similar noun phrases causing interference in long-distance dependencies. The nature of interference effects can vary depending on the context, giving rise to two types: inhibitory interference and facilitatory interference.

### 2.1.1 Interference effects in sentence comprehension

Increased processing difficulty is often observed during the comprehension of long-distance dependencies, primarily attributed to inhibitory interference. These effects are typically manifested as longer reading times, particularly at the verb region where the retrieval process takes place. For instance, Van Dyke and Lewis (2007) reported prolonged reading times (RTs) when encountering subject noun phrases with similar animacy features. Conversely, when the two nouns exhibited a mismatch in animacy, a speedup effect was observed in the processing of the verb *complaining* (5a), as compared to the match condition (5b).

(5)    a.  The worker was surprised that the resident who was living near the dangerous warehouse was complaining about the investigation.

        b.  The worker was surprised that the resident who was living near the dangerous neighbor was complaining about the investigation.

The phenomenon of agreement attraction, which is the focus of this thesis, often demonstrates *facilitatory interference*, also referred to as intrusion or attraction in the literature. These effects are characterized by faster reading times and higher rates of acceptability. In the experiments conducted by Wagers et al. (2009) using self-paced reading and speeded acceptability judgment tasks, they found that ungrammatical constructions with a plural attractor resulted in higher acceptability ratings and faster processing times in the verb region. However, grammatical constructions did not exhibit facilitatory interference, as no facilitated reading times or increased acceptance rates were observed. It is worth noting that intrusion effects are not exclusive to subject-verb agreement, as similar facilitation has been observed in other linguistic phenomena, such as negative polarity item (NPI) licensing (Drenhaus et al., 2005; Yanılmaz & Drury, 2018).

## 2.2 Theories of agreement attraction

Grammarians initially noticed systematic errors in subject-verb agreement dependencies (Quirk et al., 1972), and the first experimental investigation on agreement attraction effects was conducted by Bock and Miller (1991). Using sentence completion tasks, Bock and Miller were able to elicit robust and systematic agreement errors, where the majority of erroneous sentence completions were in constructions such as (6a), where a plural attractor is present. They additionally observed

attraction rates higher in constructions where attractors were inside a prepositional phrase (PP; 6a) rather than a relative clause (RC; 6b). They proposed that this discrepancy could be attributed to higher-level elements having limited influence on the number feature of deeply embedded elements.

(6)  a.  *The publisher of the writers were furious.

    b.  *The publisher who likes the authors yell.

This disparity in attraction rates induced by complex subjects such as the ones including PPs (6a), and those containing RCs (6b), is widely attested in agreement attraction literature. First Bock and Cutting (1992), then Solomon and Pearlmutter (2004) argued that attraction effects must be syntactic in nature, as the rates of attraction decrease as syntactic distance increases. Solomon and Pearlmutter assume the clause-boundedness model and adopt the claim that constituents within related syntactic or semantic domains may be activated at the same time during the mapping of a conceptual structure onto the syntactic frame. This is arguably analogous to exchange errors (Wagers, 2008), a type of speech error where interacting elements can create blends or exchange words, stems, or segments (*talking Turkish → Turking talkish*; Dell & Reich, 1981). Being simultaneously active in planning increases the chances of attraction effects, as it may lead to the activation of the attractor and subsequent interference during agreement processing.

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Bock and Eberhard (1993) conducted an investigation into the role of syntactic, semantic, and phonological factors in agreement attraction. They specifically examined the effects of irregular plurals (*foot-feet*), notionally plural nouns (*army*), and pseudo-plurals, which are singular nouns with final consonants matching those of plurals (*rose-rows*). Their study did not reveal attraction effects in subject-verb agreement based on phonological correlates of plural marking. However, they found that the rates of agreement variation with irregular plural attractors were similar to those induced by regular plural morphology. Additionally, their results indicated that collective nouns did not exhibit a greater ability to attract plural verbs compared to singular nouns.

While these initial experimental results come from production studies, Nicol, Forster, and Veres (1997) showed observed agreement attraction in comprehension in a speeded acceptability judgment as well as a Maze task, where the participants are asked to choose the correct continuation of the sentence word-by-word. They found that participants had increased reading time when there was a mismatch between the number marking of the attractor and number marking of the head noun: however, this effect was only present in items with singular head and plural attractor pairs (7a); items like (7b) did not trigger attraction effects.

(7)   a.  The author of the speeches was subsequently well rewarded.

      b.  The authors of the speech were subsequently well rewarded.

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Additionally, Nicol et al. confirmed that the slowdowns they observed were due to subject-verb agreement: when they used experimental items that did not have to exhibit subject-verb agreement (8), they no longer saw a difference between conditions.

(8)   The author of the speeches will be well rewarded.

Bock and colleagues proposed a Feature Percolation account of attraction effects, which is a mechanism similar to syntactic feature copying. They argued that attraction effects are not triggered by word-final phonological similarity or notional plurality, suggesting that attraction is purely a structural phenomenon. According to their account, attraction occurs when the number feature percolates upward, and the need for plurality marking arises due to a mismatch between the singular head and plural attractor. However, while this explanation can account for many cases of attraction effects, it is not comprehensive enough to explain all of them (Wagers et al., 2009).

Another encoding-based account, known as Marking and Morphing (Eberhard et al., 2005), proposes that features can percolate at any position, but the syntactic distance they need to travel is inversely correlated with agreement error rates. Additionally, the Marking and Morphing model conceptualizes plurality as a continuum rather than a binary feature, represented by SAP (singular-and-plural) values ranging from 0 (for singular nouns without collective readings) to 1 (for

plural nouns). When integrating new input, each head contributes an SAP value weighted by its syntactic distance to the subject. This model, along with the Feature Percolation model, suggests that agreement errors result from faulty representation of the subject's number. However, it is important to note that even correctly encoded representations can lead to attraction, and the process of accessing these representations can be disrupted by structurally inaccessible constituents.

Retrieval-based theories of agreement attraction propose that these effects arise from a content-accessible mechanism activated by the verb. Content-accessibility in agreement refers to using features to search for a cue-matching agreement controller, guided by the verb's cues. This search involves identifying a noun phrase (NP) with matching features, and errors can occur when multiple elements match the retrieval cues. One prominent proposal that aligns with this view is cue-based retrieval, which attributes erroneous agreement to retrieval processes that activate multiple items in memory (Van Dyke & Lewis, 2003). While content-addressability enhances retrieval efficiency, illusions of grammaticality can arise when multiple elements with matching features lead to similarity-based interference.

Wagers and colleagues offer two accounts for cue-based retrieval to capture the facilitation effect observed in attraction constructions. According to the first account, retrieval functions as an error-driven mechanism triggered when

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an ungrammatical construction is detected, leading to a perceptual repair. If the incoming verb violates predictions about its agreement features, retrieval might be engaged to recover a feature-matching (plural) noun and restore the interpretation. The second account proposes that retrieval is always engaged at the verb region, regardless of grammaticality. This predicts that grammatical constructions will not show attraction effects, as they contain a licensing NP subject that matches the retrieval cues of the verb, which has been borne out in the agreement attraction literature. Another model of agreement attraction that does not require hierarchical modulation is the scope of planning hypothesis proposed by Gillespie and Pearlmutter (2013). Gillespie and Pearlmutter observed no significant differences in constructions where the attractor and the controller are syntactically connected (PPs; 6a) and when they are not (RCs; 6b) when the overall meaning and the use of function words were kept constant. They argued that the literature on hierarchical effects in agreement attraction confounds co-planning and syntactic distance; and that agreement attraction is a result of retrieval of elements that were simultaneously encoded. They argue that conceptual similarity of the attractor and the agreement controller modulates attraction effects; and while there might be a feature-passing component to agreement computation, the effects are constrained by scope of planning.

## 2.3 Case effects

In cue-based retrieval, the success of retrieval depends on the overlap of the retrieval cues encoded by the verb and the features of a specific chunk (Lewis et al., 2005). This model assumes that partially-matching NPs are in a race to be retrieved, and whichever chunk is retrieved fastest becomes the *winner* of the retrieval. In terms of features, overt case marking is a useful indicator of the grammatical function of arguments and can be used to mark the subject distinctively. It is an outstanding question whether attraction errors are reduced in the presence of an attractor marked with a distinctive case marking incompatible with subjecthood. Case-marking is frequently confounded with other variables, potentially impacting the possibility of making agreement errors: Hartsuiker, Antón-Méndez, and Van Zee (2001) tested whether object attraction is present in Dutch. They found that overt case marking led to fewer agreement errors, but in this study, it is unclear whether the effect was due to the word category itself or the case marking of the attractor. Slioussar (2018) also showed in a sentence-completion task that error-related slowdowns were reduced in ungrammatical sentences with attractors that are ambiguous between genitive, singular marking, and accusative, plural marking; however, the specific case syncretism in Russian makes it difficult to generalize from this study. More recently, Avetisyan et al. (2020) found clear

patterns of facilitatory interference in Armenian with both nominative-marked and subjecthood-incompatible accusative-marked attractors (9), suggesting that case marking is unable to modulate attraction effects. Overall, we do not have clear evidence that the rates of attraction errors were alleviated when the attractor is distinctively case-marked as a non-subject.

(9)    a.    **The painter(s)$_{\textbf{NOM}}$** [$_{RC}$ that the sculptor$_{NOM}$ ignored] . . .

        b.    **The painter(s)$_{\textbf{ACC}}$** [$_{RC}$ that the sculptor$_{NOM}$ ignored] . . .

In the first two experiments, our controller is marked with the genitive case in Turkish, while our attractor has the unmarked, nominative case. In our Experiment 3, we probe whether the distinctive case marking of the attractor alleviates the illusion of grammaticality in ungrammatical sentences.

## 2.4   Semantic relatedness effects

Anticipation is essential to human cognition (Clark, 2013). Predictive processes are prevalent in multiple functions of cognitive processing, including joint action (Sebanz & Knoblich, 2009) as well as visual processing (Summerfield & Egner, 2009). Similarly, sentence processing is an incremental process, requiring comprehenders to rapidly integrate new input, generate expectations, and construct higher-order syntactic *and* semantic representations of the sentence (Van Berkum, Brown, & Hagoort, 1999). This incremental nature of processing extends to the lexical level.

Early studies using shadowing tasks by Marslen-Wilson (Marslen-Wilson, 1973; Marslen-Wilson & Tyler, 1980) demonstrated that shadowers could quickly repair semantic errors using earlier sentential context. There is also evidence from various methodologies supporting the incremental nature of semantic interpretation. For instance, Kutas and Hillyard (1983) found that semantically erroneous sentence endings elicit negative shifts in ERP waveforms associated with erroneous stimuli, as well as N400 effects linked to semantic anomalies. Furthermore, studies on complex constructions involving semantically similar noun phrases have shed light on the incremental processing of sentence meaning. Gennari and MacDonald (2008) found that the animacy of NP1 (the first noun phrase) has early effects on the processing of object relative clauses. They attributed these effects to what they termed *semantic indeterminacy* which refers to the challenge of generating expectations about the remainder of the sentence based on the preceding context, leading to difficulties in interpretation and influencing subsequent processing. According to their proposal, readers use the first noun of the relative clause to generate expectations about how the sentence will unfold. Additionally, investigating the influence of both animacy and semantic relatedness, Lowder and Gordon (Lowder & Gordon, 2014) employed self-paced reading tasks in their second experiment. They examined whether this indeterminacy depends on the semantic relatedness between NP1 and NP2 in object relative clauses.

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(10) Experimental items from Lowder and Gordon (2014)

    a. The mayor$_{NP1}$ that the senator$_{NP2}$ criticized received more publicity than anyone expected. **(animate–related)**

    b. The bills$_{NP1}$ that the senator$_{NP2}$ criticized received more publicity than anyone expected. **(inanimate–related)**

    c. The waitress$_{NP1}$ that the senator$_{NP2}$ criticized received more publicity than anyone expected. **(animate–arbitrary)**

    d. The recipe$_{NP1}$ that the senator$_{NP2}$ criticized received more publicity than anyone expected. **(inanimate–arbitrary)**

Lowder and Gordon conducted a study to investigate how comprehenders interpret sentences containing two nouns in object relative clauses. They proposed that the process of interpretation begins as soon as readers encounter the two nouns, and that the semantic relatedness between them plays a crucial role in establishing an association prior to encountering the verb. They also hypothesized that animacy would aid in interpretation when there was no direct semantic relationship between the two nouns.

Their findings supported their predictions. Both animacy features and semantic relatedness influenced the comprehension of object relative clauses. They observed longer reading times in the region containing the second noun phrase (NP2) prior to the verb when NP1 was animate compared to when it was inanimate. The authors

argued that this early animacy effect is a result of readers' violated expectations, as object relative clause heads are typically inanimate. Another possible explanation could be related to similarity-based encoding difficulty, where readers might have more difficulty encoding two animate noun phrases compared to one inanimate and one animate noun phrase (Lowder & Gordon, 2012). In a follow-up experiment, they found that the early effect of animacy was only present when there was no direct semantic link between the two nouns. When there was a direct semantic link, readers had less difficulty establishing a relationship and moving on to the verb. Further analysis of reading measures in later regions and comprehension accuracy revealed longer reading times at the verb region for noun phrases that matched in animacy. The authors argued that this effect is a result of semantic indeterminacy (Gennari & MacDonald, 2008), where readers are unable to use world knowledge to generate expectations about the relationship between the noun phrases due to the reversible thematic roles, and would have to use the structural properties of the verb to assign thematic roles.

Continuing the discussion on agreement attraction, there is a proposed link between the semantic relatedness of the two noun phrases involved, namely the attractor and the controller, and the occurrence of agreement errors. According to this account, agreement errors emerge while building sentence representations and are influenced by the order in which constituents are planned (Badecker &

Kuminiak, 2007). The scope of the planning hypothesis put forth by Gillespie and Pearlmutter (2013) challenges previous studies that have examined the role of hierarchical relationships in agreement attraction as these studies often conflated syntactic distance with the simultaneous planning of the two noun phrases.

The scope of planning hypothesis holds the view that the degree of structural distance between the attractor and the controller should correlate with attraction rates since structurally close elements are frequently planned simultaneously. Gillespie and Pearlmutter (2013) conducted experiments to investigate the correlation between agreement errors and semantic relatedness while keeping the structural distance between the controller and the attractor constant. Their findings revealed that agreement errors were more likely to occur with semantically related noun phrases than semantically unrelated ones, supporting the notion that semantic relatedness influences attraction rates when the structural distance remains consistent. Inspired by the findings of Gillespie and Pearlmutter (2013), an interesting avenue to explore would be conducting a similar experiment in Turkish. This experiment would compare the rates of agreement attraction between semantically related and unrelated noun phrase (NP) pairs. We propose this experiment as part of our discussion on future research directions.

## 2.5 The grammaticality asymmetry

Numerous agreement attraction studies, such as those by Dillon et al. (2013) and Schlueter, Williams, and Lau (2018), have shown that grammatical sentences with cue-matching "attractors" are generally resistant to interference effects. This suggests that a subject noun phrase (NP) with partially matching features is not retrieved when a correct subject NP with fully matching features is present. This results in an asymmetry in how comprehenders behave: ungrammatical sentences may be perceived as acceptable, indicating an illusion of grammaticality, while grammatical sentences with a number-mismatching attractor are not considered unacceptable, providing limited to no evidence for an illusion of ungrammaticality. This challenges the assumption that the faulty representation of the subject is the cause of interference effects, as encoding-based models of attraction propose that the percolation mechanism operates independently of the verb and its features. In contrast, cue-based retrieval models like ACT-R (Lewis et al., 2005) or direct-access memory retrieval, where different cues are accessed at the same speed (Van Dyke & McElree, 2011), suggest that interference effects arise from multiple encodings that match the retrieval cues of the verb. According to these models, misretrieval should not occur when the correct agreement controller matches the retrieval cues of the verb.

While there is limited evidence for an agreement attraction effect in grammatical constructions, Hammerly, Staub, and Dillon (2019) propose an alternative explanation for the grammaticality asymmetry. They introduce a drift-diffusion model, which conceptualizes decision-making as the accumulation of evidence until a threshold is reached. In sentence processing, this evidence accumulation reflects the strength of each possible sentence interpretation, with a drift rate denoted as $v$, where higher drift rates indicate more informative and less equivocal information (Ratcliff & Smith, 2004). According to Hammerly et al. (2019), participants have a bias to judge sentences as grammatical when a partially matching attractor is present, even when the agreement error is unambiguous. They argue that the observed asymmetry in agreement attraction should not be solely attributed to retrieval-based models, as the asymmetry diminishes or decreases when response bias is eliminated, lending evidence to encoding-based accounts such as Marking & Morphing. Our findings also address the issue of response bias and employ a Signal Detection Theory analysis to demonstrate why response bias alone cannot fully explain the grammaticality asymmetry, aligning with the conclusions of Wagers et al. (cf. Hammerly et al., 2019).

# Chapter 3

# Present study

## 3.1 Motivation

As discussed in Background, findings on hierarchical constraints in agreement attraction are conflicted. It is a question of interest in the sentence processing literature what the limits of these hierarchical constraints are, if any, and how retrieval processes interact with these constraints. This study focuses on the Turkish language, known for its morphological complexity, flexible word order, and distinctive case-marking system, making it an important language for psycholinguistic research. Despite its potential significance, there is a lack of empirical research on Turkish language processing. The main goal of this thesis is to test the effects of syntactic connectivity and distance in agreement attraction by making use of the grammatical flexibility of the Turkish language.

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## 3.2 An overview of the Turkish language

Turkish is the official and dominant language of the Turkish Republic. It is the most widely-spoken language of the Turkic language family, accounting for 30 percent of the total number of speakers of Turkic languages (Kornfilt, 2008). Like many languages of the family, Turkish has SOV word order, a rich morphological system, and vowel harmony (Kabak, 2011). Relevant to the present study, Turkish shows subject-verb agreement in number and person.

### 3.2.1 Number agreement in Turkish

Subject number is marked on the verb with the *-lAr*[1] morpheme for the third person plural, and with the *-Ik* for the first person and the *-Iz* morpheme for second person plurals. Göksel and Kerslake (2004) note that number agreement for third-person plurals is generally considered to be optional in the literature, but it becomes more or less obligatory when the verb indicates individuated action, *i.e.*, when the predicate has a distributive reading (11).

(11) Çocuk-lar bir-er şişe su iç-ti-ler.
     kid-PL    one-each bottle water drink-PAST-3PL

     'The kids each drank one bottle of water.'

---

[1]The morphemes are written in accordance with the Turkish linguistic tradition, with capitalized symbols representing phonemes that conform to the vowel harmony rules of the word they are being suffixed to. Some morphemes have consonants in parentheses; these are deletable and are only used if their absence creates a vowel sequence.

### 3.2.2 Complex DPs in Turkish

Turkish has various ways of expressing possessive constructions: genitive-possessive constructions (GPs; 12), possessive compounds (PCs; 13), and possessive-free genitives (PFGs; 14).

(12) **Çocuk-lar-ın başarı-sı** biz-i      mutlu    et-ti.
      kid-PL-GEN            success-POSS we-ACC happy make-PAST
      'The kids' success made us happy.'

(13) çocuk kitab-ı
      kid     book-POSS
      'children's book'

(14) çocuğ-un kitap
      kid-GEN book
      'the book of the child'

The relevant construction in the present study is the genitive-possessive (GP) construction (12, see tree schema in 15). In these constructions, the possessor is marked with genitive case marking as the genitive case marks the subjects of embedded clauses. The possessive marking on the possessee NP shows agreement with the possessor's person features, as shown in Table 3.1.

(15)

```
                              DP
                     ┌────────┴────────┐
                    DP                 D'
                     |            ┌─────┴─────┐
                    DPᵢ         PossP          D
               ┌────┴────┐    ┌───┴───┐
          çocuk-PL-GEN      tᵢ      Poss'
                                 ┌───┴───┐
                                NP      Poss
                                 |        |
                                NP       -sI
                              ┌──┴──┐
                             başarı
```
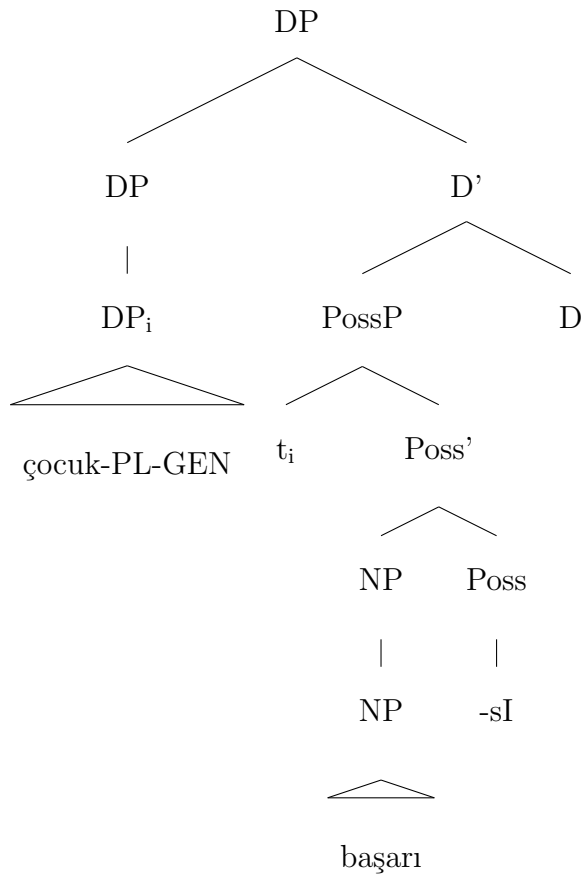
|  | Possessor | Possessee |
|---|---|---|
| 1SG | ben-**im** | dolab-**ım** |
| 2SG | sen-**in** | dolab-**ın** |
| 3SG | o-**nun** | dolab-**ı** |
| 1PL | biz-**im** | dolab-**ımız** |
| 2PL | siz-**in** | dolab-**ınız** |
| 3PL | onlar-**ın** | dolap-**ları** |

Table 3.1: Genitive-possessive allomorphy in Turkish

### 3.2.3 Relative clauses in Turkish

Relative clauses are modifier "clauses" that attach to and modify a head NP. In Turkish, relative clauses are typically non-finite and contain one of these participle suffixes attached to the RC verb: *-(y)An, -DIK, -EcEK* (Göksel & Kerslake, 2004).[2] RCs in Turkish are right-headed; they precede the NP they modify (16, 17).

(16)  ödev-i          yap-an öğrenci-ler
      homework-ACC do-SP  student-PL

      'The students who did the homework'

---

[2]*ki* clauses, borrowed from Persian, are described as appositive relative clauses in the literature; however, these constructions rarely occur in colloquial speech (Griffiths & Güneş, 2014), possibly due to their word order: unlike the relative clauses discussed in this thesis, *ki* clauses are left-headed.
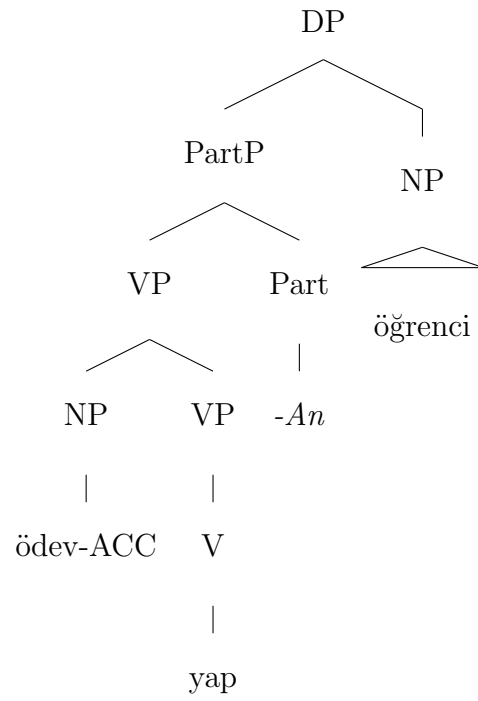
(17) öğrenci-ler-in    yap-tık-lar-ı      ödev
     student-PL-GEN do-OP-3PL-POSS homework
     'The homework that the students did'

Unlike English, the word order is the same for object and subject relative clauses. Generally, *-EcEK* and *-DIK* clauses relativize objects, and *-An* clauses relativize subjects. We are adopting the nomenclature of the syntactic literature on Turkish relative clauses by calling *-An* a *subject participle*, and *-DIK* an *object participle*. So far, we have called these constructions relative clauses in line with the syntactic tradition (Underhill, 1972). Assuming that a clause is defined by a tense phrase (TP) layer, we can argue that these constructions are not clauses, unlike the relative clause constructions in English, which show tense marking on the RC verb (18).
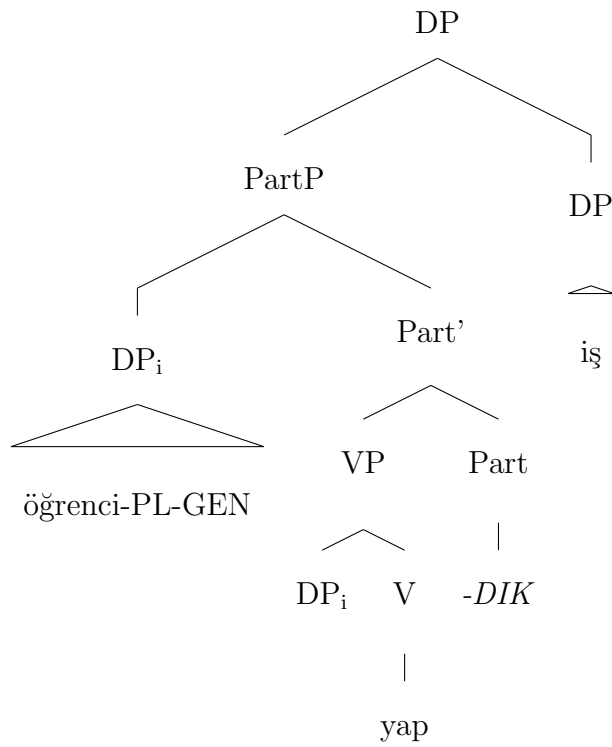
(18)   The cat [RCthe girl **adopted**] meowed.

If we look at these constructions more closely (16, 17), we can see that the syntactic composition of the two constructions is quite different (19, 20).

(19)

```
                              DP
                        ┌──────┴────┐
                     PartP          NP
                   ┌───┴───┐        △
                  VP      Part    öğrenci
                ┌──┴──┐    │
               NP     VP  -An
                │      │
            ödev-ACC   V
                       │
                      yap
```

(20)

```
                                    DP
                            ┌────────┴────────┐
                         PartP               DP
                    ┌──────┴──────┐          △
                  DPᵢ           Part'        iş
                   △          ┌──┴───┐
            öğrenci-PL-GEN    VP    Part
                            ┌─┴─┐    │
                          DPᵢ  V   -DIK
                                │
                               yap
```

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One notable distinction between subject and object relative clauses in Turkish is that subject relative clauses do not exhibit agreement with the number or person features of the subject. Conversely, object relative clauses display agreement with the genitive-marked relative clause subject. Another dissimilarity is the presence of GEN-POSS marking in object relative clauses, which aligns them in structure with nominalized clauses and genitive-possessive DP constructions in Turkish (Göksel & Kerslake, 2004). These disparities clearly indicate that the two relative clauses in Turkish differ in terms of size and structure. Since our experimental items focus on the computation of agreement within subordinate clauses, we will solely employ subordinate clauses demonstrating number agreement.

There is no consensus on the underlying motivation for the distribution of relativizing participles in Turkish. While the question of how these participles are distributed are beyond the scope of this thesis, it is important to note that the distribution of the subject and object participles are not as straightforward as in the English language; and depend on multiple factors other than the grammatical function of the relativized constituent.

Underhill (1972) argues that relativization occurs after the movement of indefinite NPs. The choice between subject *(-An)* or object participle *(-DIK, -EcEk)* depends on whether the target NP bears case before scrambling: if the sentence-initial NP is caseless, the subject participle is chosen; if it bears case, the object

participle is chosen. However, Hankamer and Knecht (1976) argue that the Under-hill's argument that is based on NP-initiality should be discarded because when the deep structure involves two genitive-marked NPs, one of them should be relativized with a subject participle, while the other should result in an object participle, as one of them will fail to occupy the sentence-initial position. Let's consider example (21):

(21) Kapı-nın      alt-ın-dan          yer-in      üzer-in-e      su
     door-GEN bottom-POSS-ABL floor-GEN top-POSS-DAT water
     ak-ıyor.
     flow-PRES
     'Water is flowing under the door onto the floor.'

Relativizing each of the genitive-marked NP will require the use of the subject participle (22):

(22)  a. alt-ın-dan          yer-in      üzer-in-e      su      ak-an  kapı
         bottom-POSS-ABL floor-GEN top-POSS-DAT water flow-SP door
         'the door under which water flows onto the floor'

      b. kapı-nın      alt-ın-dan          üzer-i-ne      su      ak-an  yer
         door-GEN bottom-POSS-ABL top-POSS-DAT water flow-SP floor
         'the floor which the water flows under the door'

Hankamer and Knecht (1976) further argue that the selection of the participle is modulated by a principle that refers to the hierarchical structure, such that if the relativized constituent is a part of the subject, the subject participle is used; otherwise, the object participle is used. However, their attempt to motivate

SP selection in subjectless clauses is achieved by positing an additional principle. Another issue later highlighted by Barker and colleagues (Barker, Hankamer, & Moore, 1990) is the presence of dialectal differences in the distribution of participles in relative clauses. Specifically, two main dialects exhibit consistent and significant disparities in acceptability judgments. Dialect B differs from Dialect A in that the object participle can be used to relativize the subconstituents of the relative clause subject. For instance, while speakers of Dialect A would consider the sentence (23) unacceptable, speakers of Dialect B would deem it acceptable. However, both dialects allow the use of subject participle to relativize subconstituents of the subject.

(23) oğlu-nun        okula        git-tiği        adam
     son-POSS-GEN school-DAT go-SP-POSS.3SG man
     'the man whose son went to the school'

The relevant construction to this study is where the verbs are marked with the OP. Since we are interested in agreement attraction, the two most frequent embedded clauses that carry agreement in number with the subordinate subject are -DIK and -EcEK clauses (24a, 24b).

(24)   a. Onlar kız-lar-ın    düğün-e      git-tik-ler-i-ni
          they   girl-PL-GEN wedding-DAT go-OP-3PL-POSS-ACC
          bil-iyor.
          know-PROG

          'They know that the girls have been to the wedding.'

b. Onlar kız-lar-ın    düğün-e     gid-ecek-ler-i-ni
   they  girl-PL-GEN wedding-DAT go-OP-3PL-POSS-ACC
   bil-iyor.
   know-PROG

'They know that the girls are going to the wedding.'

While we will not delve further into the intricacies of Turkish relative clauses, it is relevant to highlight certain parallels between the syntactic structure of relative clauses and that of nominalized subordinate clauses for our purposes. The syntactic strategy employed in nominalized embedded clauses and object relative clauses (RCs) is highly similar in Turkish. Furthermore, both structures bear a resemblance to purely nominal genitive-possessive constructions commonly found in possessor constructions (15).

In Turkish, nominalized clauses, also known as "light infinitives," make use of two types of participles on the embedded verb. The *-DIK* participle, referred to as the General Participle by Lees (1965) is used with factives, while the *-mE* participle, known as the Action Noun, is used with nouns that denote actions. Similar to possessive constructions, the subject of relative clauses and nominalized embedded clauses in Turkish is marked with genitive case. Furthermore, all types of nominalized embedded clauses involve marking the nominalized verb with possessive marking, which agrees with a genitive-marked subject, as illustrated in example (25; Öztürk & Taylan, 2016)

(25) Ali hırsız-lar-ın    o    ev-e        gir-dik-ler-in-i
    Ali thief-PL-GEN that house-DAT enter-OP-3PL-POSS-ACC
    duy-du.
    hear-PAST

    'Ali heard that the thief broke into that house.' (Lit.: Ali heard about the

    thief's breaking into that house)

(26) Ali hırsız-ın    o    ev-e        gir-me-si-ni        engelle-di.
    Ali thief-GEN that house-DAT enter-N-POSS-ACC stop-PAST
    'Ali stopped the thief from breaking into that house.' (Lit.: Ali stopped

    the thief's breaking into that house)

Again, relevant to the present study, nominalized verbs in Turkish that exhibit

the *-DIK* participle carry agreement with the number feature of the embedded

subject, which is genitive case-marked, a case-marking compatible with subjecthood

in Turkish (Kornfilt, 2003).

## 3.3   Agreement attraction in Turkish

Turkish is an ideal language for investigating language comprehension due to its

complex morphology, case-marking system, and flexible word order (Göksel &

Kerslake, 2004). However, previous studies exploring agreement attraction in

Turkish have been limited in scope, focusing on only one type of construction

and involving only two studies. These studies suggest that agreement attraction

*can* also occur in Turkish; however, it is evident that there is much more to

explore, and we aim to investigate a wider range of structures and contrasts to better understand the role of hierarchy, semantic similarity, and case-marking in agreement computation in Turkish.

Lago et al. (2019) conducted a study on Turkish participants using structures exemplified in (27). In this construction, attractors always precede the head, and the number marking is always on the predicate. More importantly, the head or agreement controller is in a containment relationship with the attractor. This is analogous to *the key to the cabinets* structures, and the conditions where ungrammatical sentences included a plural attractor generated agreement attraction, extending the results of Lago et al. (2019) in English.

(27)   Lago et al. (2019), *plural attractor condition*

Teknisyen-ler-in        eğitmen-i        hızlı koş-tu-lar.
technician-PL-GEN instructor-POSS fast  run-PAST-3PL

'The technicians' instructor ran.PL fast.'

Lago et al. (2019) discovered that genitive-possessive constructions in Turkish can lead to substantial agreement errors. As explained in the language background, the genitive case often functions as the subject of embedded and relative clauses in Turkish; and they claim that it might be the case that genitive-marked constituents create agreement attraction effects due to their subject-compatible properties. However, Türk (2022) raises a critical point regarding the potential confounds

in the items used by Lago et al. (2019). Specifically, Lago and colleagues often employed possessive heads that end with a consonant in their experiment: in Turkish, there is syncretism between accusative case marking (28) and possessive marking (29) as they are both realized as *-I* when attached to a consonant-final word.

(28) Teknisyen-ler-in     eğitmen-**i**      kov-duğ-u-nu       gör-dü-m.
     technician-PL-GEN instructor-**ACC** fire-OP-POSS-ACC see-PST.1SG
     'I saw the technicians firing the instructor.'

(29) Teknisyen-ler-in     eğitmen-**i**       gel-di.
     technician-PL-GEN instructor-**POSS** come-PAST
     'The technicians' instructor came.'

However, when the possessive marking attaches to a vowel-final word, the resulting surface form differs from the accusative marking attached to a vowel-final word. This is because different buffer consonants are inserted to avoid vowel sequences: *-sI* for possessive marking (30a) and *-yI* for accusative marking (30b).

(30)  a. teknisyen-ler-in     hoca-sı
         technician-PL-GEN teacher-POSS
      b. teknisyen-ler-in     hoca-yı
         technician-PL-GEN teacher-ACC

According to Türk (2022), it is possible that the case syncretism observed in Turkish may have caused participants to interpret the head as accusative, resulting in the retrieval of the genitive-marked attractor. This assumes that

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case information is utilized in agreement computation and that accusative-marked constituents cannot serve as agreement controllers (Avetisyan et al., 2020). To address this potential confound, Türk replicated the study conducted by Lago and colleagues using similar items with vowel-final heads. Their findings revealed similar levels of agreement attraction, indicating a consistent attraction effect in the presence of a plural attractor.

The present study aims to build on the findings of these two studies probing into agreement attraction effects in Turkish. Unlike these studies, our focus is not solely on whether or not agreement attraction is present in Turkish, but rather on examining the influence of two factors: the structural distance between the agreement and the controller, and the impact of case marking on the attractor, in relation to agreement attraction in Turkish.

## 3.4 Predictions

In light of previous literature in agreement attraction and the background on the language of interest, Turkish, our predictions are as follows:

(i) If number features are not hierarchically passed in agreement attraction, an attractor that is not in a containment relationship with the agreement controller should still result in facilitatory interference. This finding would provide counterevidence to hierarchical feature-passing explanations of agreement

attraction (Gillespie & Pearlmutter, 2013; cf. Bock & Cutting, 1992).

(ii) If no attraction effects are observed in grammatical conditions with plural attractors present, it would provide evidence for retrieval-based accounts and contradict encoding-based accounts. This finding would support the idea that retrieval processes play a crucial role in agreement attraction (Gillespie & Pearlmutter, 2011) and challenge theories that emphasize encoding factors in the production of grammatical sentences.

(iii) If the grammaticality asymmetry is attributable to the underlying mechanisms of agreement computation, we would expect no correlation the magnitude of the asymmetry displayed by individual participants and their respective response bias. This prediction would provide further support for retrieval-based theories of agreement attraction, suggesting that the observed attraction effects in grammatical conditions are not influenced by response bias (cf. Hammerly et al., 2019).

(iv) If attractors marked with a subjecthood-incompatible case marking does not lead to agreement attraction errors, this would entail that differential case marking is used in agreement computation (cf. Avetisyan et al., 2020).

The behavioral signature of agreement attraction errors is facilitatory interference, which refers to higher rates of accuracy in yes/no judgment tasks or reduced

reading times in ungrammatical sentences in reading-based tasks. Although a simple task, grammaticality judgment tasks yield results compatible with informal data collection and offer important insights for exploratory studies. To get more out of the data we collect from native Turkish speakers, we make use of the $c$ (bias) measure from Signal Detection Theory (Banks, 1970; Macmillan & Creelman, 1990) in order to address whether a correlation is present between the size of the response bias and the grammaticality asymmetry.

## 3.5   Experiment 1: Speeded acceptability judgment

In this experiment, we aim to primarily test whether agreement attraction arises in Turkish when an attractor noun phrase with matching features is present within the subordinate clause by manipulating grammaticality and attractor number. By increasing the syntactic distance, but keeping the proximity constant, we are aiming to characterize the syntactic nature of agreement attraction in Turkish.

### 3.5.1   Participants

Participants were 54 native speakers of Turkish from the Boğaziçi University community with a mean age of 24.1 (range = 19-27, SD = 2.12) and no history of language disorders. All participants spoke what is historically considered the "standard" Istanbul dialect of Turkish. Twelve percent of the participants had

another language spoken at home; all participants were fluent or near-fluent in English, as it is the language of instruction at their institution. All participants gave informed consent and were compensated \$12/hour for their participation.

### 3.5.2   Materials

Experimental materials were 24 sentence sets in a 2 x 2 within-items and within-participants design with Attractor Number (SINGULAR, PLURAL) and Grammaticality (GRAMMATICAL, UNGRAMMATICAL) as the two factors, and an additional 36 fillers were presented. Experimental items were distributed across four lists via Latin Square Design such that each participant saw all fillers but only one version of one item set. The order of items and fillers was randomized for each participant. Experimental items always followed the order of $NP_{attractor}$-$[NP_{controller}$-adverb-verb$]_{RC}$-verb. An example set is presented in Table 3.2. The verb in the relative clause region always carried the plural morphology in the experimental items due to the optionality of plural marking with plural, animate subjects.

### 3.5.3   Procedure

The experiment was run on PCIbex Farm (Drummond, 2013), a web-based platform for hosting behavioral experiments. The sentences were presented word-by-word

| Grammaticality | Attractor Number | Experimental item |
|---|---|---|
| Grammatical | Singular | Psikolog asistan-lar-ın sessizce konuş-ma-ları-nı öner-di. <br><br> psychologist.NOM assistant-PL-GEN quietly speak-N-3PL-ACC advise-PST |
| Grammatical | Plural | Psikolog-lar asistan-lar-ın sessizce konuş-ma-ları-nı öner-di-ler. <br><br> psychologist-PL.NOM assistant-PL-GEN quietly speak-N-3PL-ACC advise-PST-3PL |
| Ungrammatical | Singular | Psikolog asistan-ın sessizce konuş-ma-ları-nı öner-di. <br><br> psychologist.NOM assistant-GEN quietly speak-N-3PL-ACC advise-PST |
| Ungrammatical | Plural | Psikolog-lar asistan-ın sessizce konuş-ma-ları-nı öner-di-ler. <br><br> psychologist-PL.NOM assistant-GEN quietly speak-N-3PL-ACC advise-PST |
| Translation: | | 'The psychologist(s) advised that the assistant(s) talk quietly.' |

Table 3.2: Experiment 1 items

using the rapid serial visual presentation (RSVP) method (Figure 3.1). Participants had a chance to practice on three items and get used to the presentation method before the experiment began. Each trial began with a fixation cross, and each word appeared for 500 ms on the screen with black text on a white background. After the sentence ended, the participants were presented with an acceptability judgment task (31) on whether the sentence they had read was natural. The participants were additionally instructed to use the "F" key for acceptable or the "J" key for unacceptable sentences.
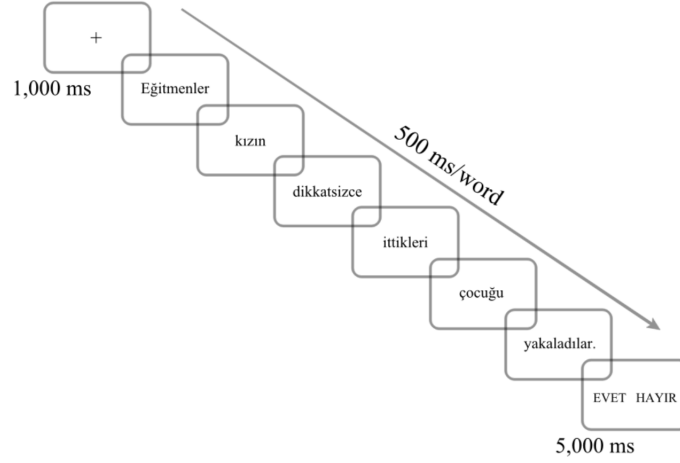
Figure 3.1: Rapid serial visual presentation (RSVP) in Exp. 1

(31)   Okuduğunuz cümle doğal mıydı?

       Did the sentence you have read seem natural?

### 3.5.4   Results

The results were analyzed by fitting a logistic regression model using the *glm* function in R (R Core Team, 2021). The logistic regression model investigated the effects of two experimental factors, GRAMMATICALITY and ATTRACTOR NUMBER, on reading times and examine the interaction between these factors as an interaction effect would point to the presence of agreement attraction effects. Accuracy results are given in Table 3.3. Two participants were excluded from the analysis due to low accuracy rates. The results revealed a significant main ef-

fect of GRAMMATICALITY and an interaction between GRAMMATICALITY and ATTRACTOR NUMBER. In the UNGRAMMATICAL condition, plural attractors resulted in lower accuracy rates (29%) than singular attractors (44%). No significant differences were found in the judgment times. The grammaticality asymmetry was replicated, as no effects were observed in UNGRAMMATICAL conditions (83% SINGULAR, 77% PLURAL; $p = 0.14$, $z = 1.48$ in a pairwise comparison).

| Accuracy (%) (SE) | Singular | Plural |
|---|---|---|
| Grammatical | 83 (2) | 76 (2) |
| Ungrammatical | 44 (3) | 29 (3) |

Table 3.3: Accuracy results by condition from Experiment 1

### 3.5.5 Discussion

Overall, the results suggest that plural attractors can increase the acceptability of ungrammatical sentences in Turkish, where there is no containment relationship between the attractor and the agreement controller. Our predictions (i) and (ii) are borne out: the results of this study showed that an attractor outside of a containment relationship in Turkish gave rise to increased acceptance rates in the judgment task, and replicated the grammaticality asymmetry as we observed no

significant effects of attractor number in the grammatical condition. However, in the ungrammatical condition, plural attractors significantly decreased the accuracy rates compared to singular attractors. These results are consistent with the results of previous research on agreement attraction. We take this replication of the grammaticality asymmetry as evidence for retrieval-based models: the asymmetry is incompatible with the claim that the error stems from the erroneous encoding of the attractor, as this would predict grammatical constructions with a non-subject, syntactically inaccessible plural NP present would also show agreement attraction effects as there is a noun phrase with overlapping features present.

## 3.6 Experiment 2: Self-paced reading

With the clear effects of attraction in non-containment relationships established in Experiment 1, this experiment aimed to see these attraction effects localized within the RC verb region in a reading study. We used experimental items syntactically similar to but lexically different from the experimental items of Experiment 1 to reduce the effects of potential participant pool overlap. Additionally, instead of using a mixture of nominalized and relative clauses, we only chose RCs that precede their head. This construction was chosen as the RC head intervenes between the RC verb and the matrix verb, with the prediction that it can catch any spillover effects of any reading times on the RC verb region induced by ungrammaticality,

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plurality, or agreement attraction effects. This change was made to avoid any confounds with increased sentence-final reading times, from the observation that wrap-up effects are cross-linguistically present in the sentence-final region, making it potentially indistinguishable from the expected effects (Warren, White, & Reichle, 2009).

### 3.6.1 Participants

Thirty-nine participants were native Turkish speakers recruited via word-of-mouth with a mean age of 25.83 (range = 18-54, SD = 7.95) and no history of language disorders. All participants spoke the Istanbul dialect of Turkish, considered the "standard" dialect. Each participant had varying levels of experience in English. All participants gave informed consent and were compensated \$12/hour for their participation.

### 3.6.2 Materials

Experimental materials were 24 sentence sets in a 2 x 2 within-items and within-participants design with Attractor Number (SINGULAR, PLURAL) and Grammaticality (GRAMMATICAL, UNGRAMMATICAL) as the two factors, and an additional 36 fillers were presented. Experimental items were distributed across four lists via Latin Square Design such that each participant saw all fillers but

only one version of one item set. The order of items and fillers was randomized for each participant. Items were lexically different from Experiment 1 to prevent any priming effects in cases of participant overlap. Experimental items always followed the order of $NP_{attractor}$-$[NP_{controller}$-adverb-verb-$N_{head}]_{RC}$-verb. An example set is presented in Table 3.4. The RC verb always carried the plural morphology in the experimental items due to the optionality of the plural morphology on the verb.

| Grammaticality | Attractor Number | Experimental item |
|---|---|---|
| Grammatical | Singular | Eğitmen kız-lar-ın dikkatsizce it-tik-leri çocuğ-u yakala-dı. |
| | | instructor girl-PL-GEN carelessly push-N-3PL child-POSS catch-PAST |
| Grammatical | Plural | Eğitmen-ler kız-lar-ın dikkatsizce it-tik-ler-i çocuğ-u yakala-dı-lar. |
| | | instructor-PL girl-PL-GEN carelessly push-N-3PL child-POSS catch-PAST-3PL |
| Ungrammatical | Singular | Eğitmen kız-ın dikkatsizce ittik-ler-i çocuğ-u yakala-dı. |
| | | instructor girl-GEN carelessly push-N-3PL child-POSS catch-PAST |
| Ungrammatical | Plural | Eğitmen-ler kız-ın dikkatsizce ittik-ler-i çocuğ-u yakala-dı-lar. |
| Translation | | 'The instructor(s) caught the child who the girl(s) carelessly pushed.' |

Table 3.4: Experiment 2 items

### 3.6.3 Procedure

The experiment was run on PCIbex Farm (Drummond, 2013), a web-based platform for hosting behavioral experiments. Participants gave informed consent and were provided with clear instructions on the task and the general goals of the

study. The sentences were presented one word at a time on the screen; the partici-
pants pressed the spacebar to move on to the next word in the sentence (Figure
3.2). Participants were given three practice items to get used to the method of
presentation before the experiment. Following each sentence, the participants were
presented with an acceptability judgment task in which they were expected to
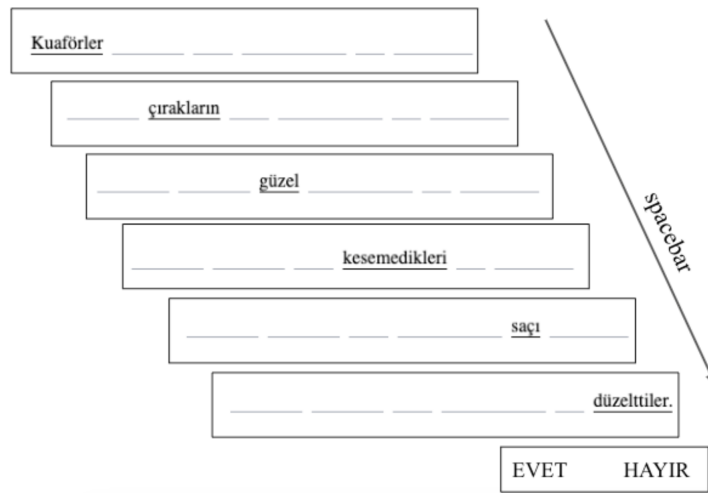judge if the sentence they read was natural.



Figure 3.2: Self-paced reading (SPR) task in Exp. 2

### 3.6.4 Results

### 3.6.4.1 Reading times analysis

The results were analyzed on two factors: GRAMMATICALITY, ATTRACTOR NUMBER, and their interaction, using a generalized linear mixed-effects model from the *brms* package (Bürkner, 2018) in R (R Core Team, 2021). The model examined any significant relationship between log-transformed reading times (logRT) and Grammaticality, Attractor Number, and their interaction. Random slopes and intercepts were included for participants and items to account for individual variation. The reading times in the critical region (RC verb) and the spillover region (RC head) were analyzed across conditions. In order to mitigate the effects of long reading times and exclude potential outliers, we removed observations that fell outside the range defined by the 0.5% and 99.5% quantiles.

Figure 3.3 shows mean reading times by region. In the RC verb (critical) region, we observed no significant main effects or interaction effects. In the RC head (spillover) region, we observed an effect of grammaticality approaching significance ($p = 0.057$) and an interaction effect between GRAMMATICALITY and ATTRACTOR NUMBER ($p = 0.047$).
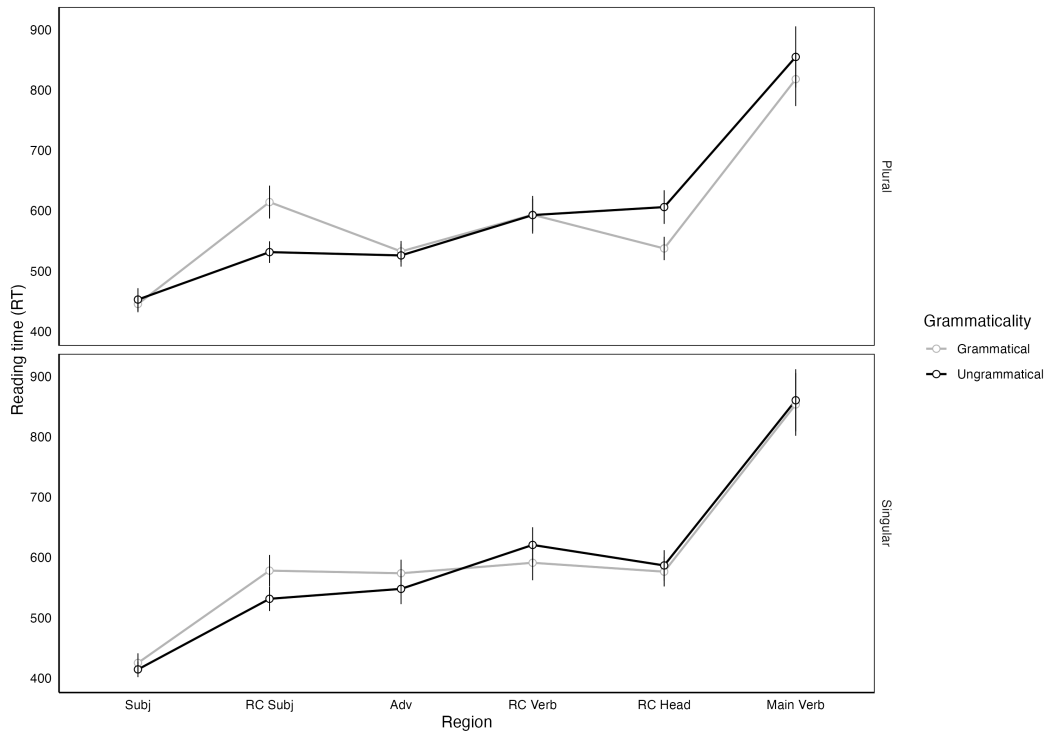
Figure 3.3: Mean RTs by region in Exp. 2

Figures 3.4 and 3.5 show reading times by region for incorrect and correct responses in acceptability judgments. We observed a general main effect of grammaticality: ungrammatical sentences resulted in higher reading times than grammatical ones at the RC verb region ($p = 0.04$). Participants who responded accurately in Ungrammatical, Plural Attractor conditions showed a slowdown at the RC verb and the subsequent RC head region.
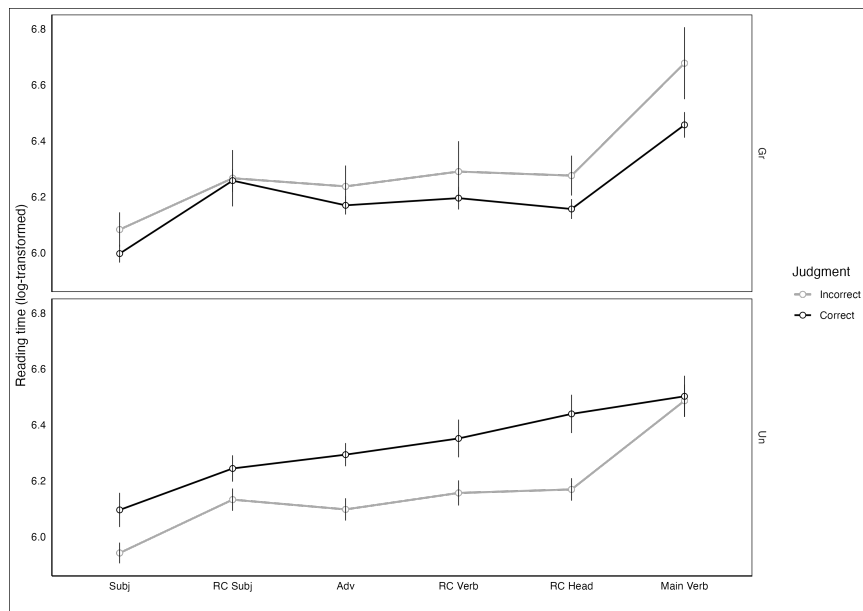
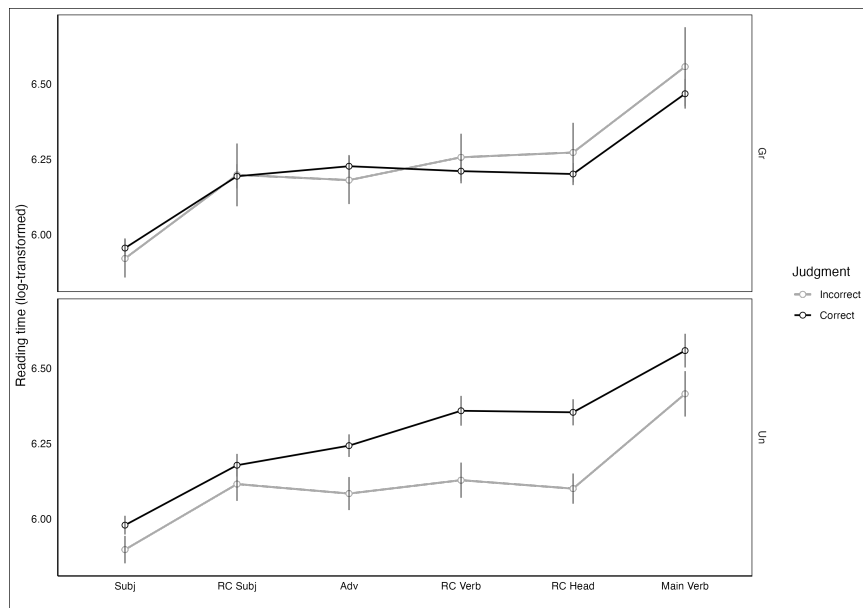Figure 3.4: Log-transformed RTs from Plural Attractor conditions in Exp. 2



Figure 3.5: Log-transformed RTs from Singular Attractor conditions in Exp. 2

While there was not a significant difference in grammatical constructions in critical regions, a speedup is present for participants who accepted constructions with agreement errors compared to participants who accurately responded *unacceptable* to ungrammatical constructions with plural attractors. We take this to be clear evidence for agreement attraction at the retrieval region; participants who showed higher rates of acceptance in the Ungrammatical, Plural Attractor condition also showed a significant speedup in the RC verb and the subsequent spillover region.

### 3.6.4.2 Judgment accuracy

The judgment accuracy rates were analyzed using logistic regression, *glm* in R (R Core Team, 2021). The model investigated the effects of two experimental factors, GRAMMATICALITY and ATTRACTOR NUMBER, and examined whether any interaction effects are present. The results of the judgment task replicated those of Experiment 1 (Table 3.5): we found a main effect of GRAMMATICALITY ($p < 0.01$), and a significant interaction effect between GRAMMATICALITY and ATTRACTOR NUMBER ($p < 0.01$, $t = $ -3.014). No significant differences were found in judgment times between conditions.

| Accuracy (%) (SE) | Singular | Plural |
|---|---|---|
| Grammatical | 84 (3) | 87 (2) |
| Ungrammatical | 56 (3) | 32 (3) |

Table 3.5: Accuracy results by condition from Experiment 2

### 3.6.5 Discussion

The current experiment investigated the localized effects of attraction within the relative clause verb region in Turkish. Our judgment results replicated the results of Experiment 1 and provided further insight into the localized effects of agreement attraction. Our results pointed to a clear effect of attraction in the spillover (RC head) region, where accurate responses in attraction conditions showed increased reading times compared to inaccurate responses. This follows from the behavioral characteristic of facilitatory interference. Additionally, we have convergent evidence for the lack of an *illusion of ungrammaticality*: our judgment task only showed a significant difference in *acceptance* in the Ungrammatical condition where plural attractors were present compared to where they were not; and our reading results showed no significant differences in reading times in Grammatical conditions.

It is also important to point out some limitations of this experiment. First, an acceptability judgment task followed the self-paced reading task, which resulted

in increased reading times in the spillover region for correct judgments, which we take to reflect the ungrammaticality effect. However, self-paced reading tasks are usually performed to measure comprehension accuracy instead of acceptability; this change might have resulted in different patterns in reading compared to previous self-paced reading experiments in agreement attraction literature.

Second, we need more experimental power to see a clear effect in self-paced reading studies. Crowdsourced self-paced reading data often shows faster reading times compared to in-lab studies (Enochson & Culbertson, 2015). This might lead to noisy data due to inattentive participants (Demiray, Ulusoy, & Logačev, 2021) and poor localization of the effects. We hope to further this study by adopting methods like Maze (Boyce, Futrell, & Levy, 2020), which offers improved localization of the effect and an efficient way to capture incremental processing difficulty in web-based experiments by making the participants choose between two words, one of which is a grammatical continuation to the sentence. Regardless of the limitations of this study, we take these results to point to a facilitation effect in participants who made agreement errors in the comprehension of ungrammatical sentences with plural attractors.

## 3.7    Experiment 3: Case effects

It is unclear whether NPs marked with distinctive case-marking affect agreement error rates in ungrammatical sentences. As pointed out in the background, the results are mixed. Case-marking can be highly confounded with word category, syntactic position, and structural distance, and many languages show case syncretisms for case-marking (Turkish included, see Türk, 2022 for a discussion of syncretism effects in agreement attraction). Building on the findings of Avetisyan et al. (2020), who investigated case effects in agreement attraction, we aim to extend their study by examining the effects of case-marking on the attractor noun phrase in Turkish, a similarly agglutinative language. In their study, Avetisyan and colleagues observed that noun phrases marked with the accusative case, which typically marks objects in Armenian, also led to attraction effects.

Avetisyan et al. (2020) proposed that the observed attraction effects with accusative-marked noun phrases could be attributed to the differential use of case and number information during agreement licensing in comprehension. We seek to explore whether similar patterns emerge in Turkish with subjecthood-incompatible case-marked attractors. While Lago et al. (2019), Türk (2022), and our first two experiments have confirmed that nominative-marked attractors cause agreement attraction effects: this might be caused by the compatibility of the nominative

case-marking with subjecthood. This experiment aims to investigate the effects of case-marking on agreement attraction in Turkish by specifically focusing on the distinction between nominative and dative case-marked NPs.

### 3.7.1 Participants

Participant recruitment is ongoing; 14 Turkish-speaking participants have been recruited via word-of-mouth with a mean age of 30.7 (range = 21-60, SD = 12) and no history of language disorders. All participants spoke the Istanbul dialect of Turkish, considered the "standard" dialect. Each participant had varying levels of experience in English. All participants gave informed consent and were compensated \$12/hour for their participation.

### 3.7.2 Materials

Experimental materials were 48 sentence sets in a 2 x 2 x 2 within-items and within-participants design with Grammaticality (GRAMMATICAL, UNGRAMMATICAL), Attractor Number (SINGULAR, PLURAL), and Attractor Case (NOMINATIVE, DATIVE) as the three factors, and an additional 48 fillers were presented. Experimental items always followed the order of $NP_{attractor}$-[$NP_{controller}$-adverb-verb]$_{RC}$-verb. An example set is presented in Table 3.6. The verb in the relative clause region always carried the plural morphology in the experimental items due to the

optionality of plural marking with plural, animate subjects.

| Grammaticality | A. Number | A. Case | Experimental item |
|---|---|---|---|
| Grammatical | SG | NOM | Kütüphaneci çalışkan öğrenci-ler-in iste-dik-leri kitab-ı şimdi bul-du. |
| | | | librarian.SG hardworking student-PL-GEN want-OP-3PL-POSS book-ACC now find-PAST |
| Grammatical | PL | NOM | Kütüphaneci-ler çalışkan öğrenci-ler-in iste-dik-leri kitab-ı şimdi bul-du-lar. |
| | | | librarian-PL hardworking student-PL-GEN want-OP-3PL-POSS book-ACC now find-PAST-3PL |
| Ungrammatical | SG | NOM | Kütüphaneci çalışkan öğrenci-nin iste-dik-leri kitab-ı şimdi bul-du. |
| | | | librarian.SG hardworking student.SG-GEN want-OP-3SG-POSS book-ACC now find-PAST |
| Ungrammatical | PL | NOM | Kütüphaneci-ler çalışkan öğrenci-nin iste-dik-leri kitab-ı şimdi bul-du-lar. |
| | | | librarian-PL hardworking student.SG-GEN want-OP-3SG-POSS book-ACC now find-PAST-3PL |
| Translation | | | 'The librarians(s) found the book that the hardworking student(s) wanted.PL now.' |
| Grammatical | SG | DAT | Kütüphaneci-ye çalışkan öğrenci-ler-in iste-dik-leri kitap dün ver-ildi. |
| | | | librarian-DAT hardworking student-PL-GEN want-OP-3PL-POSS book yesterday give-PAST |
| Grammatical | PL | DAT | Kütüphaneci-lere çalışkan öğrenci-ler-in iste-dik-leri kitap dün ver-ildi. |
| | | | librarian-PL-DAT hardworking student-PL-GEN want-OP-3PL-POSS book yesterday give-PAST |
| Ungrammatical | SG | DAT | Kütüphaneci-ye çalışkan öğrenci-nin iste-dik-leri kitap dün ver-ildi. |
| | | | librarian-DAT hardworking student.SG-GEN want-OP-3SG-POSS book yesterday give-PAST |
| Ungrammatical | PL | DAT | Kütüphaneci-lere çalışkan öğrenci-nin iste-dik-leri kitap dün ver-ildi. |
| | | | librarian-PL-DAT hardworking student.SG-GEN want-OP-3SG-POSS book yesterday give-PAST |
| Translation | | | 'The book that the hardworking student(s) wanted.PL was given to the librarian(s) yesterday.' |

Table 3.6: Experiment 3 items

### 3.7.3   Procedure

Similar to Experiment 1, this experiment used acceptability judgments with the addition of confidence level ratings. The experiment was run on PCIbex Farm (Drummond, 2013), a web-based platform for hosting behavioral experiments. The

sentences were presented one word at a time on the screen automatically (Figure 3.1). Participants were given five practice items to become accustomed to the method of presentation before the experiment. After the experiment began, the first three sentences that participants judged in the task served as a burn-in period and were not included in the data analysis. Following the presentation of each sentence, the participants will be presented with an acceptability judgment task in which they will be expected to judge if the sentence they read was natural. Additionally, the participants will be asked to rate their confidence level ranging from "very confident," "somewhat confident," and "not very confident."

### 3.7.4 Results

The results of the acceptability judgment and the following confidence rating task were analyzed using CLMM, a cumulative link mixed-effects regression model for ordinal scales, from the R package *ordinal* (Christensen, 2011). The ordinal regression model investigated whether there is any relationship between GRAMMATICALITY and ATTRACTOR NUMBER, and DISTRACTOR CASE. We found a significant interaction effect between GRAMMATICALITY and ATTRACTOR NUMBER ($p = 0.0026$, $t = -3.01$), replicating the results of our previous two experiments. We additionally found a main effect of ATTRACTOR CASE ($p = 0.028$). No other effects were significant, and no significant differences in response times were observed.

### 3.7.5 Discussion

The main effect of Attractor Case suggests that our prediction was borne out: differential case-marking in languages with rich morphology can be used in agreement computation. While we saw in our prior investigations that attractors with genitive case-marking robustly led to agreement attraction, dative case-marked attractors did not show similar rates of facilitatory interference, and this effect was significant. While we show initial evidence that differential case marking plays a role in identifying the agreement controller, we would need higher experimental power in determining whether this effect can be generalized.

## 3.8 General Discussion

The present study aimed to answer a number of prevalent questions in sentence processing. In Experiment 1, we provided evidence for agreement attraction effects from non-containment environments in Turkish from an acceptability judgment study. In Experiment 2, we replicated these effects in a self-paced reading study accompanied by acceptability judgment tasks. This experiment used object relative clause constructions to investigate the localized effects of attraction in the verb region. The use of these constructions was motivated by the prediction that it could capture any spillover effects of longer reading times induced by attraction.

The results of the reading time analysis support this prediction, as speedups were observed in the spillover region (RC head) for ungrammatical sentences with plural attractors that are judged to be acceptable. Our findings further suggest that while the number of attractors did not have a significant effect in the grammatical condition, in the ungrammatical condition, the presence of plural attractors led to a significant speedup in the critical and spillover regions compared to singular attractors. These results align with previous research on agreement attraction and support the idea behind retrieval-based models. We take this as evidence for retrieval interference rather than encoding interference, supported by the increased reading times for participants who accurately responded *unacceptable* in ungrammatical, plural attractor conditions. We return to the discussion of grammaticality asymmetry and provide a response bias analysis in the next subsection. The word order of Turkish enabled us to create environments where the attractor and the controller were neither co-indexed nor in close syntactic proximity. We additionally replicated the grammaticality asymmetry: grammatical conditions with mismatching attractors and controllers did not create attraction effects, unlike ungrammatical conditions with mismatching attractor-controller pairs. In Experiment 3, we provided initial results from our investigation of differential case marking effects on agreement attraction. We found that dative-marked attractors are unable to cause agreement attraction effects, suggesting that

differential case marking might play a significant role in agreement computation.

### 3.8.1 Response bias

Signal Detection Theory (SDT) is a framework originally designed to characterize the ability of an observer to discriminate between noise and signal (Peterson, Birdsall, & Fox, 1954). Cognitive scientists have adapted this framework to behavioral studies, such as recognition memory, where participants have to judge if they have encountered the stimuli given a lure-generating (noise) sample (Tanner & Swets, 1954). Linguists have also adopted this sensitivity measure to discrimination tasks in language research. Language perception often involves discrimination processes and decisions under uncertainty: grammaticality judgment studies in experimental syntax, as well as same-different tasks used in speech perception, utilize the ability of a speaker of the language to distinguish between stimuli; in other words, the participants need a certain level of sensitivity to be able to distinguish signal from noise.

Hammerly et al. (2019) suggests that the grammaticality asymmetry in agreement attraction can be explained by a response bias rather than an actual attraction effect. They argue that participants may tend to respond "yes" to a sentence regardless of its grammaticality, and this bias appears stronger in ungrammatical sentences due to greater uncertainty about their acceptability. Similar to Hammerly

et al. (2019), we found a response bias where participants were biased to judge most of the sentences as acceptable. To see whether this bias correlated with the size of the grammaticality asymmetry, we used the $c$ measure of response bias from Signal Detection Theory (Dillon & Wagers, 2019) to calculate participants' response bias, and aimed to model any correlations between the two. Figure 3.6 shows the output: there is no correlation observed between the size of the asymmetry and the size of participant bias, suggesting a lack of attraction effects in grammatical constructions.
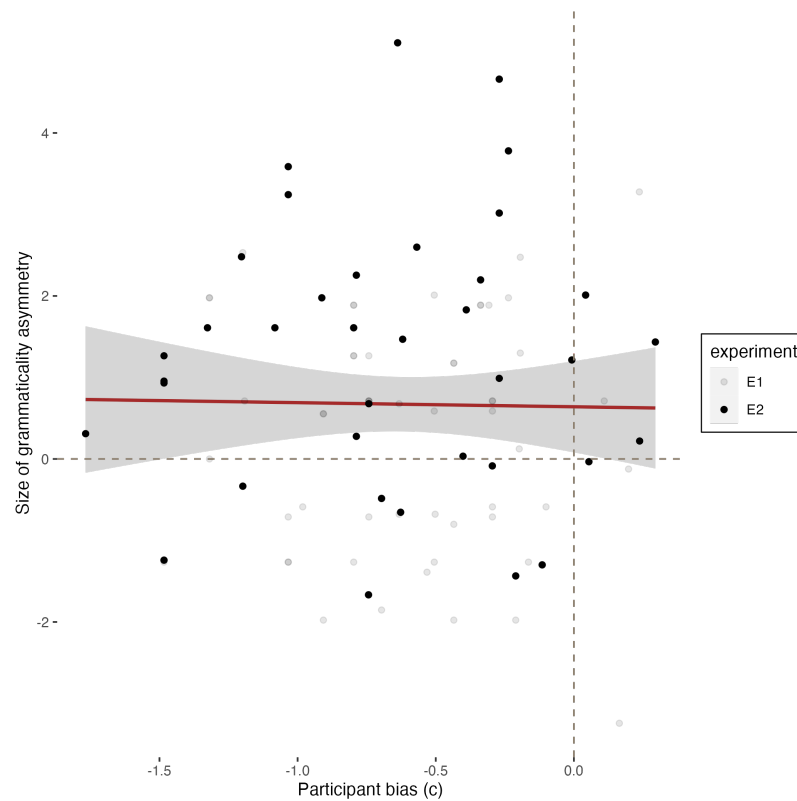


Figure 3.6: The size of the grammaticality asymmetry as a function of participant bias for Exp. 1 and 2

We interpret this lack of correlation as direct evidence of retrieval interference. Although a noticeable response bias was observed ($c < 0$), indicating a tendency of participants to say "yes" regardless of the grammaticality of the sentence, it did not align with the asymmetry displayed by participants when judging grammatical and ungrammatical constructions. As there were no attraction effects observed in the grammatical conditions that could be attributed to participant biases, the observed asymmetry must arise from errors resulting from similarity-based interference during retrieval, rather than faulty encoding of the controller and the attractor.

## 3.9 Future directions

In future research, we aim to extend our results using a different methodology, such as Maze, to further our understanding of the localization of agreement attraction in Turkish. Furthermore, we will aim to distinguish between retrieval-based models in future work. As discussed in the Background, the scope-planning hypothesis claims that co-planning of the attractor and the controller may lead to feature passing. In order to disentangle co-planning from structural effects, we propose an experiment on the effects of semantic similarity of the attractor and the controller.

### 3.9.1 Semantic similarity

As discussed in the Background, the scope planning account claims that agreement attraction is a result of number distortion in sentence planning and comprehension. According to this account, the distortion results from the co-planning of the attractor and the controller, allowing the distractor NP to interfere with the agreement computation before the subject representation is completed. While we have evidence from the replication of the grammaticality asymmetry that agreement errors are due to encoding interference, it might still be the case that simultaneous activation of semantically related constituents modulates agreement attraction. To investigate further the role of semantic relatedness in agreement attraction effects, our future investigations will test semantically related and unrelated attractor-controller pairs in object RC constructions in Turkish similar to Experiments 1 and 2. If the scope of planning hypothesis can account for our earlier results, we would expect to see higher rates of attraction when the controller and the attractor are semantically unrelated compared to when they shared a strong semantic link.

Experimental materials will be 48 sentence sets in a 2 x 2 x 2 within-items and within-participants design, crossing Attractor Number (SINGULAR, PLURAL), Grammaticality (GRAMMATICAL, UNGRAMMATICAL), and Semantic Similarity (ARBITRARY, RELATED) as the three factors, and an additional 48 fillers were

presented. Experimental items always followed the order of NP$_{\text{attractor}}$-[NP$_{\text{controller}}$-adverb-verb]$_{\text{RC}}$-verb. An example set is presented in Table 3.7. The verb in the relative clause region always carried the plural morphology in the experimental items due to the optionality of plural marking with plural, animate subjects.

| Grammaticality | Attr. Num. | Relatedness | Experimental item |
|---|---|---|---|
| Grammatical | SG | Related | Mühendis yaratıcı teknisyen-ler-in öner-dik-ler-i değişikliğ-i hemen yap-tı. |
| | | | engineer.SG creative technician-PL-GEN suggest-OP-3PL-POSS change-ACC instantly make-PAST |
| Grammatical | PL | Related | Mühendis-ler yaratıcı teknisyen-ler-in öner-dik-leri değişikliği hemen yap-tı-lar. |
| | | | engineer-PL creative technician-PL-GEN suggest-OP-3PL-POSS change-ACC instantly make-PAST-3PL |
| Ungrammatical | SG | Related | Mühendis yaratıcı teknisyen-in öner-dik-leri değişikliği hemen yap-tı. |
| | | | engineer.SG creative technician.SG-GEN suggest-OP-3PL-POSS change-ACC instantly make-PAST |
| Ungrammatical | PL | Related | Mühendis-ler yaratıcı teknisyen-in öner-dik-leri değişikliği hemen yap-tı-lar. |
| | | | engineer-PL creative technician.SG-GEN suggest-OP-3PL-POSS change-ACC instantly make-PAST-3PL |
| Translation | | | 'The engineer(s) immediately made the change that the creative technician(s) suggested.' |
| Grammatical | SG | Arbitrary | Mühendis yaratıcı ornitolog-lar-ın öner-dik-leri değişikliği hemen yap-tı. |
| | | | engineer.SG creative ornithologist-PL-GEN suggest-OP-3PL-POSS change-ACC instantly make-PAST |
| Grammatical | PL | Arbitrary | Mühendis-ler yaratıcı ornitolog-lar-ın öner-dik-leri değişikliği hemen yap-tı-lar. |
| | | | engineer-PL creative ornithologist-PL-GEN suggest-OP-3PL-POSS change-ACC instantly make-PAST-3PL |
| Ungrammatical | SG | Arbitrary | Mühendis yaratıcı ornitolog-un öner-dik-leri değişikliği hemen yap-tı. |
| | | | engineer.SG creative ornithologist.SG-GEN suggest-OP-3PL-POSS change-ACC instantly make-PAST |
| Ungrammatical | PL | Arbitrary | Mühendisler yaratıcı ornitoloğun önerdikleri değişikliği hemen yaptılar. |
| | | | engineer-PL creative ornithologist.SG-GEN suggest-OP-3PL-POSS change-ACC instantly make-PAST-3PL |
| Translation | | | 'The engineer immediately made the change that the creative ornithologist(s) suggested.' |

Table 3.7: Semantic similarity items

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