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Exploring the abstractness of number retrieval cues in the computation of subject-verb agreement in comprehension

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ABSTRACT

Subject-verb agreement has provided critical insights into the cue-based memory retrieval system that supports language comprehension by showing that memory interference can cause erroneous agreement with non-subjects: 'agreement attraction'. Here we ask how faithful retrieval cues are in relation to the grammar. We examine the impact of conjoined singular attractors (*The advice from the doctor and the nurse*...), which are syntactically plural but whose plurality is introduced by a vehicle, the conjunction '*and*', that is not an unequivocal correlate of syntactic plurality. We find strong agreement attraction, which suggests that retrieval processes do not only target unequivocal morphological correlates of syntactic plurality. However, we also find some attraction with conjoined adjective attractors (*The advice from the diligent and compassionate doctor*...), which is compatible with a system in which an imperfect correlate of syntactic plurality, like the word '*and*', can become associated with the plural retrieval cue due to frequent co-occurrence with the actual target feature.

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Introduction

In understanding sentences, comprehenders often form dependencies between linguistic items that are not directly adjacent. For example, in the sentence *The boy next to the beautiful trees probably does not hear the music,* the verb *does* has to agree in number with the subject phrase, despite being separated from it by an adverb and being separated by still more words from the head of that phrase (*boy*) which carries the relevant number information. Recent research has used a number of linguistic dependencies to investigate the architecture of the memory system underlying this process and has suggested that it relies on cue-based retrieval of content-addressable items in memory (Dillon, Mishler, Sloggett, & Phillips, 2013; Lago, Shalom, Sigman, Lau, & Phillips, 2015; Tanner, Nicol, & Brehm, 2014; Wagers, Lau, & Phillips, 2009). Here we ask how faithful retrieval is in relation to the grammar. Do retrieval models necessitate the inclusion of cues as abstract as the terms in which the grammatical dependencies are stated? Or is it sufficient for cues to target only certain instantiations of an abstract category, perhaps the most frequent ones? In this paper we pursue the issue through the comprehension of subject-verb agreement in English, aiming at the general question of how the grammar is respected in online comprehension processes (Lewis & Phillips, 2015).

Cue-based retrieval in sentence processing

Much recent work on sentence processing supports the view that the underlying memory system operates on the basis of cue-based retrieval (Lewis & Vasishth, 2005; Martin & McElree, 2009; McElree, 2000; McElree, Foraker, & Dyer, 2003; Van Dyke & McElree, 2006). Here, we will assume a cue-based retrieval system as outlined in detail by Lewis and Vasishth (2005). In this system, linguistic items are encoded in memory as bundles of features and are content-addressable based on the features they contain. Each item stored in memory is associated with a certain level of activation. When a comprehender encounters a retrieval cue in the input, this triggers a search for a target containing a matching feature. Due to the content-addressable nature of the system the search proceeds in a parallel rather than serial fashion (Martin & McElree, 2009). Items with a matching feature receive a boost of activation from the retrieval cue and the item with the highest activation level is retrieved from memory.

This model gives us an outline of the process underlying memory retrieval in language comprehension. But it does not specify whether the retrieval cues can be as abstract as the terms in which

a dependency is stated in the grammar. In the grammar, dependencies like subject-verb agreement typically respond to very general features, such as [plural], and not more specific categories, such as *suffixal plural* or *ablauting plural*, or even particular items, such as *duck'* or *geese* (Bock & Eberhard, 1993; Corbett, 2000). It is possible that retrieval cues are only associated with the morphological exponence of a feature, or its *vehicle*. However, the memory processes used to establish these dependencies might be equally abstract, targeting the relevant general feature, regardless of specifically how it is introduced or signaled. This would not preclude the possibility that cues might also be associated with particular morphological pieces, sometimes. But it would necessitate the inclusion of general or abstract cues in our retrieval models that are not linked to a specific morphological form. Here, we use the phenomenon of subject-verb agreement attraction in comprehension to explore this question.

Subject-verb agreement attraction in production

Agreement attraction was first systematically studied in production by Bock and Miller (1991). They found that in a sentence completion task participants were more likely to produce agreement errors if a preamble with a singular subject contained a plural noun inside a prepositional modifier (*The key to the cabinets*). Subsequent work has used agreement attraction with the aim of teasing apart the roles of notional, morphophonological and syntactic number in agreement production. Initially, Bock and Eberhard (1993) found no clear evidence for an impact of either morphophonological form or notional number in error elicitation tasks, as no significant increase in plural verb form errors was observed when the attractor was a syntactically singular pseudoplural ending in *-s* (e.g., *course*) or a syntactically singular collective (*fleet*), nor did attraction rates differ for regular and irregular plurals (*kids* vs. *children*) in attractor position. However, more recent crosslinguistic studies do find effects of morphophonology on agreement production (Franck, Vigliocco, Antón-Méndez, Collina, & Frauenfelder, 2008; Hartsuiker, Schriefers, Bock, & Kikstra, 2003; Lorimor, Jackson, Spalek, & van Hell, 2016; Mirković & MacDonald, 2013). Haskell and MacDonald (2003) also observed small effects of morphological regularity on agreement production in English when there was a conflict between the subject's notional and syntactic number information.

Similarly, there is accumulating evidence that notional number – that is, whether we view the referent of the noun as a single individual or a collection of many – impacts subject-verb agreement in production. Bock and Eberhard noted a non-significant numerical trend for the plural form of collectives (*fleets*) in attractor position to elicit more agreement errors than the plural form of individual nouns *(ships)*, despite their general conclusion that subject-verb agreement in production is controlled by syntactic number. There was also a correlation between how likely the singular form of a collective noun (*fleet*) was to be judged to refer to multiple entities and the frequency of agreement errors. A later study on the impact of notional number on agreement production by Humphreys and Bock (2005) used collectives as the subject's head noun followed by a prepositional modifier encouraging either a collected reading (*The gang near the motorcycles*) or a distributed reading (*The gang on the motorcycles*). They found that the rate at which preambles with (syntactically singular) collective head nouns elicited plural verb forms depended on whether their referents were construed as collected or distributed. Distributed readings more frequently led to the production of plural verbs, indicating that the notional number of the subject affects subject-verb agreement in production. Likewise, Brehm and Bock (2013) showed that the likelihood of producing plural agreement with a singular subject depends on how semantically integrated its referent is: more integrated preambles (*The drawing of the flowers*) were less likely to cause agreement errors than less integrated preambles (*The drawing with the flowers*). Brehm and Bock argue that this shows the effect of notional number: The less integrated a complex referent is, the more likely it is to be mentally construed as plural. Some of the crosslinguistic studies (Lorimor et al., 2016; Mirković & MacDonald, 2013) also report higher rates of plural agreement for notionally plural subjects. It should be noted that these studies manipulated the notional number of the entire subject, not the notional number of the attractor.

Accounts of agreement attraction in production have largely focused on representational explanations. The claim is that the number feature of a singular subject is affected by the presence of a plural attractor, either through feature percolation or spreading activation (e.g., Bock & Eberhard, 1993; Bock, Eberhard, & Cutting, 2004; Pearlmutter, Garnsey, & Bock, 1999). The most influential representational account is the marking and morphing model (Eberhard, Cutting, & Bock, 2005). According to this model, the number information on a noun phrase ranges continuously from unambiguously singular to unambiguously plural and the number marking on the verb is probabilistic. Although a subject with a singular head noun should be valued as unambiguously singular, the presence of a plural element inside it (*The key to the cabinets*) will raise the value and make the subject number more ambiguous. This sometimes results in agreement attraction errors. The marking and morphing model can account for the effects of number on agreement production: The impact of notional number can be seen as a message-level effect from the subject's intended referent.

Subject-verb agreement attraction in comprehension

Representational models have also been proposed for comprehension (Pearlmutter et al., 1999). But here they do not capture data as well as do cue-based retrieval models. Unlike cue-based retrieval models, they predict that grammatical sentences should sometimes be perceived as ungrammatical in the presence of a plural attractor (*The key to the cabinets is*…). But importantly, this does not seem to be the case (Lago et al., 2015; Tanner et al., 2014; Tucker, Idrissi, & Almeida, 2015; Wagers et al., 2009; but cf. Pearlmutter et al., 1999). Based on this grammatical asymmetry, we take the view that the mechanisms underlying agreement attraction are at least partially distinct processes in production and comprehension (Acuña-Fariña, 2012; Tanner et al., 2014), and therefore do not presume that the two domains must be governed by the same principles. We will assume that agreement attraction in comprehension has a retrieval-based account. At the end of this paper, in the General Discussion, we will broach the question of how the results from our experiments can be interpreted in an alternative, spreading activation account.

In comprehension, agreement attraction occurs when a subject-verb agreement violation is erroneously perceived to be grammatical in the presence of a non-subject that matches the verb in number. For example, comprehenders are much less likely to notice the agreement violation in a sentence like *The key to the cabinets are rusty*, which contains the structurally inaccessible plural noun *cabinets*, than in the same sentence without this plural non-subject. The facilitative impact of a number-matching non-subject can be accounted for very naturally by a cue-based retrieval model (Wagers et al., 2009). Subject-verb agreement is a dependency in which the syntactic number of the verb has to match the syntactic number of the subject. In order to check this, the subject has to be retrieved from memory. In the cue-based memory retrieval system assumed here, the verb provides a number cue (e.g. [plural]) as well as a structural cue (e.g. [subject]). When one of the items from memory has features that match both