Beyond the Subject: The Interaction of Syntax and Semantics in the Production of English Verb Agreement

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BEYOND THE SUBJECT:
THE INTERACTION OF SYNTAX AND SEMANTICS IN
THE PRODUCTION OF ENGLISH VERB AGREEMENT

by

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Beyond the Subject: The Interaction of Syntax and Semantics in the Production of English Verb Agreement
written by Cecily Jill Duffield
has been approved for the Department of Linguistics and the Institute of Cognitive Science

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Date________________________

The final copy of this thesis has been examined by the signatories, and we find that both the content and the form meet acceptable presentation standards of scholarly work in the above mentioned disciplines.

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Abstract

A key debate in the psycholinguistic study of grammatical language production is whether the process is a syntactocentric one, driven by grammatical information and grammatical rules, or a dynamic, interactive one, involving both semantic and syntactic information. Examining how speakers produce subject-verb number agreement has been useful in addressing this debate. Verb agreement is widely considered to be primarily a syntactic process in which grammatical number features of the subject are copied onto the verb. Variation in verb agreement patterns can, however, reflect the construal of the subject number. Such variation suggests that speakers are sensitive to both syntactic and semantic information about the subject during the production of agreement. However, psycholinguistic accounts of how speakers integrate these two types of information cannot yet account for the full range of variation seen in agreement in spontaneous, natural speech.

This dissertation concerns a subject-verb number agreement pattern that cannot be explained either in terms of grammatical form or semantic construal of the subject, exemplified by the utterance [One thing I thought about the other day]-SG were-PL batteries. The research presented here examines how verb agreement is affected by grammatical and semantic features outside of the subject noun phrase: the number of the post-verbal nominal, the concreteness of the post-verbal noun relative to the subject, and the semantics of the construction used when agreement is produced. I used a corpus study and three elicited production experiments to investigate how these features correlated with speakers’ likelihood of producing verb agreement that did not match the grammatical number of the subject.
Results demonstrate that speakers are sensitive to both grammatical and semantic information outside of the subject when producing verb number agreement. Specifically, the grammatical number of the post-verbal nominal affects speakers’ production of verb agreement. Furthermore, the effects of post-verbal number are modulated by constructional semantics. These findings cannot be accounted for by syntactocentric models of language production, in which grammatical forms are processed in isolation from semantic information. Rather, they suggest that grammatical language production is an interactive process in which semantic information can modulate the effects of activated syntactic features.
To Scot and Aaron,

who are my breath, my life, my all, my everything.
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Chapter 1. Introduction

Speaking a language is a complex task. Speakers must be able to integrate messages about referents, events and relations, and map these messages onto intricate syntactic structures. And they must do it accurately. While a listener may be able to obtain the gist of a message from an incomplete utterance (e.g., Warren, 1970) and may not even create a complete representation of the message communicated (Ferreira, Bailey, & Ferraro, 2002), speakers are, in a sense, obliged to produce the full form, even those details that seem irrelevant to the sentence meaning (Bock, 1982, p. 1). Yet whether or not listeners make use of the full grammatical forms produced for them on a case-by-case basis, those forms overall are what provide the input to language comprehension (e.g., Gennari & MacDonald, 2009; MacDonald & Thornton, 2009; Pickering & Garrod, 2004, 2006), language acquisition (e.g., Berko-Gleason & Weintraub, 1976; Snow, 1972; Snow & Ferguson, 1977), and also form the basis for grammatical systems of languages as a whole (e.g., Bybee, 2006; Bybee & Hopper, 2001; Slobin, 2002).\(^1\) It is difficult, then, to imagine how any account of language could hope to be complete without at least some reference to how its speakers produce it.

Because language production involves the complicated task of creating detailed grammatical forms (as opposed to just accessing single words mapped to isolated concepts), studying language production is often equated with studying the grammatical encoding of utterances. For this reason, grammatical encoding has been called the “heart of the language faculty,” (Ferriera & Sleve, 2007), the “linguistic engine’ of language production” (Bencini, 2013), and the process by which

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\(^1\) It may seem obvious that grammatical forms produced by speakers constitute a language system, yet many formal descriptions arguably display a bias toward comprehension as the basis for determining what forms are legitimately within the bounds of the language system, simply by taking an approach based primarily upon grammatical judgments (usually conducted by an individual or a small number of theorists), i.e., how a particular individual comprehends a particular form—rather than looking at the distributions of attested forms that are actually produced (see Schutze, 1996 for a discussion of problems with such methods.)
communicative intentions are translated into articulated utterances (Garrett 1975, pp. 133-135). A theory of grammatical encoding must account for a speaker's ability to do a wide variety of tasks, from accessing the appropriate words for the message that the speaker intends to convey and arranging them in an appropriate order (e.g., Bock & Irwin 1980; Bock & Warren 1985; Onishi, Murphy, & Bock 2008; inter alia) to organizing them in appropriate hierarchical relationships (e.g., Chang, Dell, & Bock, 2006). Consequently, understanding the nature of grammatical encoding requires careful investigation of the various grammatical patterns produced. This dissertation concerns the grammatical encoding of one such pattern: the grammatical dependency of subject-verb agreement. More specifically, it concerns how, during the course of agreement production, speakers integrate the semantic and grammatical features of nominal elements other than the subject noun phrase as well as the semantic information of the construction used when subject-verb agreement is produced.

1.1 The production of agreement: Syntax and semantics

Of the tasks that grammatical encoding must accomplish, the formation of appropriate grammatical dependencies is one of the more complex (and less well understood) tasks. Grammatical dependencies are cases in which features of certain elements in the utterance (which may or may not be overtly expressed) are dependent upon the features of other elements within a particular grammatical domain and under particular conditions (Corbett, 2006). A prime example of a grammatical dependency is subject-verb agreement, in which the verb takes on features such as person, number and/or gender features of the subject noun phrase. For example, in the previous

2 Person, number, and gender are considered to be the main features involved in agreement; less clear features that may be involved in agreement include case, definiteness, and tense/aspect/modality features. See Corbett (2006, Sections 4.3-4.4) for discussion. In addition to subject-verb agreement, other types of agreement in English include pronoun-antecedent agreement (e.g., The teacher...she, John...he, The bowls...they)
sentence, the subject *A prime example* is a singular, third person nominal, and that information is reflected in the verb *is*. Likewise, in the sentence prior, the subject *Grammatical dependencies* is plural, so the verb *are* takes the plural form. Because verb forms often match the grammatical (syntactic) form of the subject noun phrase, it is often assumed that speakers primarily draw upon syntactic information when producing agreement (Bock & Miller, 1991, p. 83; Bock et al., 2006, p. 99; Vigliocco & Franck, 2001, p. 370). For example, the noun *scissors* is grammatically plural, and it (normatively) pairs with plural verbs (e.g., *The scissors are on the table*) regardless of the fact that it refers to a single item. Stronger examples come from languages with grammatical gender. *La table* “the table” displays feminine grammatical gender in French, although tables themselves are not female entities. This assumption that agreement is a matter of syntax and not semantics is supported by several formal approaches in linguistics that treat agreement as basically a syntactic feature-copy process: syntactic features corresponding to the subject are copied onto the verb (e.g., Adger & Smith, 2005; Chomsky, 1995; Lasnik, 1995, Zwart, 1993).

Despite the assumption that subject-verb agreement is a syntactic phenomenon, speakers routinely display sensitivity to conceptual, meaning-based information during subject-verb agreement production. This can be seen in cases of agreement mismatch. In such utterances, the features marked on the verb do not match the grammatical features of the subject noun phrase, but convey some semantic information about the subject referent. Consider the examples in (1-4) showing number agreement mismatch, taken from both linguistic literature (Pollard & Sag, 1994, pp. 69-70) and spontaneous conversations in the Switchboard Corpus (Godfrey, Holliman & McDaniel, 1992).

and determiner-noun agreement (e.g. *those books/*this book*). See Corbett (2006) for a thorough cross-linguistic overview of agreement phenomena, and Barlow (1992, pp. 98-153) for a discussion of various properties of agreement.
The oft-cited Pollard and Sag example (1) is a constructed utterance in an imaginary conversation between two waitresses in which an angry customer is referred to by his order of the hash browns. This is a case of “reference transfer,” or metonymic construal, a metaphorical use of language (Nunberg, 1977; Pollard & Sag, 1994, pp. 68-69; see also Ward, 2004). Example (2), also apparently constructed, presents a case of “singular plurals,” where the subject is conceptually singular but grammatically plural. In this case, the subject refers to the general phenomenon of unleashed dogs, not the dogs themselves (Pollard & Sag, 1994, p. 70); consider the change in the semantic proposition if the verb were to take the plural form: Unleashed dogs-pl. …threaten-pl.….law abiding citizens, where the utterance then refers to multiple dogs and their menacing behavior. The attested, spontaneous utterance in (3) illustrates how multitudes can be conceptualized in various ways. The subject-verb agreement conveys the sense that the speaker conceptualizes The only bills as a collection of individual items that is considered a single entity, similar to phrases indicating quantities or measures that are often treated as such (e.g., Ten dollars-pl. is-SG all I have left) (Barlow, 1992, pp. 90-91). Seemingly opposite to this is the well-documented phenomenon of collectives: nominals that are primarily classified as singular entities, but may be considered as a multitude of individuals (e.g., The faculty-SG are-pl. voting themselves a raise, Pollard & Sag, 1994 pp. 70-71.) Finally, example (4) presents a bit of a puzzle. This is not a case of reference transfer, as in (1), nor is it a case of a collection or collective, as discussed with (3). It may seem that the agreement marking on the verb conveys a semantic interpretation of the subject referent, similar to example (2). And yet, unlike in (2), if the verb in (4) is changed to the singular to match the grammatical form of the subject (e.g., One thing I thought about the other day WAS batteries), the propositional content does not change.
Speakers may intuitively feel that the verb’s agreement morphology is not simply a random error, and that on some level it makes sense. A straightforward explanation of the pattern seems to be lacking.

Linguists are not alone in pondering the mysteries of agreement. Native speakers untrained in linguistic theory also display sensitivity to the syntactic and semantic contributions to the production of subject-verb agreement, as illustrated by a conversation in an internet forum chat shown in example (5) (italics mine):³

5. A: My brother and best friend is coming home from overseas! I literally am an emotional wreck right. So excited.
   B: Is that one person or two?
   A: One!
   B: I knew that…
   A: (:P)
   B: I should have got it where you put is not are.

This dissertation is motivated by an interest in how speakers integrate syntactic (grammatical) and semantic (conceptual, meaning-based) information in the production of subject-verb agreement.⁴ In an effort to better understand the semantic and syntactic conditions under which


⁴ The terms “semantic” and “conceptual” will be used fairly interchangeably here. The term “semantic agreement” is often used to refer to agreement that is consistent with meaning-based information rather than with the presence of syntactic features (see Corbett, 2006, pp. 155-165) and has often been used synonymously with “notional agreement” or “conceptual agreement” (e.g., Corbett, 2006, p. 155; Eberhard, Cutting & Bock, 2005, p. 533). The difficulty with the term “semantic agreement” becomes apparent when one considers some of the tacit assumptions regarding representations in production models. Lexical representations (“lemmas,” discussed below) are assumed to be stored representations of semantic and syntactic properties of lexical items. The term “semantic agreement” implies to some degree that agreement draws upon a limited set of stored semantic features of lexical items and phrasal expressions. There are problems with assuming that “semantics” should be constrained to linguistic-specific expressions of meaning (see Fodor, 1983; Fodor, & Garrett, 1975, and Jackendoff, 2002, Ch. 9 for discussion), and I will use “semantics” here to refer to a more general sense of meaning-based information that speakers draw upon when producing language, whether or not such “meaning” can be conveniently described in terms of stored lexical entries. Nonetheless, because of the baggage associated with the term “semantics”, I will occasionally use the term “conceptual” to emphasize that the meaning-based information that speakers draw upon during language production is not limited to what can be described by formal semantic theory.
speakers routinely produce variations in subject-verb agreement, I examined utterances in the Switchboard Corpus (Godfrey et al., 1992) for attested examples of speakers producing verbs whose forms did not match their subject in terms of grammatical number. This led to the discovery of an agreement pattern that seems to defy a straightforward explanation in terms of the semantic or syntactic properties of the subject noun phrase, a pattern exemplified by the “puzzling” utterance in (4), above, One thing I thought about the other day were batteries.

Consider the additional attested examples in (6-8).

6. [The only thing we’ve taken back recently]-SG are-PL plants-PL.
7. [The other one]-SG is…are-PL the Saturns-PL.
8. And [their rebellions right now]-PL is-SG [the result of that]-SG.

While some theoreticians would call these occurrences “errors” because of their deviation from a prescriptively syntactic rule of subject-verb agreement, native speakers may feel that these utterances, perhaps strange when read in isolation, are really not all that bad. Although the subject-verb agreement is technically ungrammatical, it makes sense. First of all, there seems to be a nominal in each sentence that pulls the verb to agree with it instead of the subject, and in each case, it is the post-verbal nominal (e.g., batteries, plants, the Saturns, the result of that). Intuitively, speakers can sense that this is not random; the post-verbal nominal feels like “what the speaker is really talking about,” or is “more subject-like.” This may be due, in part, to a semantic property of the head nouns of the subject noun phrase. In each case, the subject head noun is an abstract lexical noun (e.g., One thing, the other one, the only thing and the non-concrete rebellions). When a speaker is discussing a particular discourse referent as a “thing” and as “batteries,” the noun “batteries” seems more concrete, more salient, and even a more accurate name for the item under discussion. It makes sense that the speaker would be pulled in the direction of producing verb agreement with that more concrete, salient noun. This observation highlights one final, but crucial, feature that may lead speakers to produce these variations in agreement: All of these utterances are sentences in which the subject is
equated with the post-verbal nominal. In other words, when the speaker produces the subject noun phrase *One thing I thought about the other day* in (4), he or she is actually referring to the batteries. As such, when the speaker produces the subject noun phrase, it makes sense that the post-verbal nominal, which describes the very same referent, may be highly activated in the mind of the speaker—making it even more likely to interfere with grammatical agreement production. The impact of these features (a post-verbal nominal that differs in number from the subject, an abstract subject head noun, and the use of a construction that equates the subject with the post-verbal nominal) on the agreement produced can be illustrated intuitively by considering whether or not the utterances without such features feel more or less acceptable. Consider the variations of the utterances without (9) a post-verbal nominal differing from the subject in grammatical number, (10) the equative construction, and (11) an abstract subject head noun.

9. ?? *[One thing I thought about the other day]-SG were-PL a Duracell. (where the speaker is thinking about multiple batteries of the same brand).*
   ?? *[The only thing we've taken back recently]-SG are-PL being recalled. *
   ?? *[And their rebellions right now]-PL is-SG causing these economic crises.*

10. ?? *[One thing I thought about the other day]-SG use-PL batteries. (where one thing refers to the general category of power tools)*
    ?? *[The other one]-SG drives...drive-PL the Saturns. (where the other one refers to a driver)*
    ?? *[And their rebellions right now]-PL overshadows-SG the result of that.*

11. ?? *[One source of power I thought about the other day]-SG were-PL batteries.*
    ?? *[The other car that he owns]-SG is...are-PL the Saturns.*
    ?? *[And their armies right now]-PL is-SG the result of that.*

Native speaker intuition allows us to talk about why this agreement pattern makes sense, but analytically, what makes this worth examining further is that it is difficult to explain these variations solely in terms of properties of the subject noun phrase. In each of the examples (4) and (6-8), the verb does not match the grammatical features of the subject noun, but neither does it seem to convey a specific construal of the subject referent (contrary to the metonymic *bash browns* and the
unleashed dogs examples in (1) and (2), above). Furthermore, this agreement pattern cannot be reliably explained by reference to the grammatical features of the subject noun phrase. For example, the subject noun phrases do not always contain other “distractor” nouns that might result in agreement error (i.e., in (7), there is no plural lexical noun embedded in the subject noun phrase that might lead the speaker to erroneously produce a plural verb). The fact that this agreement pattern defies the traditional explanations based on the interpretation or form of the subject noun phrase suggests a hypothesis that has not seriously been considered in psycholinguistic investigations of subject-verb agreement: when speakers are producing subject-verb agreement, they may be integrating information that is “beyond the subject.” Not only might nominals that are outside of the subject noun phrase contribute to agreement production, but the semantic message-level properties of the construction in which agreement is produced (i.e., the message that expresses the relationships between the nominals) may also determine the degree to which various nominals may interfere with or contribute to agreement production.

To briefly summarize, what we see here is a particular pattern in which a subject noun phrase is equated with another noun phrase differing in grammatical number, and in which the verb agrees with the second noun phrase. This pattern is exemplified by One thing I thought about the other day were batteries (in (4), above) and can be characterized by the schema \( [\text{NP}_1]_{\text{SG/PL}} \text{BE}_{\text{PL/SG}} \ [\text{NP}_2]_{\text{PL/SG}} \). The three defining features of this pattern, along with the hypotheses regarding how they affect agreement production, are listed here:

- **Verb agreement features matching those of a noun outside of the subject noun phrase.** In the examples above, the verbs each display the number features of the following, post-verbal nominal (e.g., are…plants). It is possible that this grammatical number feature—a grammatical feature of a
nominal that is not in the subject—plays a role in subject-verb agreement production in these utterances.

• *Abstract subject head nouns.* The subject head nouns in these utterances are items such as thing, or one, which are highly abstract and non-concrete (relative to concrete nouns such as “batteries,” “plants,” and “Saturns”). Other observed examples include lexical nouns that name general, abstract entities (e.g., rebellions, solution, pattern, rate, issue). These abstract nouns intuitively feel less salient, less important, as if the speaker is not talking about “things” or “ones,” but rather, “batteries” and “plants.” Abstract, non-concrete subject head nouns may somehow be more susceptible to interference effects from other more concrete nouns in the sentence, particularly when the subject is equated with that concrete noun. In other words, the semantic properties of not only the subject head noun, but also other nominals in the entire utterance in comparison to the subject head noun (i.e., whether those other nominals are more or less abstract or more or less imageable than the subject) may affect the degree to which those nominals interfere with subject-verb agreement.

• *Equative (“X = Y”) constructions.* The structures in which agreement mismatch occurs are equative constructions, which depict a co-indexical relationship between the subject and the predicate nominal (as compared to, say, a transitive construction, which often depicts a subject referent acting upon a separate object referent, Goldberg, 1995, pp. 117-119.) It may be the case that equating the subject noun phrase with a second nominal causes that second

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5 It should be noted that often the grammatical number of the post-verbal nominal is conflated with the semantic number. For example, the noun plants is grammatically plural, but it also semantically plural—it refers to multiple plants. In this study, the semantic number of the post-verbal nominal will not be manipulated. Because of this, and further, because we cannot be entirely sure of speakers’ conceptualizations of semantic number without some independent measure, I will be discussing the effects of the grammatical number of the post-verbal nominal on agreement. Nonetheless, I will occasionally make reference to the semantic number in order to acknowledge the confound between grammatical and semantic number, and to further acknowledge that this semantic number may also provide some information to the agreement production process.
nominal to be more highly activated during agreement production, allowing its grammatical features to have a stronger influence on subject-verb agreement choices than the subject noun phrase itself. In other words, it is not just the syntactic structure of the construction that matters, but the semantics as well. The constructional semantics in the case of the equative construction may allow the post-verbal nominal to play a larger role in subject-verb agreement than it would in other construction types.

While the pattern $[\text{NP}]_{1\text{SG/PL}} \text{BE}_{\text{PL/SG}} [\text{NP}]_{2\text{PL/SG}}$ has not been previously cited as a typical challenge to the assumption that subject-verb agreement is a strictly syntactic phenomenon, it should not be particularly surprising. Similar cases of non-canonical agreement patterns have been well documented in English. For example, agreement patterns with a post-verbal nominal in English that are widely accepted as grammatical include there-existential constructions (e.g., *There are three cats* vs. *There is a cat*) and locative inversion constructions (e.g., *On the shelf sits a teapot* vs. *On the shelf sit three teapots*). Bresnan (1994) argues that these are indeed cases of non-subject agreement. In her analysis, while the post-verbal nominal is the highest-ranking argument, the preverbal locative prepositional phrase and the THERE are the functional subjects in these constructions. In light of existing post-verbal agreement constructions, examples (4) and (6-8) are arguably not errors (a label which implies that the produced form does not match the speaker’s intended utterance), but might be better described as “mismatch”—the verb simply does not match the subject in terms of grammatical form.

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6 The term “equative construction” here is used to encompass the range of NP₁-COPULA-NP₂ constructions, including predicative, specificational, identificational and identity constructions (Higgins, 1979). My use of the term “equative” rather than “copula” is intended to emphasize the conceptual link between the two NPs, and is not intended to disregard research in semantic theory that recognizes the differences among copula constructions. There is currently no motivation from a psycholinguistic perspective to hypothesize a difference in agreement production among the different types of copula construction, and as such, the cover term “equative” intends to capture the particular essence of copula constructions that separates them from other constructions, in which the two NPs are not co-indexed in the discourse.

7 These may or may not be considered instances of non-subject agreement, depending upon the theoretical definition of “subject” (see Bresnan, 1994, for evidence that the pre-verbal constituents in these constructions count as subjects; see McCloskey, 1997 for a review of the definition of subject in the generative grammar tradition; see Sag, 2012, for discussion of subject in construction grammar.)
While acknowledging that the agreement productions investigated in this thesis are arguably not errors, I realize that labeling these patterns as cases of “mismatch” may still be deemed inappropriate by those who would consider these patterns to be fully acceptable. Nonetheless, I follow Pollard and Sag (1994, Section 2.3.2), Barlow (1992, Section 3.4) and Corbett (2006, Ch. 5) in intending it to be a theoretically neutral term. This is in part because it makes no assumptions about the intentions of the speaker (as “errors” are defined as deviations from intended productions), and in part because it attempts to strike a middle ground between theoreticians who interpret these patterns as errors, and those who would consider these patterns to be grammatical instances of non-subject agreement. Setting aside a judgment regarding whether or not these forms are acceptable, the question to be dealt with here is, what leads speakers to produce mismatch? In other words, what are the conditions that lead to such variation in speakers’ production of subject-verb agreement?

Several lines of research in linguistics have strived to explain the variation seen in agreement in spontaneous language use. Pollard and Sag (1994, Ch. 2) argue that agreement is not a grammatical dependency, but a linking of referential indices, “formal object[s] employed by the language user as a kind of mental tab kept on the things being referred to in the discourse at hand,” (Pollard & Sag, 1994, p. 72). A referential index is not an expression of the semantic or conceptual number of the subject, and it is not directly tied to the grammatical form of the subject. Instead, it is a formal index that is “anchored” to the subject. As such, it can flexibly reflect either semantic or grammatical number as appropriate in the discourse. This proposal by Pollard and Sag is fleshed out by Wechsler and Zlatić (2003), who provide a detailed formal account of mismatches between the grammatical form of the subject and the agreement marking on the verb, using primarily Serbian/Croatian data. Similarly, Barlow (1992) claims that agreement is anchored in discourse, illustrating his Discourse Linking Theory (DLT) with examples in both English and Arabic, among other languages. But these are formal linguistic descriptions, not on-line accounts of how speakers actually produce agreement.
And to some extent, these linguistic descriptions may feel a little post-hoc; if a verb displays agreement that does not match the subject’s grammatical form, it is assumed that the subject’s referential index features must then differ from the features that determine its grammatical form. It may be difficult, however, to establish independently of the agreement morphology what the subject’s referential index is in every case of mismatch. These studies provide detailed descriptions of the agreement patterns produced, highlighting what needs to be accounted for in production. Linguistic descriptions do not, however, explain psychological mechanisms. We have a fair description of what we produce, but the question still remains: how do we produce these forms?

One approach in the psycholinguistic modeling of agreement production maintains that subject-verb agreement is essentially a syntactic process (e.g., Bock, 2003; Bock & Miller, 1991; Bock et al., 2006; Franck, Frauenfelder, & Rizzi, 2007; Franck, Soare, Frauenfelder, & Rizzi, 2010; Franck, Vigliocco, Antón-Méndez, Collina, & Frauenfelder, 2008). Grammatical features of the subject are the primary determinants of the agreement features produced on the verb. Within this approach, there are two ways in which subject-verb agreement may deviate from the grammatical pattern. First, errors may occur due to syntactic interference, in particular, the interference of grammatical features of other lexical nouns. For example, when a speaker produces the singular subject noun phrase, “The tree with the leaves…” interference may come from the plural number feature of leaves, the noun embedded in the modifier (what researchers in agreement production often call a “local noun”). Such interference may lead the speaker to produce a plural verb (e.g., “…are turning yellow”). Interference effects from nouns other than the subject head noun are typically referred to as “attraction effects.” Attraction effects resulting from grammatical features of local nouns are constrained by syntactic structure; the likelihood that a particular noun’s grammatical features will interfere is directly related to its structural distance from the subject head noun. The second way in which subject-verb agreement may deviate from the grammatical pattern is due to semantic
agreement, in which the verb reflects the semantic (or conceptual) number of the subject referent. Variation in agreement due to the semantic or conceptual number value is assumed to be relatively rare, compared to grammatical interference. Semantic number is a minor influence compared to the grammatical value of the subject (i.e., when the semantic number and the grammatical number of the subject are in conflict, the grammatical number usually determines the verb agreement). Semantic information is also constrained during agreement production, even more so than grammatical information. Although the grammatical features of local nouns (nouns other than the subject head noun that are embedded in the subject noun phrase, e.g., leaves in *The tree with the leaves*) may interfere with agreement, no other semantic information beyond that of the subject referent can interfere with or contribute to subject-verb agreement. In other words, semantic properties of local nouns cannot interfere with subject-verb agreement, even if their grammatical features can.

A very different psycholinguistic approach to agreement production asserts that semantic information has a strong influence in the agreement process; verbs are highly sensitive to the conceptual representation of the subject, perhaps even as much as to its grammatical form, depending on the language being spoken (Vigliocco, Butterworth, & Garrett, 1996; Vigliocco, Butterworth, & Semenza, 1995; Vigliocco, Hartsuiker, Jarema & Kolk, 1996). Furthermore, the extent to which semantic information determines agreement patterns depends upon other features in the language being spoken; for example, in languages in which subjects are often omitted, semantic information is expected to have a stronger influence on the verb agreement morphology (e.g., Italian: Vigliocco et al., 1995; Spanish: Vigliocco, Butterworth, & Garrett, 1996), whereas in languages that require subjects to be overtly expressed (as in English), the grammatical form of the subject has a much stronger influence (although it doesn’t entirely rule out semantic influences on agreement). Simply put, we have two basic stories of agreement production: one that is based strictly
in syntax, and another that claims that semantics and syntax simultaneously interact to inform the agreement process.

This debate surrounding subject-verb agreement highlights a key issue of language production research over the past several decades with respect to the role of syntactic and semantic information in language production: Is language production primarily a (1) syntactocentric process, which entails that grammatical encoding is reliant on syntactic (grammatical) representations and is highly resistant to the effects of other information types (e.g., semantic or phonological), or a (2) interactive process, which not only allows speakers to draw upon multiple information types in order to successfully produce appropriate grammatical forms, but which also assumes competition and interaction among the various sources of information, such that the presence of one feature may promote or inhibit the effect of another? The tenacity of the “syntactocentric vs. interactive” framing of issues in language production, and specifically grammatical encoding, is likely due to the vast amount of research supporting the independent effects of abstract syntactic representations that are resistant to influences from other types of linguistic information (e.g., Bock, 1986b; Bock, Dell, Chang, & Onishi, 2007; Bock & Griffin, 2000; Chang et al., 2006; Chang, Dell, Bock, & Griffin, 2000; Loebell & Bock, 2003; Wardlow Lane & Ferreira, 2010). This evidence for the independence of syntactic representations motivates a stage of production at which syntactic processes are

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8 The term “syntactocentric” was coined by Jackendoff (2002) to describe formal theoretical approaches which assume that syntax is the only generative component of the language architecture, and that the semantic component is purely interpretive (i.e., determined by the syntactic structure), in contrast to a parallel architecture in which a number of independent combinatorial systems (e.g., semantic, phonological) interact. I am extending the term “syntactocentric” here to psycholinguistic models of production that assume that grammatical encoding is an encapsulated process, making use primarily of grammatical features encoded in the lexicon and operating strictly on syntactic principles. The use of “syntactocentric” to describe such models is within the spirit of the original use (even if these models do not exactly correspond to the syntactocentric architectures that Jackendoff discusses), and I believe it to be a more appropriate term than “modular” (Franck et al., 2006) (which is outdated and carries a lot of theoretical baggage), “hierarchically-based” (Gillespie & Pearlmutter, 2011) (which only addresses the nature of structural constraints and ignores the role of grammatical features stored in the lexicon), or “Minimalist” (Vigliocco & Frank, 1999; Vigliocco & Hartsuiker, 2002) (which linguists will find to be misleading, as it calls to mind the Minimalist Program, Chomsky, 1995).
impermeable to the effects of semantic (and/or morphophonological) information. Syntactocentric approaches retain a strong footing in language production research, despite increasing evidence for interactive processes at various levels of production (e.g., Acheson & MacDonald, 2009; Dell, 1985, 1986; Dell, Chang, & Griffin, 1999; Dell, Oppenheim, & Kittredge, 2008; Goldrick, 2006; Haskell & MacDonald, 2003; Solomon & Pearlmutter, 2004; Stallings, MacDonald, & O'Seaghdha, 1998, inter alia) and despite a strong body of research supporting interactive language processing in comprehension (e.g., Eberhard, Spivery-Knowlton, Sedivy, & Tanenhaus, 1995; Kim & Osterhout, 2005; Hanna, Tanenhaus, & Trueswell, 2003; MacDonald, Pearlmutter, & Seidenberg, 1994; McRae, Spivey-Knowlton, & Tanenhaus, 1998; Seidenberg & MacDonald, 1999; Tanenhaus & Trueswell, 1995, inter alia).

The “syntactocentric vs. interactive” framing is especially tenacious in research of the production of subject-verb agreement, which typically describes models of subject-verb agreement production in terms of syntactocentric and interactive approaches (Franck et al., 2008; Haskell & MacDonald, 2003). The unique nature of subject-verb agreement as a reflection of syntactic and semantic information, together with observed variation in subject-verb agreement production across and within speakers, affords an opportunity to investigate how speakers integrate various types of information during the grammatical encoding process. For this reason, subject-verb agreement been a major focus in the psycholinguistic study of language production (e.g., Bock, 2011; Bock & Cutting, 1992; Bock & Middleton, 2011; Bock & Miller, 1991; Bock, Eberhard, Cutting, Meyer, & Schriefers, 2001; Brehm & Bock, 2013; Gillespie & Pearlmutter, 2011; Haskell, Thornton, & MacDonald, 2010; Solomon & Pearlmutter, 2004; Staub, 2009; Thornton & MacDonald, 2003; Vigliocco et al., 1995; Vigliocco, Hartsuiker, Jarema, & Kolk, 1996; Vigliocco & Franck, 1999, 2001), across a wide variety of languages, including Hebrew (Deutsch & Dank, 2009), Russian (Lorimor, Bock, Zalkind, Sheyman, & Beard, 2008), Italian, French and Dutch (Vigliocco, Hartsuiker, Jarema, & Kolk, 1996).
French and English (Franck, Vigliocco & Nicol, 2002), Dutch (Hartsuiker, Antón-Méndez & van Zee, 2001), and Spanish (Bock, Carreiras & Meseguer, 2012; Nicol & Greth, 2003). Yet there still is not a psycholinguistic model of on-line agreement production that can handle the wide variation of agreement patterns documented in spontaneous language use. Syntactocentric approaches in psycholinguistics cannot fully explain the strong and predictable influence of semantic information in particular contexts, such as in the examples above. Interactive approaches give a stronger role to the semantic value of the subject referent, but have difficulty predicting the balance between semantic and syntactic information. That is, interactive approaches provide evidence that semantics and syntax do interact (e.g., Haskell & MacDonald, 2003; Pittman & Smyth, 2005; Solomon & Pearlutter, 2004; Thornton & MacDonald, 2003), but exactly when semantic information becomes the primary determinant of agreement, and when syntactic information maintains its stronghold is unclear. They cannot explain the conditions under which semantic agreement occurs and under which syntactic agreement occurs.

One reason why the psycholinguistic mechanisms responsible for the production of subject-verb agreement are not well understood may be that the scope of investigation is too narrow. The main assumption in psycholinguistic research on agreement production is that the syntactic and semantic information relevant to subject-verb agreement production is limited to that of the subject noun phrase. Very few experimental studies on subject-verb agreement production have considered that semantic and syntactic information beyond that of the subject noun phrase may interact with the subject to influence the production of agreement morphology on the verb. For example, grammatical features of nominals outside of the subject noun phrase might interfere with (or contribute to) the agreement production process. A small number of studies have considered this possibility (Franck et al., 2008, 2010; Hartsuiker et al., 2001), but the results have not been integrated into dominant models of agreement production. Furthermore, the influence of nominals outside of
the subject noun phrase might be strengthened or weakened depending upon the full message context of the utterance, or by their semantic properties relative to those of the subject head noun. In other words, by expanding the scope of investigation in subject-verb agreement production by manipulating features of nominal elements outside of the subject noun phrase as well as the semantic context of the construction in which agreement is produced, and by considering how semantic and syntactic information in the entire utterance may interact to influence agreement production, we may be better able to understand the mechanisms behind the formation of this grammatical dependency. This, in turn, may shed light on the mechanisms involved in grammatical encoding in general.

The widening in scope proposed in this dissertation is motivated by the agreement mismatch pattern in utterances exemplified by (4) *One thing I thought about the other day were batteries*, above. Specifically three features outside of the scope of the subject noun phrase will be considered: the grammatical number of the nominal appearing outside of the subject noun phrase, the relative abstractness of that nominal in comparison to the subject head noun, and the semantic relationship conveyed by the constructional context in which these nouns occur.

**1.2 Beyond the subject: Expanding the scope of research with new data**

Until now, the data that have been examined in investigating agreement production have for the most part concerned variations within the subject noun phrase. Experimental studies of the effect of syntactic information on agreement have varied grammatical number features and position of local nouns—nouns embedded within the subject noun phrase—on the number feature of the verb (e.g., the effect of the plural local nouns *presidents* and *companies* in the subject noun phrases *The threat to the presidents of the company…is/are* vs. *The threat to the president of the companies…is/are*, Franck et al., 2002). The current state of the field of agreement production, in which the question of whether
agreement is a syntactocentric process or an interactive one, rests on experimental work that has, for the most part, limited its scope to the study of the subject noun phrase.

Very few studies of subject-verb agreement have considered nominals outside of the subject noun phrase as possible contributors to the subject-verb agreement production process (see Franck et al., 2007, 2010; Hartsuiker et al., 2001 for limited exceptions). For the most part, only the subject head noun and local nouns embedded within the subject noun phrase (e.g., only the head noun threat and the local nouns president(s) and company(y/ies) in the noun phrase The threat to the president(s) of the company(y/ies)) are assumed to contribute any information to the number value of the subject noun phrase, and consequently the verb. A handful of studies have considered whether object nominals can interfere with subject-verb agreement (Hartsuiker et al., 2001; Franck et al., 2008, 2010), concluding that object interference is possible, but that it is tightly restricted by syntactic structure. No study (to the best of my knowledge) has yet considered other types of nominals outside of the subject noun phrase (e.g., predicate or equative nominals, nominals within locative predicates, etc.).

Examples (4) and (6-8) above, however, suggest that nominals outside of the subject noun phrase are able to influence the agreement patterns that speakers produce (e.g., in (4), the verb were matches the post-verbal nominal batteries for plural number)—but importantly, this influence seems to occur in a particular semantic context.

The observation that constructional context might matter highlights a second aspect of the narrow scope of previous work on subject-verb agreement. Almost all experimental studies investigating semantic influences on subject-verb agreement production have focused on lexical

9 The term “post-verbal nominal” is used here as a general term to describe any nominal in a linear position after the verb, including objects and referential nominals in equative predications. Because many syntactic descriptions of predicates make a distinction between nominals that are objects of verbs (e.g., the president in She sees the president) and nominals that form the predicate (e.g., the president in She is the president) (e.g., Rothstein, 2004) I have chosen not to conflate these two types of post-verbal nominals under the term “object,” but to label them as “objects” and “equative nominals” when referring to them separately, and as “post-verbal nominals” when referring to both types.
semantic properties of the subject head noun or local nouns within the subject noun phrase or the specific number construal of the subject noun phrase. For example, studies examining semantic features of the subject noun phrase have varied the interpretation of the subject (as in the label on the bottles vs. the baby on the blankets, where label is interpreted as referring to multiple items, while baby refers to one) or the semantic features of local nouns (e.g., the possibility that company in the previous example could be interpreted as a multitude of individuals and therefore be conceptually plural). Very little research on subject-verb agreement production has considered the role of semantic information beyond the conceptual number (or gender) of the subject referent. The notably few exceptions (which will be reviewed in detail in Chapter 2) have examined the semantic relationships between subject head nouns and local nouns embedded within the subject noun phrase. To the best of my knowledge, no study has recognized that an influence on subject-verb agreement may come from the semantic properties of nouns outside of the subject noun phrase relative to the subject (e.g., whether an object or other post-verbal nominal is more concrete than the subject head noun), or even the semantic information of the construction in which agreement is produced.

The lack of consensus regarding whether agreement production is syntactocentric or interactive may be due, at least in part, to the constrained scope of investigation. It may be the case that the dynamic interaction between semantic and syntactic features has not been consistently demonstrated because the only semantic and syntactic features that have been experimentally manipulated have been properties of the subject noun phrase. The constructional semantics in which agreement has been produced have not been manipulated, nor have the semantic properties of the subject relative to nominals outside of the subject noun phrase. Once these variables are considered, interactions between semantic properties and grammatical features may emerge. The spontaneous, attested examples of agreement mismatch in (4) and (6-8) above suggest that information beyond that encoded by the subject noun phrase may, in fact, affect the on-line production of subject-verb
agreement relations. The hypothesis put forth in this dissertation is that the production of subject-verb agreement, and by extension, the ways in which speakers create dependencies among linguistic elements during on-line grammatical encoding, is a complicated and dynamic process in which syntax and semantics are deeply intertwined, and that it is not limited to syntactic processing alone. Examining these data will lead to a more empirically supported model of agreement production that considers a wider range of variables than previous models have considered. By extension, this examination will also highlight the types of information involved in language production in general, and support an interactive approach to future research in psycholinguistic models of production.

1.3. Purpose and scope of the dissertation

The purpose of this study is to investigate the types of information that speakers draw upon when producing subject-verb agreement by widening the scope of investigation from the features of subject noun phrase to the syntactic and semantic properties of the utterance as a whole. This work addresses the question: Is subject-verb agreement strictly a syntactocentric process, in which only syntactic information from the subject noun phrase (and only very limited semantic information about the subject referent) may interfere with the encoding process, or is it instead an interactive process during which speakers draw upon available syntactic and semantic information from post-verbal nominals and constructional contexts to successfully encode the agreement relation? This will be done through corpus and experimental studies examining speakers’ productions of subject-verb agreement in the semantic context of particular constructions (the equative and transitive constructions), particular grammatical features (singular subjects and plural post-verbal nominals), and particular lexical properties (the abstractness of the subject head noun relative to post-verbal nominals). The investigation will be anchored in the framework of current architectures of language production and grammatical encoding, which will allow for clear predictions regarding the roles of
semantic and syntactic information in agreement production. Results will demonstrate that speakers are significantly more likely to produce agreement mismatch in the presence of an equative construction with a post-verbal nominal differing in grammatical number from the subject. Furthermore, it will be argued that only a dynamic, interactive account of language production in which semantics and syntax are deeply intertwined during the grammatical encoding process can handle these data.

The thesis is organized in the following manner. Chapter 2 presents an overview of psycholinguistic models of grammatical encoding and language production and of psycholinguistic perspectives on subject-verb agreement production. Specifically, the overview will outline the two sub-stages of grammatical encoding, functional processing and positional processing, and will explore the predictions that the syntactocentric and interactive approaches make regarding the input of semantic and syntactic information during those two sub-stages, with specific reference to agreement production. Chapter 3 presents a corpus study of almost 2,700 utterances extracted from the Switchboard Corpus (Godfrey et al., 1992) which I hand-annotated for features hypothesized to be relevant to the subject-verb agreement production process, namely, the presence of a post-verbal nominal that does not match the subject in number, the use of an equative construction, and an abstract subject head noun. The corpus study provides a solid foundation for the experimental studies to follow, ensuring that the features being examined are those that influence speakers’ syntactic choices in spontaneous language use, and not only in a laboratory setting. Chapters 4, 5, and 6 present experimental investigations of subject-verb agreement production using an innovative adaptation of a well established elicited production paradigm. Chapter 4 examines whether there is a significant effect of the grammatical number (singular or plural) of the post-verbal nominal and the construction type on speakers’ preferences in subject-verb agreement production, and if so, whether or not that information is mediated by the constructional context in which the subject-verb
agreement is produced—specifically comparing the effects of equative and transitive constructions. Chapter 5 investigates the role of subject type (abstract or concrete), addressing the issue of whether or not semantic properties of the subject lexical item interact with the grammatical features of the post-verbal nominal. Chapter 6 addresses the issue of whether the dynamic, interactive processes illustrated in the previous experiments are the result of priming in the experimental paradigm (early activation of relevant information prior to the production process) or on-line processing (the integration of relevant information during the actual production). Finally, Chapter 7 concludes with a summary of the corpus and experimental studies and the implications for psycholinguistic models of agreement production and language production at large, along with a discussion of the findings in the context of linguistic research on agreement phenomenon.

Before continuing, I would like to add a brief note about terminology to be used throughout this thesis. I will be using both the terms “mismatch” and “error.” “Mismatch” will be used to refer to agreement patterns that deviate from syntactic subject-verb agreement as described above, which may be considered acceptable to varying degrees; “error” will be reserved for deviations from syntactic that have been elicited in production experiments and are described in past literature as such (i.e., where experimental results are discussed in terms of error rates.) For the corpus and experimental studies presented here, the term mismatch will be used. Also, throughout the remainder of this thesis, the use of the term “agreement” should be understood as a shorthand to refer to the particular type of agreement under investigation: subject-verb agreement with respect to number features (rather than person and gender). This is not to disregard the complex phenomenon that is the full spectrum of agreement across languages (see Corbett, 2006 for a thorough review), but is intended to refer to the limited scope of this study, which cannot address all possible variations that comprise the linguistic phenomenon of agreement.
Chapter 2. Background on Language Production and Agreement

In order to discuss how on-line models of language production can move toward an account of the variation seen in spontaneous production of subject-verb agreement, and in particular, an account of the production of agreement in such tokens as *One thing I thought about the other day were batteries*, we must first discuss the architecture of the language production system. This chapter will present a basic overview of language production models, with attention to the process of grammatical encoding. The two sub-stages of grammatical encoding, *functional processing* and *positional processing*, will be outlined. These two sub-stages set the foundation for discussing how semantic and syntactic information contribute to agreement production and language production in general. The syntactocentric and interactive approaches provide distinct accounts of how semantic information contributes during grammatical encoding; the syntactocentric approach restricts semantic information to only providing limited input during the first functional processing stage, whereas an interactive approach allows a wide range of semantic information to contribute to both the early functional processing and the later positional processing stage. These two approaches make very different predictions about the type of agreement patterns that can be produced. The former has difficulty explaining why such tokens as *One thing I thought about the other day were batteries* are produced on a regular basis, whereas the latter more easily allows such productions.

2.1 Overview of language production models and grammatical encoding processes

The study of language production concerns how speakers produce a well-formed utterance that expresses an intended message. Within the field, there is a general consensus that the architecture of the language production system involves three basic stages, as initially outlined by Garrett (1975, 1989): conceptualization, formulation (also called grammatical encoding), and phonological encoding.
(Bock, 1995; Bock & Levelt, 1994; Dell, 1985, 1986; Garrett, 1975; Kempen & Hoenkamp, 1987; Levelt, 1989; see also Bencini, 2013, and Ferreira & Slevc, 2007 for an overview), illustrated in Figure 2.1.\(^\text{10}\)

![Figure 2.1. The basic architecture of language production models.](image)

Production begins with a formulation of the conceptual structure of the message, which includes perspective taking, information structure, and the organization of conceptual/semantic information. The process then continues to the grammatical encoding stage, which involves accessing the lexical, structural, and morphophonological information necessary to encode the message. The final stage of sentence production is the articulation of the message. Of these three stages, grammatical encoding is the stage that is of most interest to researchers of sentence or

\(^\text{10}\) Some discussions of language production include phonological encoding in the formulation stage and treat articulation as the third stage of language production (e.g., Kempen & Hoenkamp, 1987; Levelt, 1989). Others treat phonological encoding as the third stage of language production processing, whereas articulation appears to be treated as a physiological process that is outside of the realm of language production per se (e.g., Bock & Levelt, 1994). In either case, phonological encoding is assumed to follow grammatical/syntactic encoding (even if they are bundled together in “formulation”). As such, these variations in models make no different predictions with respect to the studies presented here.
utterance production (as compared to single-word production or phonological production) because it is during this stage that linguistic representations matching the message to be communicated are accessed and combined into a coherent structure. Grammatical encoding is also the stage at which agreement relations are constructed; the architecture and mechanisms of grammatical encoding are therefore a main concern of this dissertation.

Generally, grammatical encoding is understood to involve two main sub-stages, first proposed in Garrett (1975). These are referred to as *functional processing* and *positional processing* (see also Bock, 1995; Bock & Levelt, 1994; Levelt, 1989). Each of the sub-stages involves interacting lexical (content) and syntactic (structural) processes. The breakdown of grammatical encoding into these sub-stages and processes is illustrated in Figure 2.2:

![Figure 2.2. Processing mechanisms involved in grammatical encoding.](image)

During the first sub-stage, functional processing, “‘semantic’ factors pick lexical formatives and grammatical relations” (Garrett 1975:176). In other words, on the lexical side, referents and relations in the message are mapped to grammatical information in the appropriate lexical entry (e.g., DOG or CHASE) that specifies lexical category (e.g., NOUN or VERB) and, for example, definiteness and
person/number/gender information (for nouns) or tense/aspect information (for verbs). This lexical representation, underspecified for morphological or phonological form, is referred to as the *lemma*. On the structural side, referents from the message are tagged with grammatical functions such as *SUBJECT* and *OBJECT* that will determine their place in the utterance structure, and these grammatical functions are linked with the appropriate lemmas that have been retrieved by lexical processes.

During the second sub-stage, positional processing, “syntactic factors pick positional frames with their attendant grammatical formatives [and] phonemically specified lexical formatives are inserted into frames,” (Garrett 1975, p. 176). Thus, on the lexical side of positional processing, lemmas are mapped to their phonemic form, called *lexemes*. On the structural side, the hierarchical structure of the utterance is built, and lexemes are fit into this structure. The structural side of positional processing is also where subject-verb agreement is actually formed, as this is the stage where the subject and verb are joined together in a syntactic relationship. If, as noted in Chapter 1, Section 1.1, agreement is a phenomenon in which features of certain elements in the utterance are dependent upon the features of other elements within a particular grammatical domain (Corbett, 2006), then it is during the structural processing at the positional processing sub-stage where that grammatical dependency is created.

Before discussing the details of agreement processing, it is useful to see first how arguments of a sentence are mapped to their grammatical functions and to their places in the syntactic structure. The basic architecture of grammatical encoding, situated within the three-stage process of language production, is illustrated in Figure 2.3, for the arguments of the simple sentence, “The dog chases a squirrel.”
Figure 2.3. An example of utterance production. This figure shows a simplified illustration of the processing of nominal arguments during the production of the utterance, “The dog chases a squirrel.”

This basic skeletal architecture is supported by a vast amount of speech error data, both spontaneous and elicited (e.g., Bock, 1995; Dell, 1986; Garrett, 1975, 1989; Stemberger, 1982), which show that early errors of lexical selection at the functional processing stage affect syntactic processing at the later positional processing stage. For example, in the error *Most cities are true of that* (intended: *That is true of most cities*), the production of the verb form *are* necessarily must occur after the switch of the nominals *most cities* and *that*; otherwise the error would be *Most cities is true of that* (Stemberger, 1982). Further support for two distinct grammatical encoding levels involving lemmas and lexemes comes from tip-of-the-tongue (TOT) phenomena. These are cases in which a speaker reports the ability to access the meaning and syntactic properties of a word (the lemma), but fails to retrieve its form (the lexeme) (see Butterworth, 1989; Dell, 1986; Garrett, 1989; Harley & Bown,
Experimental evidence for the two stages comes from studies demonstrating dissociation between grammatical function (assigned during functional processing) and linear order (determined at positional processing) (Bock, 1986b; Bock & Warren, 1985; McDonald, Bock, & Kelly, 1993). For example, Bock and Warren (1985) show that referents that are more accessible are assigned to grammatical functions that appear earlier in the sentence (e.g., if squirrel is more accessibly than dog, speakers are more likely to produce A squirrel was chased by the dog, than The dog chased a squirrel); conceptual accessibility had no effect, however, on ordering within phrasal conjuncts (e.g., squirrels and dogs), where the two noun phrases did not differ in grammatical function.

Although the two-stage grammatical encoding architecture is widely accepted, models may vary with respect to the details of the production process. Various debates concern whether or not sentence production is an incremental and cascading process—that is, whether the full representation of an utterance at one level must be fully selected before access at the next level can occur, or if constituents can be processed in the order that they are accessed (see Bock & Levelt, 1994; De Smedt, 1990, 1994; Kempen & Hoenkamp, 1987); how far in advance constituents are planned and processed (e.g., Allum & Wheeldon, 2007, 2009; Gillespie & Pearlmutter, 2011, 2013; Wheeldon, Ohlson, Ashby, & Gator, 2013); and the degree to which semantic meaning and syntactic assembly are separated (e.g., Ferreira & Sleve, 2007; Garrard, Carroll, Vinson, & Vigliocco, 2004; Meteyard & Patterson, 2009; Treiman, Clifton, Meyer, & Wurm, 2003; Vigliocco & Hartsuiker, 2002). It is primarily this last debate—essentially, the degree to which grammatical encoding is an encapsulated, syntactocentric process or an interactive and dynamic process—that concerns the work of this dissertation.

But see Caramazza (1997) for arguments against a two-stage architecture of grammatical encoding.
The term “grammatical encoding” implies to some extent that the processes occurring during this stage of sentence production are encapsulated within and specific to the domain of syntax. The extent to which non-syntactic information affects the grammatical encoding process is, however, a matter for empirical investigation. Many of the standard models of language production (e.g., Bock, 1995; Bock & Levelt, 1994; Garrett, 1975, 1989; Levelt, 1989; Levelt, Roelofs, & Meyer, 1999) have been to some degree modular in nature, assuming an isolated, encapsulated stage of grammatical encoding. Semantic information merely provides the initial input from the conceptualization stage to the functional processing level, where lemma selection and grammatical function assignment occur, but semantic information does not affect lexeme selection or the assembly of the syntactic structure during the positional processing stage. These models usually assume a minimal amount of input to each stage of processing, and a unidirectional flow of information. The early foundation for a production system that operates with minimal input and unidirectional flow of information was strongly based in research on lexical retrieval (e.g., Levelt et al., 1991; Levelt et al., 1999; Schriefers, Meyer, & Levelt, 1990). Evidence in favor of such models of sentence production comes from work in syntactocentric approaches to agreement production (reviewed below in Section 2.2.1), and from the large number of studies demonstrating that syntactic priming (the tendency of speakers to repeat particular syntactic structures), which occurs at the positional processing stage, is not influenced by semantic information. For example, Bock and Loebell (1990) demonstrate that passive structures (e.g., The 747 was alerted by the airport’s control tower) primed locatives (e.g., The 747 was landing by the airport’s control tower), which has a similar surface structure but different event structure.

An alternative view of language production is the Maximal Input Hypothesis espoused by Vigliocco and Hartsuiker (2002). This view claims that grammatical encoding is a dynamic, interactive process. According to the Maximal Input Hypothesis, at each stage of production speakers may draw upon information from earlier or later stages to the extent that such information
is available. As such, semantic information has a role to play in determining the syntactic choices of
the speaker, as illustrated by examples (1-4) in Chapter 1 (e.g., *The hash browns at table nine is getting
angry*) where the conceptualization of the subject referent reliably drives the agreement production
(counter to the syntactocentric claims that the semantic number of the subject has a very small
influence, resulting in semantic agreement only a small proportion of the time that the opportunity
arises).\(^\text{12}\) Much of the evidence that Vigliocco and Hartsuiker cite in support of the Maximal Input
Hypothesis comes from research concerning semantic influences on agreement production
(reviewed below in Section 2.2.2). A truly interactive approach, however, should not depend upon
demonstrating that semantic influences dominate syntactic choices. An interactive approach does
not deny the importance of syntax or the possibility of independent, abstract syntactic
representations. Rather, it allows for the possibility that semantic information may influence the
processes by which syntactic representations are processed.

Consider other findings in psycholinguistic studies of language production that may be
interpreted as supporting an interactive approach to varying degrees: In an experimental study of
lexical/syntactic priming effects, Cleland and Pickering (2003) show that syntactic priming effects
can be enhanced by lexical information; participants were more likely to reuse a particular syntactic
structure (e.g., “the sheep that’s red”) if reusing a lexical item in that structure (e.g., the head noun
“sheep”), or a semantically related lexical item (e.g., “goat”)\(^\text{13}\). In an examination of syntactic blend

\(^{12}\) Vigliocco and Hartsuiker (2002) also discuss the effects of morphological information on
agreement production, but those effects will not be addressed in this dissertation. While effects of feedback
from phonological encoding on agreement production has not been examined in any experimental study, the
Maximal Input Hypothesis predicts that such effects are possible. Feedback from phonological processing
has most often been examined with respect to lexical production, but some work has been done on phrasal
production; see Vigliocco and Hartsuiker (2002, pp. 453-5) for discussion.

\(^{13}\) Cleland & Pickering (2003) did not, however, find an effect of phonologically related items (e.g.,
“the ship that’s red”) suggesting that phonological information does not contribute to syntactic processing.
They interpret these results in opposition to a fully interactive approach to language production, which would
allow feedback from the phonological processing level to the grammatical encoding level.
speech errors (e.g., “It’s not so pretty bad” a blend of “not so bad” and “pretty good”), Coppock (2010) argues for a production model in which alternate possible syntactic encodings of the same message compete during the grammatical encoding stage (rather than being isolated in separate buffers)—showing that the semantics of the message can determine which syntactic competitors arise during the production of a particular utterance. Finally, Hartsuiker and Pickering (2008) demonstrate cross-linguistic influences during grammatical encoding, such that lemmas in one language that are linked via conceptual nodes to a second language can influence syntactic processing in that second language.

Examining grammatical encoding in terms of two distinct stages of processing allows us to recognize the subtle differences between the predictions that each approach makes concerning the roles of syntactic and semantic information during the grammatical encoding process. Syntactocentric models are not “all-syntax-all-the-time.” They do indeed allow semantics to contribute to grammatical encoding; it is simply that the contribution is restricted to initial input at the functional processing sub-stage of grammatical encoding. Conversely, interactive approaches do not deny the importance of and independence of abstract syntactic representations; rather, they allow semantic information to interact with these syntactic representations in order to determine the final syntactic form of the utterance, influencing grammatical encoding processes even at the later positional processing sub-stage. Recognizing these subtle distinctions in the two-stage grammatical encoding model does away with a black-and-white view of the debate while providing many clear predications regarding how semantics and syntax will interact in determining the form of particular utterances.

This subtle yet clear distinction can be clearly illustrated in the production of subject-verb agreement during grammatical encoding. Agreement is a grammatical dependency, in which meaning is “displaced” (Moravesik, 1988, p. 90); number (and person and gender) information overtly coded
in the grammatical form of the subject appears on the verb. For this reason, it makes sense to assume that the only relevant semantic information concerns that of the subject referent, encoded at the early functional processing level. At the later positional processing level, grammatical information about agreement features of the subject determine the grammatical form of the verb, which is in a defined syntactic relationship with the subject. Given these initial observations, it makes sense to assume that agreement production is a definitively syntactic process. Yet variations in agreement patterns seen in both experimental studies and spontaneous language suggest that semantic information plays a larger role in agreement than might be assumed. The question is, what type of semantic information influences agreement production, and at what stage does it influence the production process? If semantic information involved in agreement production is not restricted to information about the subject referent, or if semantic information affects agreement production during positional processing, this would support a dynamic, interactive account. The next section provides an overview of psycholinguistic approaches to agreement production that allows us to address this question.

2.2. Overview of psycholinguistic accounts of agreement production

Although the question of how speakers produce subject-verb agreement has long been of interest (e.g., Woodworth, 1938, p. 817 and Jespersen, 1924, p. 345, cited in Bock & Miller 1991), research leading to the current state-of-the-art accounts began with Bock and Miller's (1991) seminal investigation of elicited errors in subject-verb agreement. This study has essentially been the foundation for almost all contemporary experimental investigations of agreement production. The paradigm used in this experiment has been used in some form by almost all elicited production studies of agreement, and several of the key findings have been replicated time and again. In this series of experiments, Bock and Miller looked at the degree to which error rates were correlated with
the presence or absence of particular semantic and syntactic features on the sentential subject noun phrase. Participants were asked to repeat subject noun phrase preambles and then continue on to make complete sentences. They then looked to see whether participants produced agreement that matched the subject head noun, or whether they erroneously produced a verb that agreed with a local noun (a noun embedded inside the subject noun phrase) displaying a particular grammatical or semantic property.

More broadly, this research was situated in the context of debates concerning the “interactivity or isolability of processing” (Bock & Miller 1991, p. 47). Identifying the mechanisms and processes involved in the production of subject-verb agreement errors should provide insight as to whether language processing draws upon general cognitive resources (e.g., Anderson, 1983, cited in Bock & Miller, 1991, p. 47), allowing dynamic interaction among various types of information (e.g., McClelland, 1987, cited in Bock & Miller, 1991, p. 81) or is a unique, differentiated processing component that has little in common with other cognitive processes (e.g., Fodor, 1983, cited by Bock & Miller 1991, p. 47) and which would severely restrict contributions from components of general cognition.

In the case of subject-verb agreement production, evidence that would serve to differentiate between these two views of language production lies in the extent to which features of the message to be communicated (i.e., semantic or conceptual features) can “exert fine control over” the syntactic features in the utterance (Bock & Miller, 1991, p. 47). Such features include notional correlates of subjecthood, including animacy, humanness, and definiteness. Consider the following examples of potential agreement errors (12-13):

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14 Bock and Miller also investigated the role of working memory (a general cognitive faculty) in agreement production by examining whether or not linear distance between the subject head noun and the verb was a predictor of error rates; results were non-significant.
12. * The blanket on the babies are dirty.
13. * The baby on the blankets are dirty.

It could be the case that speakers are more likely to produce the plural verb error in (1) than in (2) because the plural local noun *babies* in (1) is an animate noun, and therefore might be more likely to be mistaken as the subject. In other words, the question was whether or not there would be an increase in subject-verb agreement error rates due to the presence of semantic features such as animacy and humanness in nouns that are not subject head nouns (i.e., an increase in the verb agreeing with the number of the local noun rather than with the subject head noun). If so, this would demonstrate that semantic features beyond conceptual information about subject referent number could influence syntactic processes. Such results would support a dynamic, interactive view of language processing. On the other hand, if linguistic processing is restricted to domain-specific information then only grammatical (i.e., syntactic) features of local nouns should have the potential to cause any disruption during the production of agreement; semantic features should not be able to interfere.

Results of the experiments demonstrated that semantic features of local nouns (e.g., animacy or collectivity as in *gang* or *family*) had no direct affect on agreement production, while grammatical features such as plurality and hierarchical structure did affect error rates. The principal claim of Bock and Miller was that subjecthood (a grammatical construct) drives agreement production, and not notional correlates such as animacy, humanness and definiteness. While a semantic feature such as animacy on a particular noun may cause the speaker to inadvertently treat that noun as the subject, once the subject role is assigned to a particular noun, syntactic processes take over, and semantic information becomes irrelevant. These results were interpreted within a highly constrained, 

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15 Bock and Miller did show an indirect affect of animacy, but they conjecture that the effect was limited to the assignment of the subject grammatical role at the functional processing level, which does not conflict with a syntactocentric account of agreement. This will be further discussed in Chapter 4, Section 2.
syntactocentric account of agreement production, in line with modular approaches to language production.

Since the Bock and Miller study, experimental investigation of subject–verb agreement production has flourished, with much of it focusing on the role played by semantic and syntactic features of the subject head noun and local nouns within the subject noun phrase. The bulk of this research has supported Bock and Miller’s principle claim that “what controls and mediates agreement is the abstract syntactic relation of subject, not the notional properties...of noun phrases” (Bock & Miller, 1991, p. 89) by showing how syntactic features can interfere with agreement production. There are, however, studies that have supported a dynamic, interactive account of agreement production in which semantic influences can interact with the syntactic processing. The following sections will review these two lines of research here, and the models of agreement production that have emerged from these two lines of research.

2.2.1 Syntactocentric approaches to agreement production

The syntactocentric approach to agreement production in psycholinguistics (Bock & Cutting, 1992; Bock & Miller, 1991; Bock et al., 2006; Franck, Lassi, Frauenfelder & Rizzi, 2006; Franck et al., 2010) takes as its starting point the observation that agreement is a grammatical dependency, and thus treats it as a primarily syntactic phenomenon. This approach has strong roots in certain formal linguistic theories. Within linguistics, agreement is widely considered to be an asymmetrical relationship in which the formal marking of one element of a sentence, the target, is determined by a semantic or formal property of another element, the controller, defined within a particular syntactic relationship under particular conditions (Corbett 2006, p. 4). This basic definition encompasses a wide range of agreement phenomenon in which semantic, pragmatic, lexical, and morphological features play a role (see Corbett, 2006, for a thorough cross-linguistic overview). Many formal
theories in the Chomskyan tradition, however, have constrained agreement to be a syntactic phenomenon; whereas semantic, pragmatic, and morphological information may contribute to the person/gender/number features of the *controller*, the agreement morphology, which is marked on the *target*, is strictly formal. Agreement, then, is merely a syntactic reflex of the properties of the controller (e.g., Chomsky, 1995). Although not all linguistic theories treat agreement as a unidirectional, asymmetric controller-target relationship (e.g., Pollard & Sag, 1994; Wechsler & Zlatin, 2003, as will be discussed in Section 2.2.b below), the syntactocentric approach to agreement production in psycholinguistics has not integrated such approaches. Instead, agreement is treated as a feature-copy operation, whereby speakers must copy features of the subject noun phrase onto the verb during grammatical encoding. This copying process is encapsulated within the domain of syntax (and further constrained to the structural relationship between the subject and the verb) and operates strictly on syntactic principles (only syntactic principles can determine which elements can interfere during the agreement process). Syntactocentric approaches to agreement production embody this theoretical approach in two respects. The first is a restriction on the type of information that contributes to agreement production, and the second is a restriction on the structural domain in which agreement is produced.

Evidence regarding the restriction on the type of information that contributes to or interferes with agreement production comes primarily from studies showing that only syntactic, and not semantic, features of local nouns interfere with agreement errors. When the local noun differs from the head noun in syntactic number features, the verb may erroneously agree with the local noun rather than the head noun. For example, speakers are more likely to produce the error in (14) than in (15), because in (14) the grammatical (plural) number feature of the local noun *blankets* differs from that of the (singular) head noun *baby*, whereas in (15), the grammatical number features on both nouns match.
14. * The baby on the blankets are dirty.
15. * The baby on the blanket are dirty.

Interference from nouns outside of the subject noun phrase has been investigated by a small number of studies (Franck et al., 2008, 2010; Hartsuiker et al. 2001), showing that in very restricted syntactic configurations, grammatically plural objects can interfere with singular subject-verb agreement. These effects have not been replicated to nearly the extent that the effects of local nouns have; they will be discussed further in Chapter 4, where the effects of post-verbal nominals on agreement production will be experimentally investigated.

Crucially, only the grammatical (syntactic) features of local nouns elicit significant effects. Animacy of local nouns does not result in interference effects (Bock & Miller, 1991; Barker, Nicol, & Garrett, 2001). A local noun that is syntactically singular but semantically plural (e.g., *gang* or *family*) will not result in the erroneous production of a plural verb (Bock & Cutting, 1992; Bock et al., 2001; Bock & Miller, 1991). In other words, there is no increase in the likelihood of producing agreement errors in sentences like (16), in which the local noun *team* is a collective, over (17), where the local noun *bench* is not.

16. * The player on the team are tired.
17. * The player on the bench are tired.

Of particular significance is that plural local nouns paired with singular subject head nouns are correlated with higher error rates than singular local nouns paired with plural subjects (Bock & Miller, 1991: Experiment 1). In other words, speakers are more likely to produce an agreement error in (18) than in (19).

18. * The baby on the blankets are dirty.
19. * The babies on the blanket is dirty.
This asymmetry has been replicated time and time again (Barker et al., 2001; Bock & Eberhard, 1993; Bock & Miller, 1991; Eberhard et al., 2005; Vigliocco et al., 1995; Vigliocco et al., 1996; interalia). The most common explanation is that the singular noun is a default form, not “marked” with a number feature, whereas plural nouns possess a number feature (or are “marked” with the feature (Bock & Eberhard, 1993; Bock & Miller, 1991; Eberhard, 1997). Unmarked, singular head nouns are thus more vulnerable to effects from the presence of a marked feature of the plural local noun than vice versa, because the agreement mechanism may detect the presence of the local noun’s number feature, while a singular local noun has no feature to detect.¹⁶

Secondary evidence for the syntactocentric restrictions on the information available to agreement production concerns the limited influence of the semantic/conceptual representation of the subject referent. Subject noun phrases with distributive interpretations (e.g., *The label on the bottles...* compared to the syntactically similar *The baby on the blankets...*, which does not depict multiple babies) and those with collective head nouns (e.g., *gang, family, team, etc.*) provide semantic information that conflicts with the syntactic information encoded by the lexical head noun. Some studies have shown that this information results in slightly higher rates of agreement mismatch than when the subject referent is semantically or conceptually singular (in English: Eberhard, 1999; Humphreys & Bock 2005; Italian: Vigliocco et al., 1995; Spanish: Vigliocco, Butterworth, & Garrett, 1996), but overall, speakers are still more likely to produce singular (grammatical) agreement with these subject types.

Regarding the syntactocentric restrictions on the structural domain of agreement production, evidence comes from studies investigating the structural properties of the subject noun phrase. Bock

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¹⁶ See Badecker and Kuminiak (2007) for an alternate explanation of this asymmetry framed in the context of a content addressable working memory system.

¹⁷ Earlier studies found no such effects in English (Bock & Miller, 1991), but the later study by Eberhard (1999) suggested that this was due to methodological problems.
and Cutting (1992) demonstrated that clausal boundaries isolating local nouns from head nouns make them less likely to interfere with agreement (e.g., books in *The editor [who rejected the books]...* is less likely to cause an agreement error than in *The editor of the history books...*). In another study examining structural effects of the subject noun phrase on error rates, Franck et al. (2002) demonstrated that local nouns that are higher in the subject noun phrase hierarchical structure are more likely to cause attraction effects than those lower in the structure. For example, the local noun *presidents* in *The threat to the presidents of the company are...* is more likely to cause an attraction effect, eliciting a plural verb than *companies* in *The threat to the president of the companies are...*, because it is structurally closer to the subject head noun, as illustrated in Figure 2.4 (adapted from Franck et al., 2002).

![Hierarchical structure and local nouns](image.png)

*Figure 2.4. Hierarchical structure and local nouns. An illustration of how hierarchical structure restricts the influence of local nouns on the computation of subject noun phrase number. Nouns that are higher in the hierarchy (e.g., *president(s)*), and therefore closer in terms of syntactic distance to the subject head noun (here, *threat*), have a stronger effect, as indicated by the thick dashed line. Nouns that are further down the hierarchical structure have a lesser effect, indicated by the smaller dashed line.*

Similar restrictions have been demonstrated in the few studies that have investigated interference effects of post-verbal nouns. In particular, the effect of nouns outside of the subject noun phrase is hypothesized to only occur when such nouns appear in non-canonical positions,
intervening between the subject and the verb (Franck et al., 2008, 2010). This claim will be discussed further in Chapter 4.

Vigliocco and Nicol (1998) demonstrate the independence of the structural domain of subject-verb agreement from another angle, by showing that changes in linear order only (and not in hierarchical structure) do not result in significant differences in agreement error rates. They compared production of agreement in declarative and interrogative sentences such as, “The helicopter for the flights is(are) safe,” and “Is(are) the helicopter for the flights safe?” They found that the distribution of errors (e.g., *Are the helicopter for the flights*… and *The helicopter for the flights are*…) was similar for both types—even though the local noun is closer to the verb in the second case. From this, Vigliocco and Nicol concluded that the attraction effects of local nouns are dependent upon the structural relationship between the local and head nouns, and not the linear distance between the local noun and the verb.

Most of the evidence reviewed here has been in English, but there is a fair amount of cross-linguistic research that is compatible with the syntactocentric approach. Hierarchical constraints on attraction effects have been shown in French (Franck et al., 2002). The advantage of grammatical information over notional information in subject-verb agreement has been shown in Hebrew with regard to both gender and number features (Deutsch & Dank, 2009), as well as in Russian (Lorimor, Bock, Zalkind, Sheyman, & Beard, 2008). Further evidence for a bias toward syntactic information in agreement production has been found in French (Franck et al., 2010), German (Berg, 1998), and L2 Spanish (Nicol & Greth, 2003).

*Syntactic models of agreement production.* The primary syntactocentric psycholinguistic model that has emerged from the line of research initiated by Bock and colleagues, and the model that currently stands as the most-widely accepted as the state-of-the-art in subject-verb agreement production, is
the Marking and Morphing model (Eberhard et al., 2005). The assumptions behind this model are very much in line with linguistic theories that describe subject-verb agreement as an asymmetrical syntactic relationship involving controllers and targets; number information is computed on the subject and then copied onto the verb. Although testing this model is not a main focus of the thesis here, it will be helpful to examine the model in some detail in order to understand how a syntactocentric approach allows restricted semantic information to influence agreement choices, as well as the restrictions on the types of syntactic information that can interfere with agreement production.

Following the two-stage model of grammatical encoding described above, the model describes agreement production as a two-stage process. The first is MARKING, which occurs during the functional processing sub-stage of grammatical encoding. MARKING is a process in which nominal referents—the controllers—are “marked” for message-based conceptual features that are relevant to agreement morphology (notional number, notional gender, and person features). Marking supposedly “constrains the syntax” (Eberhard et al., 2005, p. 538) by marking the conceptual value of agreement features on the abstract subject grammatical function of the sentence (i.e., conceptual information is translated into syntactic features which then inform syntactic processes). This specification of conceptual number is a separate process from the specification of grammatical number via lexical activation of number features. For example, in the case of “[The label on the bottles] are peeling off,” the subject noun phrase The label on the bottles would be

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18 The model has not been fully specified in terms of gender and person agreement. Although the Marking & Morphing model is designed to account for both grammatical number agreement relations (i.e., subject-verb agreement, determiner-noun-adjective agreement) and discourse number agreement (i.e., between anaphors and pronouns, as in, “Mary-sg ate lunch, and then she-sg went back to work,”) in this thesis, the model will be discussed only in terms of subject-verb number agreement.

19 One may assume that conceptual values of person, number, and gender are marked on other grammatical functions as well (and this would be necessary for languages that have object agreement), but the model does not explicitly state this.
semantically marked as plural (because conceptually, there are many labels on many bottles), even though the lexical item *label* in the subject head noun slot is syntactically singular.

This is the only point during which semantic information may contribute to the syntactic expression of agreement. In this model, the contribution of semantics is constrained to the conceptual representation of the subject noun phrase referent. It is here that semantic information about referent number can sometimes drive a speaker’s production of subject-verb agreement, as in *The committee are voting tomorrow* and *Forty minutes is too long to wait.* Once that conceptual value of the subject has entered into the production process, all other variables are syntactic in nature. No other semantic information—neither the conceptual representation of local nouns, nor the conceptual relationship between the subject and other nominals—can disrupt the agreement production process.

The second stage of agreement production in this model is MORPHING, during which verbs—the targets—take a specific form to correspond to both the notional and grammatical agreement features of the controllers. MORPHING occurs during the second sub-stage of grammatical encoding, positional processing. It is here that the grammatical specifications of the lexical items in the subject NP play a role and verbs take a specific grammatical form to correspond to the agreement features defined by semantic and syntactic information of the controllers. There are two parts to the Morphing stage. First, the semantic features that have been marked on the subject noun phrase are reconciled with the grammatical features of the lexical items in the subject noun phrase. During this process, marked number features of local nouns may sometimes be “passed up” through the syntactic structure to the subject noun phrase node, overriding the subject head noun number value. This process of reconciling semantic and grammatical information results in a final number value for the subject noun phrase. It is during this process that most agreement mismatches and/or errors occur in that this is when the incorrect number value of the subject noun phrase is calculated. During the second part of the morphing stage, that final number value of the subject noun phrase is
copied over to the verb. (It is presumably after this second part of morphing that the morphological form of the verb is accessed.)

The morphing process is what characterizes this model of agreement as being syntactocentric. While semantic information about the subject noun phrase referent serves as input to the grammatical encoding of agreement, that semantic information is weakened by the syntactic specification of number of lexical items in modifiers of the subject noun phrase. Furthermore, the copying of number features from subject to verb is a strictly syntactic process, that is, the verb takes its features from another element in the sentence as defined by a syntactic, and not semantic, relationship.

An illustration of the theoretical architecture of the Marking and Morphing model (Eberhard et al., 2005) is given in Figure 2.5.
Figure 2.5. The Marking and Morphing model. An illustration of the procedures responsible for subject-verb agreement production (from Eberhard et al., 2005, p. 538). This particular figure illustrates the production of agreement with a semantically plural subject referent (and is ambiguous for whether or not the subject noun phrase is grammatically plural, as in *The players*, or grammatically singular but semantically plural, as in *The team*). MARKING (indicated by the dotted line) is illustrated during the structural procedures of the functional processing level (here, labeled “Functional Assembly”). During the lexical procedures of the functional processing level, the lexical items corresponding to the subject are retrieved from the lexicon; that information is passed down to the positional processing level (here, labeled “Structural Integration”). At the positional processing level, MORPHING occurs, integrating the semantic information marked on the subject noun phrase and the grammatical information retrieved with the lexical items for the subject noun phrase. Agreement errors are assumed to result from interference with this integration process (e.g., when grammatical features of local nouns override those of the subject head noun). Once this integration occurs, the final number value is passed up through the structural representation to the S node and then down to the verb through the VP node.

A simple quantitative version of the model (Eberhard et al., 2005), in which conceptual number of the subject referent and grammatical number of subject head and local nouns are
weighted for their relative contribution to the probability of producing singular or plural agreement is presented in Figure 2.6.

![Diagram of the Marking and Morphing model](image.png)

**Figure 2.6.** A quantitative version of the Marking and Morphing model. Sources of singular and plural (SAP) number values of the subject noun phrase are illustrated. The solid arrow leading directly to the Subject NP reflects the greater weight of the Lexical specification value as compared to other sources. The final number value of the subject NP is then copied onto the verb (from Eberhard et al., 2005).

The quantitative version allows the Marking and Morphing Model to be framed in terms of the activation of features, in which features that are more highly activated are more likely to interfere with agreement; activation is then constrained by syntactic position and feature type (grammatical or semantic). The quantitative specifications for this model were based upon a survey of experimental findings, and were tested against the experimental results of Bock, Eberhard, and Cutting (2004); no corpus data were used to evaluate the model.

In summary, the Marking and Morphing model provides an explicit syntactocentric account of agreement production. Contributing semantic information is restricted to that of the subject noun phrase referent; neither the semantic features of other nouns nor the semantic relationship between the subject and other arguments to the verb matter. Contributing grammatical information is
restricted to the grammatical features of nouns within the subject noun phrase; nouns outside of the subject noun phrase are excluded from the grammatical encoding of agreement.

In sum, a fair amount of the experimental work in agreement production supports a syntactocentric approach as embodied by the Marking and Morphing model. These studies have succeeded in demonstrating that the type of information that interferes with and constrains subject-verb agreement production is primarily syntactic in nature, and furthermore, that the contribution of semantics is limited to the conceptual number of the subject referent. In essence, these studies have apparently shown that there is no interaction between semantics and syntax in agreement production. But that may not be the case, given that the agreement patterns and sentence types examined experimentally comprise only a subset of those in spontaneous and communicative language use. Furthermore, given the substantial amount of research in language comprehension that supports a dynamic, interactive approach to language processing, it is worth considering the evidence for an interactive account of agreement in language production. The next section reviews evidence counter to the syntactocentric approach.

2.2.2 Interactive approaches to agreement production

The syntactocentric approach, rooted in formal syntactic theories in the Chomskyan tradition and psycholinguistic experimental work discussed above, starts from the assumption that agreement is a syntactic process, and attempts to explain agreement variation within that view. Early work in the interactive approach on the other hand, was motivated from observations of agreement variation illustrated by the Pollard and Sag (1994) examples (e.g., the hash browns at table nine and Unleashed dogs examples 1-2 in Chapter 1) as well as typological observations that agreement patterns may vary widely across languages (see discussion in Vigliocco et al., 1995, pp. 188-190; Vigliocco, Butterworth, & Garrett, 1996, Section 2). Setting aside the wide variety of agreement relationships
beyond that of subjects and verbs (e.g., determiner-noun agreement, noun-adjective agreement, anaphor-pronoun agreement, etc.), a typological survey of subject-verb agreement suggests that syntax cannot be the only source of information used during agreement production; semantics can also inform agreement (Corbett, 2006, Section 5.4; see also Section 5.5.1). We have already seen examples in English where the verb appears to reflect semantic properties of the subject referent. Consider the following examples of agreement mismatch with respect to the person feature in Tamil. Example (20) illustrates an appropriate greeting when answering the phone. Example (21) shows an example of a mother’s speech to her child. In each case the lexical subject is in third person, but the verb features are first person, reflecting the fact that the subject refers to the speaker.

20. Mohan peecur-ee
   Mohan (man’s name) speak.PRESENT-1SG
   ‘Mohan speaking’ (literally ‘Mohan am speaking’)

21. ammaa edo paNNaa por-ee
   mother something do go. PRESENT-1SG
   ‘Mother is going to do something’ (literally ‘Mother am going to do something’)
   Tamil (Bhuvana Narasimhan, cited in Corbett 2006, p. 161)

The fact that such agreement variation occurs in utterances that speakers consider acceptable and not just in speech errors signals that agreement cannot simply be a feature-copy operation, where grammatical values of the subject are copied onto the verb. Furthermore, it cannot be the case that the semantic (or conceptual) features of the subject are always a lesser force in determining the feature value of the subject. In particular contexts, the conceptual information is the major determinant of agreement.

Linguistic theories that aim to explain such variation without resorting to syntactic mechanisms include Head-driven Phrase Structure Grammar (HPSG) and Sign-Based Construction Grammar (SBCG) frameworks (Michaelis, 2013; Pollard & Sag, 1994; Sag, 2012; Wechsler & Zlatic, 2003), and the Discourse-Linking Theory (Barlow, 1992). Subject-verb agreement is treated in each
of these approaches as a bi-directional relationship in which both the subject and the verb can express partial information (including grammatical, semantic, discourse, morphological information) about the subject referent. Unified, the agreement features of the subject and those of the verb provide a specification of the subject discourse referent (Barlow, 1992) or referential index (Pollard & Sag, 1994; Wechsler & Zlatic, 2003).

*An interactive model of agreement production.* In the spirit of linguistic work showing the various types of information involved in agreement, the Maximal Input/Unification Model (Franck et al., 2002; Vigliocco, Butterworth, & Garrett, 1996) of agreement attempted to move beyond syntactic constraints to integrate semantic information into the agreement production process. The stages of grammatical encoding assumed by this model are essentially no different than in the Marking and Morphing model, but the amount of semantic information that can contribute to agreement and the points at which it may contribute are unrestricted. In this model, early marking of notional number during functional processing occurs not just on the subject, but also on the verb. During the later positional processing stage of grammatical encoding, agreement is not encoded through a morphing (copying) procedure. Instead, during the construction of the syntactic structure of the utterance, a unification procedure occurs during which the number features of both the subject and the verb are reconciled at the highest level of the hierarchical syntactic structure. In this way, the model allows for various types of information to contribute to agreement; different types of information (e.g., syntactic and semantic) have different degrees of influence across languages (Vigliocco et al., 1995).20

The model is illustrated in Figure 2.7.

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20 Along with syntactic and semantic information, morphophonological information is also assumed to be able to interfere with agreement production; see Vigliocco and Hartsuiker (2002) for an overview of studies concerning morphophonological effects on agreement production.
Figure 2.7. Agreement in the Unification model (from Vigliocco, Butterworth, & Garrett, 1996). Number features from the conceptual representation are independently marked on nominal and verbal nodes, and then passed up to the S-node, where a unification procedure reconciles the number values. (The local noun “blanket” should presumably be plural “blankets”; this figure appears as in the original publication).

Empirical support for the Maximal Input/Unification model comes from cross-linguistic differences dependent upon the richness of verbal morphology. Languages with rich verb inflection systems, such as Italian, Spanish, French and Dutch, tend to show stronger effects of conceptual information than a morphologically impoverished language such as English (Vigliocco, Hartsuiker, Jarema, & Kolk, 1996). In other words, in languages where such information is not specified on the verb, there may be no need for the verb to access such information, and so the conceptual number feature is not usually retrieved from the discourse model during the production of the verb. In languages where the verb must encode agreement information, the verb encoding process has direct access to relevant information in the discourse model (although the authors note that exactly why
the structural differences between languages with regard to morphological richness would lead to such processing differences is unclear; see Vigliocco, Hartsuiker, Jarema, & Kolk, 1996, pp. 435). These cross-linguistic differences could not be accounted for by a feature-copying model (Vigliocco, Butterworth & Garrett, 1996, p. 290), presumably because such a model would predict that any conceptual effects would be marked on the subject noun phrase, and therefore should be the same for all languages.

Beyond these cross-linguistic studies, there is not much experimental evidence for agreement as a unification, rather than syntactic feature-copy, process. And although several studies of agreement have framed their results within the context of this model (Vigliocco et al., 1995; Vigliocco, Butterworth, & Garrett, 1996; Vigliocco, Hartsuiker, Jarema, & Kolk, 1996; Vigliocco & Franck, 2001; Franck et al., 2002), those results may actually be interpretable within a syntactocentric approach (see discussion in Franck et al., 2002, p. 393). As discussed above, influences from the conceptual representation of the subject referent itself can usually be accounted for in a syntactocentric model. The flaw of the syntactocentric approach with respect to this issue is that it currently assumes that semantic information will always be a weaker contributor than syntactic information, and therefore does not predict that semantic information will reliably determine agreement in particular contexts (as in cases of reference transfer, as in The hash browns at table nine is getting angry, or grammatically plural but conceptually singular subjects, as in Unleashed dogs on city sidewalks threatens the health of citizens). But if the syntactocentric Marking and Morphing model makes explicit exactly which subject referents should allow an increased contribution of their semantic/conceptual number to subject-verb agreement, without allowing other types of semantic information to interfere with agreement production mechanisms, then it would be able to account for the data that the Maximal Input/Unificat model is based upon.
Stronger evidence in support of an interactive, dynamic account of agreement comes from studies that examine whether semantic properties beyond number can affect the nature of agreement production. These studies recognize that distinguishing between syntactocentric and interactive accounts does not depend upon whether the semantic representation of the subject referent determines subject-verb agreement, but rather, whether or not there are interactions between semantic and syntactic properties of the utterance in determining agreement production. An interactive account predicts that semantic properties will affect syntactic processes, for example by promoting or inhibiting the influence of other grammatical features. As described by Haskell and MacDonald (2003, p. 762) in a study of the effects of morphological features on agreement production, “[I]n cases where one or more factors strongly promote a certain alternative (say, the singular form), then a weaker factor which promotes the plural form will have little effect. If, however, other factors are evenly divided in which form they promote, then even a weak factor can play a decisive role.” 21 Consider, for example, subject-agreement production in an utterance in which a speaker produces a singular subject and a plural post-verbal nominal. If the utterance is a transitive construction (e.g., [The animal in the cage]-SG…(FRIGHTEN) …[birds]-PL), the singular subject is likely to be more activated during agreement production, and the plural object will have only a weak interference effect (presumably resulting in singular agreement, e.g., frightens). If, however, the utterance is an equative construction (e.g., [The animal in the cage]-SG… (BE) …[birds]-PL), then it is possible that both the subject and post-verbal equative nominal will be activated (as they both have the same referent in the message), leading the post-verbal nominal to play more of a “decisive role” (resulting in a greater likelihood of producing plural agreement, e.g., are).

21 See also Franck et al. (2008), Hartsuiker, Schriefers, Bock, and Kikstra, (2003), and Vigliocco et al., (1995) for investigations of morphophonological effects on subject-verb agreement production.
One study supporting an interactive account of agreement production is that of Thornton and MacDonald (2003), which demonstrated an effect of plausibility on agreement by manipulating the semantic relationship between the verb (e.g., praised or played) and the head and local nouns in the subject NP (e.g., The album by the composers….) Verbs that could take the local noun as a plausible passive subject, (e.g., composers can be praised but not played) were more likely to show attraction effects than those that were not (e.g., The album by the composers were praised was more likely than The album by the composers were played.) In another study, Solomon and Pearlmutter (2004) demonstrated an increase in likelihood of attraction effects when local nouns are more tightly integrated, semantically, to the head noun (e.g., flowers is more likely to cause plural agreement in The picture of the flowers than in The picture by the flowers.)

Each of these studies demonstrates an interaction between different sources of information during agreement production. The semantic relationships between nouns within the subject noun phrase do not directly contribute to agreement by providing semantic number information. Rather, they affect syntactic processing of agreement by promoting the effect of the grammatically plural local nouns. This type of interference could occur not during the early, functional processing sub-stage of grammatical encoding, when semantic information contributes at a lexical level (i.e., when individual lemmas and individual grammatical functions are specified for semantic number). This is because these semantic relationships do not change the construal of the subject referent. They do not cause the subject role to be “marked” as plural. The interference must then occur during the

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22 Subject noun phrases in which a local plural noun is highly integrated with a singular subject head noun (e.g., The picture of the flowers) differ from distributive noun phrases (e.g., The label on the bottles) in that the former does not depict a multitude. In other words, a distributive noun phrase like The label on the bottles depicts multiple instances of the item named by the head noun—multiple labels—whereas a semantically integrated noun phrase depicts a single item named by the subject head noun, in this case, a single picture (which happens to depict multiple flowers.) Thus, the semantics of the integrated subject noun phrase result in an increase in agreement error through increasing the attraction effects of the local noun, not by promoting a plural construal of the subject referent.
later, positional-processing sub-stage, when all relevant contributors to agreement are joined in a structural relationship that defines the domain of subject-verb agreement. In other words, the semantic properties of integration or of plausibility promote the influence of the grammatical number of a local noun that would not otherwise have such an influence.

This more recent line of research in the interactive approach to agreement production, in which various semantic constraints on syntactic forms are investigated, is the necessary course in distinguishing between the syntactocentric and interactive accounts of agreement production and grammatical encoding in general. Yet even in these studies, the focus of the research has remained almost entirely on variables within the subject noun phrase. Because of this limitation, most experimental studies supporting an interactive account are still vulnerable to syntactocentric counterarguments claiming that any effects of semantic features are actually interfering with the construction of the subject representation, rather than interfering with the syntactic production of agreement (e.g., Brehm & Bock’s 2013 response to Solomon & Pearlmutter, 2004). For example, it may be argued that the plausibility of a local noun as the subject referent for a verb does not allow its grammatical features to interfere during agreement production, but that the local noun’s plausibility as subject causes speakers to actually assign it the subject grammatical function. Taking the next step in agreement production research requires considering the elements outside of the subject noun phrase. This consideration includes looking at nominals other than those in the subject, and considering the effects of constructional semantics of the full message conveyed by the utterance.

2.3 Summary of current research and contributions of the thesis

In sum, the syntactocentric and interactive approaches to subject-verb agreement production both attempt to explain variation in agreement patterns, and they both incorporate syntactic and
semantic influences into their proposed mechanisms, but they do so in very different ways. The syntactocentric approach proposes that variation in agreement arises from two sources: syntactic features within the subject noun phrase (whose influence is determined by their structural distance from the subject head noun), and a limited influence of the conceptual representation of the subject referent. When the conceptual number of the subject referent that serves as input during the functional processing stage conflicts with its grammatical number, speakers occasionally produce subject-verb agreement reflecting the conceptual number value. Crucially, no other semantic or conceptual information may contribute to agreement—not the semantic features of other nouns or the context of the utterance in which subject-verb agreement is produced.

The interactive approach, on the other hand, in theory allows any number of information types to contribute to agreement production, and in particular allows a strong influence of conceptual and semantic information. Conceptual information may directly determine the form of the verb, and the semantic relationship between the subject head noun and local nouns as defined in part by the constructional context can allow the grammatical features of those local nouns to have a lesser or greater influence on agreement production. The interactive approach does not claim that agreement is semantically driven, but that semantics and syntax interact in determining the final agreement marking on the verb. In other words, semantic information is not limited to providing input to the subject noun phrase at the functional processing stage. Semantic information can permeate the positional processing level, promoting or inhibiting the influence of various nouns during the integration of all elements into a hierarchical structure, where subject-verb agreement is finally calculated.

These two approaches are summarized in Figure 2.8:
Figure 2.8. A comparison of the syntactocentric and interactive approaches. In the syntactocentric approach, the contributions of conceptual information are limited to activating the lemma of the subject and marking number on the subject grammatical function. In the interactive approach, conceptual information can reach down into the positional processing substage and contribute to agreement by boosting the effects of other nouns within the utterance, regardless of those nouns’ syntactic positions.

Although models of agreement production have emerged from both of these approaches, neither approach has been able to fully account for the full range of agreement patterns seen in spontaneous language use. In particular, the tokens of interest presented in Chapter 1 (repeated here as examples (22-25) for the readers’ convenience) still need to be explained:

22. One thing I thought about the other day-SG were PL batteries PL.
23. The only thing-SG we’ve taken back recently are-PL plants-PL.
24. The other one-SG is…are-PL the Saturns-PL.
25. Repeating patterns-PL is-SG what you have to check for when you buy your paper-SG.

These examples provide a particularly strong challenge to the syntactocentric approach, because the agreement mismatch cannot be explained in terms of interference from grammatical features of local nouns. Nor is it entirely clear that the conceptual representation of the subject drives the agreement choice, because, as noted in Chapter 1, changing the verb forms to matching grammatical forms does not seem to convey a different conceptualization of the subject referent.
The interactive approach appears more likely to handle such data, if it can be shown that the agreement mismatch consistently results from the interaction of syntactic and semantic factors. The hypothesis that will be explored here is that the interaction of three particular features of these utterances predicts the agreement mismatch. The grammatical form of the post-verbal noun contributes to agreement, but this contribution is strengthened in the context of an equative construction, and also when the subject head noun is abstract and less imageable (as compared to that post-verbal noun). In the following chapters, results will be presented from a corpus study of subject-verb agreement patterns produced in spontaneous, conversational utterances, as well as from three production experiments in which agreement patterns were elicited in controlled, but somewhat conversational, settings. The final chapter of this thesis will revisit the implications for linguistic descriptions of agreement, and for agreement production and grammatical encoding in general.
Chapter 3: A Corpus Study of Agreement Mismatch

In the past two decades, the psycholinguistic study of subject-verb agreement has played a strong role in our understanding of the grammatical encoding stage of production. Much of this experimental work makes reference to observations of naturally occurring errors, but does not, for the most part, draw on the quantitative, distributional evidence that is derivable from spoken language corpora (notable exceptions are Bock et al., 2006; Haskell, Thornton, & MacDonald, 2010; and Lorimor, 2007). Relatively few psycholinguistic experiments have been based upon corpus studies of agreement-mismatch patterns in spontaneous, communicative contexts (but see Lorimor, 2007, for experimental studies based on a large-scale corpus investigation of agreement patterns with conjoined noun phrases). The corpus study presented in this chapter aims to serve as a foundation for the experiments in the following chapters.

This study considers three features (equative construction, a post-verbal nominal that does not match the subject in number, and an abstract subject head noun) as exemplified in the utterance, *One thing I thought about the other day were batteries*. It is predicted that speakers will be most likely to produce agreement mismatch when using a construction that equates the subject referent with a post-verbal nominal, and when the grammatical number of that nominal does not match that of the subject. Furthermore, it may be that the relative abstractness of the subject and the mismatching nominal interact, with more abstract subjects allowing an increased level of influence from the mismatching nominals. If these features contribute to the production of agreement mismatch, and such utterances are not merely random errors, then there should be a significant correlation between the presence of these features and the production of agreement mismatch in spontaneous language use.
3.1 Agreement mismatch: speech errors or linguistic patterns?

The agreement mismatch pattern of interest to this study is exemplified by the attested examples of subject-verb agreement mismatch discussed in Chapter 1, and repeated here as examples (26-28):

26. The only thing-sg we’ve taken back recently are-pl plants.
27. The other one-sg is…are-pl the Saturns.
28. Repeating patterns-pl is-sg what you have to check for when you buy your paper.

In each of these cases, the speaker makes use of an equative construction and produces a verb that does not agree with the grammatical number of the subject, but instead with the post-verbal nominal. This pattern has been observed in spontaneous language use, and intuitively, the production of agreement mismatch in these cases makes sense (as discussed in Chapter 1, Section 1.1). A brief review of non-subject agreement patterns in English and other languages also suggests that this agreement mismatch pattern is not a random occurrence.

Agreement with a nominal other than the subject in languages that have obligatory subject agreement is not unheard of. Already in English, there are cases in which speakers regularly produce non-canonical agreement. In locative inversion constructions (e.g., In the corner was-SG a lamp-SG / In the corner were-PL several lamps-PL), inversion constructions with the copula BE (e.g., Conspicuously absent was-SG Mary-SG / Conspicuously absent were-PL the boys-PL) and THERE-existential constructions (e.g., There are-PL many prime numbers-PL / There is-SG one even prime number-SG) the verb regularly agrees with a post-verbal nominal, and in some analyses may be considered non-subject agreement (Bresnan, 1994). According to Bresnan (1994), these agreement patterns in English are only permitted under

23 There is, of course, debate regarding whether or not the post-verbal NP may, in fact, be the subject in these utterances. See Breivik (1981) for a discussion of subject in THERE-existential constructions; Insua and Martinez (2003), in which the post-verbal nominal in THERE-existential constructions is treated as the “logical” or “notional” subject; and Birner (1994) p. 252, fn 20, for an example of the difficulty in
certain structural, semantic, and discourse constraints (e.g., the absence of a nominal in subject position, location predicated of a theme, presentational focus in which the post-verbal nominal is a referent is (re)introduced as part of the scene depicted by the locative subject), suggesting that various sources of information interact in determining the speaker’s production of agreement forms. Non-subject agreement has also been documented in languages other than English where subject agreement is obligatory, demonstrating that agreement can in fact make reference to levels of structure other than syntax. For example, in Northern Ostyak (a Uralic language spoken in Russia), subject agreement is obligatory, but verbs show agreement with primary objects (which align with secondary topics) as well (Dalrymple & Nikolaeva 2005; also see Nikolaeva, 1999). In Maithili (Indo-Aryan, spoken in India), however, non-subject agreement occurs with secondary topics regardless of syntactic role (Dalrymple & Nikolaeva, 2005).

Beyond the general phenomenon of non-subject agreement, is there evidence for the regular occurrence of the agreement mismatch exemplified in (26-28), in which the verb agreement features in an equative construction reflect the features of a post-verbal nominal? Two patterns described by Corbett (2006) are relevant here. The first is back agreement, a pattern in which the copula agrees with the noun phrase in the predicate (Corbett, 2006, p. 63-4). The phenomenon of back agreement is illustrated by examples (29-31) in Czech (Vanek, 1970, cited in Corbett, 2006), where the copula takes plural agreement if the predicate nominal expresses a cardinality of ‘four’ or less, but takes singular if it refers to a cardinality of ‘five’ or above.

29. jedna a dvě jsou tři
   one and two be-3PL.three
   ‘one and two are three’

determining the subject of English inversion constructions. See also McCloskey (1997) for an overview of the notion of subject in Chomskyan grammars.
Establishing the existence of back agreement across languages has, however, been problematic. While some languages are claimed to show examples of back agreement (e.g., Czech: Vanek, 1970, cited in Corbett, 2006; Russian: Corbett, 1986, pp. 1019-1020; Crockett, 1976, pp. 406-407; Padučeva & Uspenskij, 1997; Slavic: Corbett, 2010; Tsakhur: Kibrik 1999, cited in Corbett, 2006) establishing the conditions under which back agreement occurs can be difficult if, for example, a language commonly exhibits predicate-subject word order (in which case the mere presence of copula agreeing with a post-verbal nominal is not sufficient to establish “back agreement”), or if the nominal which appears to control agreement cannot be established as being part of the predicate (Corbett 2006, p. 63; Corbett 2010, p. 45 for discussion).

In the second pattern relevant to non-subject agreement, dubbed “pancake sentences” by Corbett (2006, p. 150), agreement targets exhibit default forms rather than agreeing with their controllers, signaling that additional information is available. The term “pancake sentences” comes from this example (32) in Norwegian:

32. Pannekake-r er god-t
    pancake-pl cop good-n.sg
    ‘Pancakes is good.’ (‘Eating pancakes is good.’)
    (Faarlund, 1977, cited in Corbett 2006)

Rather than reflecting grammatical agreement, the use of the singular adjective here indicates that it is not pancakes, but “what goes with pancakes (the eating of them)” that is being predicated upon. In this respect, pancake sentences are similar to examples of Pollard and Sag's (1994, p. 70)
“singular plurals” (conceptually singular plural noun phrases, e.g., *Unleashed dogs on city sidewalks threatens the health and welfare of law abiding citizens*) and reference transfer (e.g., *The hash browns at table nine is getting angry*) discussed by Pollard and Sag (1994, p. 85; above, in Chapter 1 Section 1.1) in which case the verb’s agreement features reflect the discourse referent (e.g., the phenomenon of unleashed dogs rather than the dogs themselves in the first example, the customer, not the hash browns, in the second). Unlike cases of reference transfer, singular plurals, and “pancake” sentences, however, changing the verb in sentences (26-28) does not indicate a different referent for the subject noun phrase. For example, changing the verb from *are* to *is* in (26) above, resulting in, *The only thing we’ve taken back recently IS plants* does not change the propositional content of the utterance.24

In summary, there is evidence to suggest that the agreement mismatch exhibited in (26-28) is not simply the result of random speech errors, and that agreement with post-verbal nominals in equative constructions is not an unexpected occurrence. However, this pattern differs from the examples previously discussed. These cases of agreement mismatch cannot be fully explained in terms of “semantic” agreement (as with reference transfer, singular plurals and “pancake” sentences). Furthermore, they differ from locative inversions and **there**-existential constructions (where agreement with the post-verbal nominal can be explained by the lack of nominal elements in the preverbal position—what Bresnan (1994) analyzes as the subject). Before addressing psycholinguistic accounts of how speakers might produce such patterns through experimental investigation, it is therefore important to establish, beyond native speaker intuition, that the features of (1) an equative construction, (2) an abstract subject head noun, and (3) a post-verbal nominal

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24 While a change in verb agreement form does not change the propositional content, it is possible that it reflects a subtle change in the construal of the subject referent as either a single collective group, or as an aggregate of multiple individuals (see Pollard & Sag, 1994, pp. 70-72, and Talmy, 2006, Sections 2.2 and 2.11 for discussion). This remains an issue for future research.
number that does not match the subject for grammatical number should correlate with the production of agreement mismatch. This corpus study aims to do just that.

### 3.2 Methods

#### 3.3.1 Data collection

The data for this study were collected from the Treebank portion of the Switchboard corpus, which contains 400 of the 2400 conversations in the full version of the corpus (Godfrey et al., 1992). Ideally, the data set would comprise all tokens that could potentially display agreement mismatch in terms of number, that is, all 3rd person present tense forms of regular verbs, as well as 3rd person past forms of BE\textsuperscript{25}. Because the version of the corpus used was not annotated for tense, search strings had to be specified for particular lexical items. Collected tokens were therefore constrained to those containing the 3rd person present forms of the verbs BE \textit{(is, are)}, DO \textit{(does, do)}, and HAVE \textit{(has, have)}, along with the 3rd person past forms of BE \textit{(was, were)} in the main clause of the sentence. This was determined to be the most efficient way of collecting as many tokens as possible which would contain verbs displaying grammatical number, meaning that they could potentially display agreement mismatch (the alternative would be to either choose an arbitrary set of lexical verbs—which could be biased—and to collect their present tense forms, or to sort through all verbs in the entire corpus, which would be unwieldy.)

Collected tokens were hand-sorted. Tokens were excluded from the data set if they exhibited the following properties:

\textsuperscript{25} 1st and 2nd person present tense verbs in English are ambiguous for number (e.g., I run, we run; you-SG run, you-PL run). Although 1st person present tense forms of BE are not ambiguous, only 3rd person forms were collected for the sake of consistency among verb types.
• 1st or 2nd person subjects (e.g., I/you/we do, I was, you/we are, we/you were): These forms (do, was, were, are) are identical to 3rd person forms, and as a result, were collected by the initial search strings and needed to be removed from the data set.

• There-existential constructions (e.g., There is, There are): There-existential constructions potentially displaying non-subject agreement patterns would have inappropriately biased results in favor of the hypotheses being tested in this study (i.e., the copula verb often agrees with the post-verbal nominal). Theoretical linguistic explanations for the THERE-existential construction already exist, but these accounts do not extend to the agreement mismatch pattern of interest to this thesis.

• Incomplete utterances: Tokens in which the main clause was not completed were omitted because they could not be annotated for the legitimate presence or absence of a post-verbal nominal, and therefore post-verbal nominal number could not be evaluated.

The total of the remaining utterances was 4694. Of these, 84 (approx. 2%) contained agreement mismatch, whereas 4610 (approx. 98%) did not. Although the proportion of tokens displaying mismatch is small, it is similar to rates of agreement errors in some elicited production experimental studies (e.g., Bock & Miller, 1991; Bock, Nicol, & Cutting, 1999; Eberhard, 1997), and was sufficient for statistical analysis.

3.3.3 Scoring

Each token was hand-annotated for agreement mismatch as well as for the three features that allow us to investigate the hypothesis that agreement mismatch occurs in a specific constructional context. Those features were: an abstract subject head noun; the presence of a copula as the main verb; and a post-verbal nominal whose number did not match that of the subject head
noun. In addition, tokens were annotated for the presence of a phrasal or clausal subject modifier. The inclusion of this feature in the analysis was to control for the influence of local nouns (i.e., attraction effects, as in *The baby-SG on the blankets-PL are-PL…*) or for any effects on the construal of the subject noun phrase that a modifier might have (e.g., an effect of distributive construal, as in *The label on the bottles are…*). All tokens were annotated for the presence (Y) or absence (N) of the features of interest.

The scoring criteria were as follows:

- **Abstract subject head noun.** Preliminary investigation of the data set suggested that a broad range of semantically light lexical items (e.g., abstract nouns including solution, issue, problem, feeling, difference) may be correlated with agreement mismatch. However, in the interest of defining a reliable, replicable scoring criterion, this category was limited to the abstract lexical items thing and one. Tokens with subject head nouns thing(s) or one(s) were annotated as displaying this feature; all other tokens were annotated as lacking this feature. Examples of an utterance with an abstract subject head noun and one without are given in (33-34).

  33. Y=Probably the biggest thing we've got going now is the robberies.
  34. N=The only problem with these are that they are very expensive.

- **Copula main verb.** The presence of a copula main verb was taken to be a hallmark for the equative construction. Because the equative construction itself is defined by several linguistic features (e.g., a copula, post-verbal nominal) and a communicative function (i.e., to equate two NPs or other constituents: Birner, Kaplan & Ward, 2007), annotating for the equative construction directly would have conflated several features of interest. Annotation of the copula separate from the presence of a post-verbal nominal also allows us to see if agreement mismatch arises simply from use of the copula and not the actual use of the equative construction itself. For example, if there is a main effect of the use of a copula, it could be the case that mismatch arises anytime the
copula is used (e.g., even with an adjectival predicate, as in *One thing I thought about BE good*, or an auxiliary usage, as in *One person I thought about BE leaving tomorrow.*) If the interaction of the copula with a post-verbal nominal is significant in predicting agreement mismatch, then we have evidence for a constructional effect. This will be discussed further in Section 3.4. Examples (35-38) illustrate utterances coded for the copula main verb (Y) or lack thereof (N).

35. Y=One of the quick examples *is* the Aborigines.
36. N=A friend from Germany *was visiting* in March.
37. N=The cats *do* it in there.
38. N=And uh, men, uh, a lot of them *have, uh, come around* and *have seen* the error of their ways

• *Post-verbal nominal number match with the subject.* All tokens were annotated for the presence or absence of a post-verbal nominal argument with a number feature differing from that of the grammatical number of the subject. Tokens annotated as having this feature contained post-verbal nominal elements with grammatically singular or plural forms that differed from the number value of the subject. In cases where the post-verbal nominal was paired with a subject with a quantifier head, the number of the post-verbal nominal was compared to that of the noun embedded in the subject NP. For example, in the utterance *Most of my things are dust collectors*, the plural *collectors* was compared to the plural *things* and not to the quantifier *Most*. All other tokens (post-verbal nominals matching in number, nominals embedded in prepositional phrases, tokens without post-verbal nominals) were annotated as not displaying this feature. Examples are shown in (39-44).

39. Y= *(PL-SG)* *My parents-PL have a treadmill-SG.*
40. Y= *(PL-SG)* *Most of my CDs-PL are classical music-SG.*

26 The feature annotated was the grammatical number of the post-verbal nominal. It should be kept in mind that semantic and grammatical number often coincide (e.g., if a noun has a plural grammatical number, it is often semantically plural as well, as in *cats or dogs*), although it is not always the case (e.g., *scissors* is grammatically plural but semantically refers to a singular item). Semantic number was not independently coded in this study.
41. N = (PL-PL) **Most of my things**-PL are **dust collectors**-PL.
42. N = (PL-PL) Good grief, **these**-PL are well-fed **cows**-PL.
43. N = She teaches **at a preschool**.
44. N = They do.

- **Subject modifiers.** All tokens in which the subject head noun was modified by a phrasal or clausal modifier were annotated as having this feature. All other tokens marked as not having this feature included those with unmodified subjects, other types of modification (e.g., adjectival), and those with quantifier head nouns (e.g., *all of X, most of X*) because the local noun often determines agreement in those cases. Examples are given in (45-50).

45. Y = Everyone **on the boat** was catching snapper except for guess who.
46. Y = Everything **we buy** is paid for.
47. N = The Constitution doesn’t apply. (no subject modifier)
48. N = My **current** one has been most successful.
49. N = **Most of the family** is in West Virginia.
50. N = **Most of the guys** were all in one class.

3.3.3 Analysis

A multiple logistic regression analysis was performed using R statistical software, with agreement mismatch as the dependent variable. Main variables of interest included lexical subject type (*abstract* vs. *concrete noun*), post-verbal nominal number match with subject number (*match* vs. *nonmatch*), copula verb (*present* vs. *absent*), and an interaction between construction type and post-verbal nominal number. In addition, one control variable was added: the presence of a phrasal or clausal modifier. A fair amount of psycholinguistic experimental research has demonstrated that subject modifiers can contribute to agreement mismatch, most reliably through the presence of a local noun that causes attraction (e.g., Barker et al., 2001; Bock & Cutting, 1992; Bock & Miller, 1991; Bock & Eberhard, 1993; Eberhard, 1997; Vigliocco & Nicol, 1998). Local nouns may also manipulate the semantic construal of the subject referent (i.e., by presenting a distributive construal, e.g., *The label on the bottles,*
The picture on the postcards: Bock et al., 2001; Bock & Eberhard, 1993; Eberhard, 1997 Humphreys & Bock, 2005). This variable was included in the analysis in order to determine whether or not the main variables of interest had a significant effect on agreement above and beyond the well-established effects of features of the subject noun phrase (i.e., attraction effects and effects of distributive construal).

3.4 Results

Results are presented in Table 3.1.

**Table 3.1.** Experiment 1. Analysis of Maximum Likelihood Estimates.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>DF</th>
<th>Estimate</th>
<th>z value</th>
<th>Standard Error</th>
<th>Pr &gt; ChiSq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1</td>
<td>-4.8213</td>
<td>-16.827</td>
<td>0.2865</td>
<td>&lt;2e-16***</td>
</tr>
<tr>
<td>Abstract subject (thing(s) or one(s))</td>
<td>1</td>
<td>-0.7449</td>
<td>-1.849</td>
<td>0.4028</td>
<td>0.0644</td>
</tr>
<tr>
<td>Subject modifier (PP or RC)</td>
<td>1</td>
<td>1.6066</td>
<td>6.060</td>
<td>0.2651</td>
<td>1.36e-09***</td>
</tr>
<tr>
<td>Main copula verb</td>
<td>1</td>
<td>-0.0858</td>
<td>-0.257</td>
<td>0.3335</td>
<td>0.7970</td>
</tr>
<tr>
<td>Mismatch post-verbal nom</td>
<td>1</td>
<td>0.2533</td>
<td>0.392</td>
<td>0.6465</td>
<td>0.6953</td>
</tr>
<tr>
<td>Equative * Mismatching post-verbal nom</td>
<td>1</td>
<td>3.1478</td>
<td>4.484</td>
<td>0.7020</td>
<td>7.32e-06***</td>
</tr>
</tbody>
</table>

Results demonstrated two significant main effects in the data. First, speakers were more likely to produce agreement mismatch when producing a subject modified by a prepositional phrase or relative clause, as demonstrated a main effect of subject modifier, ($\beta =1.6$, $z$-value 4.986, $p < 0.0001$, 95% CI: 1.087, 2.126). Second, speakers were also more likely to produce mismatch when producing a post-verbal nominal that differed in grammatical number from that of the subject, but only in the context of a copula main verb. This was shown by the highly significant interaction between these two features ($\beta =3.15$, $z$-value 4.484, $p < 0.0001$, 95% CI: 1.772, 4.524). Neither of
these features (the number of the post-verbal nominal or the use of the copula) alone contributed to agreement mismatch, as demonstrated by the lack of main effects of either feature. That is, merely using a copula main verb (with a post-verbal nominal sharing the same grammatical number as the subject, or in other predicate types, including adjectival predicates or an auxiliary usage) or simply producing a post-verbal nominal whose number differed from that of the subject (in, say, a transitive construction) resulted in agreement mismatch. The presence of both features was necessary. The presence of an abstract subject head noun trended toward, but did not reach, significance ($\beta = -0.74$, $z$-value = 1.849, $p = 0.064$). This trend was, however, negatively correlated with the presence of mismatch.

3.5 Discussion

Results from the corpus study suggest that the agreement mismatch patterns under investigation here are not merely random errors. When speakers are using equative constructions, if they produce a post-verbal nominal that does not match the subject in grammatical number, that nominal appears to have a strong potential to contribute to the agreement production process. This interaction between construction type and mismatching post-verbal nominal was significant even in the presence of a main effect of the control variable, a subject modifier. In other words, the interaction of construction type and post-verbal nominal number contributes to agreement production over and above the well-established effects of local nouns (i.e., attraction effects) and subject construal as determined by the modifier (e.g., in distributive subject noun phrases). These results suggest that while the post-verbal nominal number may usually go unnoticed during agreement production, the use of the equative construction promotes it, to the extent that it becomes a major contributor to the agreement process. This interaction between post-verbal nominal number and construction type will be investigated further in Experiment 1.
This corpus study only looked at the presence of agreement mismatch in spontaneous utterances, without looking at the number value of the mismatch produced. It is worth noting, however, that in the utterances displaying mismatch, a majority of tokens (59/84, or 70.2%) displayed singular mismatch (e.g., *My step classes and toning is the only thing, Drugs is a big problem right now, The issues is what you believe in*). While this asymmetry is not a main focus of this thesis, it will be very briefly revisited in the context of the experimental results and the conclusions drawn from the studies presented herein.

The lack of significant effect of an abstract subject is slightly more difficult to interpret. It could be the case that the abstractness or concreteness of the subject relative to that of the post-verbal nominal does not factor into the agreement process. In other words, speakers do not produce verbs agreeing with post-verbal nominals when making use of equative constructions just because the subject is somehow semantically weak or vague. It may be the case, however, that the lack of effect is due to the limited definition of “abstract subject” as the lexical item *thing(s)* or *one(s)*. Visual inspection of the collected data suggests that many of the errors observed occurred with such abstract subjects as *cuts, issues, problems, solutions* or headless relative clauses (e.g., *What I want...*). Because the lack of significance may be due to the wide variety of subject items throughout the corpus, the role of abstractness of the subject head noun will be examined under more controlled conditions in Experiment 2.

Alternatively, it may be the case that “abstractness” does not capture the intuitions behind why speakers may produce a verb that agrees with, say, *batteries* and not *thing in, One thing I thought about the other day were batteries.* Rather than lexical semantics, it may be the information structure of the utterance that interacts with the syntactic and semantic features to bias the speaker in favor of agreeing with the post-verbal nominal. In other words, the speaker may fail to produce agreement with the subject not because it is abstract, but because it is not the focal element of the sentence
(Michaelis, personal communication). In light of the linguistic evidence regarding the effects of information structure on agreement as discussed in Section 2, it is worth briefly considering whether or not information structure plays a role in the production of agreement in these utterances.

To investigate the possibility that speakers are producing agreement with the post-verbal nominal just in the case that the post-verbal nominal is the focal element of the sentence, a quick post-hoc analysis was conducted. The previous discourse context of each utterance containing mismatch was extracted from the corpus (up to ten sentences prior, as available.) Within the realm of information structure, there is a general consensus as to the definition of “focus” as the “semantic component of a pragmatically structured proposition whereby the assertion differs from the presupposition” (Lambrecht 1994, p. 213). In other words, the focus conveys new information to the addressee (Lambrecht 2000, p. 612). The measure of focus is, however, much more variable. Methods used to determine focus includes the use of question-answer pairs (where the focus is the answer to the question) as well as a variety of morphosyntactic, prosodic and behavioral features (Lambrecht, 2000). Furthermore, the notion of focus often involves assumptions about the cognitive states of speakers and listeners (e.g., Gundel, Hedberg & Zacharski, 1993, 2001; Gundel, Hegarty & Borthen, 2003), which must be measured independently from the linguistic forms used (Menn, Duffield, & Narasimhan, 2013)—something that cannot be done here. For this brief investigation, the measure of being discourse-new was used as a proxy for focus, with discourse-new being defined as having no previous mention in ten prior conversational turns. A quick investigation of the data reveals that mismatch occurs with both discourse-old and discourse-new post-verbal nominals, with discourse-old nominals illustrated in (51-52):
51. A: Well, **the Saturns**, you can get air bags in them.

(8 conversational turns intervening)

A: Because you see the reliability and the types of problems they have, and, and the two cars that apparently are close to that. That actually have high reliability, the Taurus is one of the highest U S cars.

B: Uh-huh.

A: And the other one is, are **the Saturns**.

52. B: We have **engineers** who, uh, go out to the oil well, to the, to the client's oil well, and, and work with a lot of heavy equipment and put tools down the oil well and stuff, so the clients are very concerned that, you know, the engineers who go out there are adhering to their drug policy, because they're on their, their, you know, territory and everything, but the thing that's interesting is that I w-, I'm an **engineer** and, a **software engineer**.

A: Um.

B: and I work in the software, uh, house, and everybody there, you know, are all **software engineers**.

These examples suggest that, at the very least, a more rigorous linguistic investigation is necessary to establish whether or not agreement mismatch is correlated with information structure or discourse function. It should be kept in mind that the interactive approach discussed in Chapter 2 does not rule out the possibility that discourse factors can contribute to agreement. The exact nature of discourse influences on production of agreement is simply a matter of future investigation.

For now, the corpus study presented here has established that at least one feature in the pattern exemplified in examples (26-28) is highly correlated with the likelihood of speakers producing agreement mismatch: the interaction of a grammatical feature (the number of the post-verbal nominal) with a construction with a particular semantic function (the equative construction). This interaction is enough to provide a testing ground for the two approaches to agreement production discussed in Chapter 2, and it will be investigated in Experiment 1. Although the presence of an abstract subject head noun was not shown to be significant in the corpus study, the non-significance may be due to coding decisions. Experiment 2 will follow up on the role of subject type in these agreement patterns.
Chapter 4: Experiment 1—The Role of Post-verbal Nominal and Construction

This chapter presents the first of three experimental investigations of the agreement patterns observed in spontaneous utterances in the corpus study. Specifically, this chapter will address two core questions: (1) the extent to which post-verbal elements outside of the subject noun phrase can contribute to the production of subject-verb agreement, and (2) how such effects may be modulated by the construction in which these nominals appear.

In Chapter 3, agreement with post-verbal nominals rather than with subjects was attested in the spontaneous utterances of adult native English speakers. This occurred in equative constructions where the (equative) post-verbal nominal did not match the subject in number value, exemplified in (53) and (54).

53. One thing I thought about the other day were batteries.
54. The other one is…are the Saturns.

Relatively little experimental work has been done on the effects on agreement of nominals outside of the subject noun phrase (exceptions being Bock & Miller, 1991, Experiment 3; Chanquoy & Negro, 1996 (written production); Franck et al., 2006, 2007, 2010; Hartsuiker et al., 2001; and Hemforth & Konieczny, 2003 (written production)). Studies that have examined elements outside of the subject noun phrase have looked only at interference from objects: other types of post-verbal nominals, including equative nominals as in (53) and (54) above, have not been examined. To the best of my knowledge, all work on subject-verb agreement production assumes, either tacitly or overtly, that a (non-subject) nominal can only interfere with subject-verb agreement if it is produced before the verb. As such, there have been no psycholinguistic studies that have examined in depth the role of post-verbal non-subject nominals in subject-verb agreement; the possibility that the
semantics of the construction in which such nominals appear may further affect agreement has
certainly not been examined.

In this chapter, I will first review evidence concerning whether or not a post-verbal nominal
appearing outside of the subject-verb domain can interfere with the production of subject-verb
agreement, and I will discuss the role of syntax and semantics in these interference effects. Then, I
will discuss evidence concerning how the semantics of the construction in which the post-verbal
nominal appears may modulate these interference effects (should they occur). After reviewing the
current state of psycholinguistic accounts of agreement production with regard to these two issues, I
will present my experimental investigation and discuss the results, framing them in terms of the
degree to which they illustrate the interaction of syntax and semantics during the on-line production
of subject-verb agreement.

4.1 Can post-verbal nominals interfere in the production of subject-verb agreement?

Much of the experimental research on the production of subject-verb agreement has
investigated which structural elements can interfere with agreement production. These studies have
primarily examined elements within the subject noun phrase: local nouns embedded inside different
types of subject modifiers (e.g., prepositional phrases and relative clauses, Bock & Miller, 1991;
prepositional phrases, relative and complement clauses, Bock & Cutting, 1992), and to various
depths within the subject noun phrase (e.g., Franck et al., 2002). Throughout these studies runs the
tacit assumption that the production of subject-verb agreement privileges information in the subject
noun phrase above other elements in the sentence—which is of course not unwarranted. This is,
after all, subject-verb agreement.

Perhaps somewhat surprisingly, elements outside of the subject noun phrase have been
correlated with interference effects, under very specific conditions. Possible object interference
effects in subject-verb agreement were first demonstrated in Bock and Miller (1991; Experiment 3). In this study, Bock and Miller examined subject-verb agreement error rates in relative clauses modifying subject head nouns. Participants were asked to make complete sentences from subject preambles exemplified in (55-58) (with possible completions in italics). Of interest was whether participants produced a relative clause verb (VERB$_2$, in italics) that agreed with the appropriate noun (NOUN$_2$)$^{27}$:

55. The flag(s)$_1$ that the politician(s)$_2$…wave(s)$_2$ represent(s)$_1$, the dominant party.
56. The politician(s)$_1$ that the flag(s)$_2$…adorn(s)$_2$, speak(s)$_1$, to the crowd.
57. The song(s)$_1$ that the composer(s)$_2$…write(s)$_2$, inspire(s)$_1$, millions around the world.
58. The composer(s)$_1$ that the song(s)$_2$…inspire(s)$_2$, spend(s)$_1$, hours at the piano each night.

In each case, the subject head noun (NOUN$_1$) is co-referential with the object of its modifying relative clause (e.g., in (1), flag(s)$_1$ would be the object in the relative clause …[that the politician(s)$_2$ wave(s)$_2$…]). As such, if the verb of the relative clause (VERB$_2$) were to display agreement features matching those of the subject head noun (NOUN$_1$), it may be possible that the object of the relative clause has interfered to some degree (even though the object is not overtly produced in the gap of the relative clause).

Results showed that the conditions where participants did produce agreement features on VERB$_2$ that reflected the features of the wrong noun (NOUN$_1$) were those in which NOUN$_1$ was animate and NOUN$_2$ inanimate (as in examples 56 and 58). Bock and Miller argue that agreement errors in these conditions were due (at least in part) to difficulty in conceptualizing the intended relationship (where an inanimate entity acts upon an animate one). For example, when presented with *The composers that the song…* speakers may produce a completion such as *The composers that the song

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$^{27}$ Bock and Miller also examined the effects of error rates in the production of the main clause verb (VERB$_1$). Results were in line with other studies of the effects of local nouns embedded in phrasal or clausal modifiers of subject head nouns: speakers are more likely to produce errors when the local noun (NOUN$_2$) does not match the subject head noun in number, particularly when the local noun is plural and the subject head noun is singular.
write… indicating that they mistakenly took composers as the subject noun phrase of the relative clause simply because it is odd for songs to act upon composers, while the other way round is expected. 28

Essentially, these results provide evidence that a noun outside of the subject noun phrase, in linear and hierarchical position preceding the verb, can interfere with the correct number production on the verb. But it is only under certain semantic conditions—specifically, in object relative clauses when the subject is inanimate and the object animate—that such interference occurred. This would seem to support an interactive account of agreement production.

Bock and Miller do not, however, claim that this is evidence for semantic information interacting with syntactic information. Rather, these are “genuine subject identification mishaps,” (Bock & Miller, 1991, p. 74). In other words, they claim that participants incorrectly interpreted preambles as in (56) The politician that the flag… as The flag that the politician… such that politician was the relative clause subject and flag was the main clause subject. If, as Bock and Miller claim, errors on VERB₂ are likely to result from speaker confusion about which noun is the subject, then these errors may be better characterized as comprehension errors, and may not reflect processing that occurs during spontaneous production in everyday speech, As such, there is no clear evidence for object interference—these are, instead, errors in subject assignment. On the other hand, it should be noted that participants produced such errors while still correctly repeating the subject noun phrase preamble, rather then switching the order of the two nouns (i.e., participants did not actually produce The flag that the politician… even though Bock and Miller claim that they interpreted the

28 This explanation would be highly compatible with ERP studies in comprehension demonstrating that under certain conditions, language users may rely more heavily on plausible thematic role mappings than syntactic structure—specifically, when interpreting semantically anomalous sentences containing a verb and highly expected nominal arguments (Kim & Osterhout, 2005; Kim & Sikos, 2011). For example, presenting language users with a sentence like The hearty meal was devouring the hungry boys elicits neural responses reflecting syntactic reanalysis, suggesting that language users interpret The hearty meal as the thing being devoured rather than doing the devouring.
preamble in this way.) This finding leaves open the possibility that participants did indeed correctly interpret the subject noun phrase preambles, but that semantic information (e.g., a more plausible event construal in which the second noun is subject) interferes with the production of grammatical agreement. As a result, the actual mechanisms behind the interference remain vague, leaving more questions than answers with regard to how objects may interfere in subject-verb agreement production.

Although psycholinguistic investigations of subject-verb agreement production flourished following Bock and Miller’s (1991) seminal study, effects of nominals outside of the subject noun phrase were essentially ignored for the next twenty years. The first study to directly examine nominals outside of the subject noun phrase came from Hartsuiker et al. (2001). Hartsuiker et al. examined interference effects from nominal and pronominal objects on subject-verb agreement in Dutch subordinate clauses. Results showed an effect of syntactic function: Although objects did in fact interfere with grammatical agreement production, the same nouns embedded in prepositional subject modifiers had a stronger effect. For example, the plural monteurs “mechanics,” was more likely to result in the subject-verb agreement error in (59) than in (60):

59. *Peter roept dat de baas-SG van de monteurs-PL hebben-PL gebeld
   “Peter shouts that the boss-SG of the mechanics-PL have-PL called”
   *Peter shouts that the boss of the mechanics have called.

60. *Peter roept dat de baas-SG de monteurs-PL hebben-PL gebeld
   “Peter shouts that the boss-SG the mechanics-PL have-PL called”
   *Peter shouts that the boss have called the mechanics.

In a second study, Hartsuiker et al. (2001) demonstrated that preverbal pronouns exert interference effects as well. In this study, there was an effect of animacy/case. Inanimate pronouns, 

29 Hartsuiker et al. (2001) only manipulated grammatical number. In their examples, semantic number appears to coincide with grammatical number; the semantic number of the object was not independently manipulated. Although this study confirms that grammatical number of the object interferes with agreement, it does not rule out the effects of semantic number.
which were ambiguously marked for case, resulted in more errors, whereas animate pronouns, which were unambiguously marked as non-nominative, resulted in fewer errors. These results may be interpreted in line with Bock and Miller’s (1991) claim that under certain conditions involving animacy (and here, case marking), speakers may mistakenly process the incorrect nominal as subject when calculating subject-verb agreement.

Setting aside issues of animacy, Hartsuiker et al. (2001) explain these results in terms of a syntactic distance hypothesis. In this hypothesis, the effect of an interfering noun is determined by the syntactic (hierarchical) distance between that noun and the subject NP node. Nouns further away from the subject NP node have a weaker effect than those closest to the subject NP node. This account supports the two-step production of subject-verb agreement. First, number information from any noun in the syntactic hierarchy is transmitted to the subject NP node, contributing to a final number calculation on that node (with the contribution of more distant nouns being weaker than that of closer nouns). This final number value is then copied onto the verb. The process is illustrated in Figure 4.1.
Figure 4.1. Object interference in subject-verb agreement. Object interference, illustrated using examples from Hartsuiker et al. (2001), involves the passing of number features through the syntactic hierarchy (in Figure 1-A: “de baas van de monteurs hebben gebeld” the boss of the mechanics have called, and in Figure 1-B: “de baas de monteurs hebben gebeld” the boss the mechanics have called). In A, the plural feature from a local noun migrates up through the hierarchy to the NP_{SUBJ} node, passing through two nodes (the lower NP and PP) before landing at the NP_{SUBJ} node. In B, object interference occurs when the plural feature is passed up through the hierarchy, via the S node, to the NP_{SUBJ} node. This path requires the plural feature to pass through three nodes (the object NP, the VP, and the S node) before landing at the NP_{SUBJ} node. The difference in number of nodes between the interfering noun and the NP_{SUBJ} node is assumed, in this account, to explain why the objects exert less of an interference effect than local nouns embedded in the subject.

This account does not necessarily rule out an interactive approach of agreement production (and in fact, much of the work done by Hartsuiker and colleagues (2001) promotes a more interactive account of agreement production, and language production in general, e.g., Vigliocco & Hartsuiker, 2002). Recall that the interactive approach does not deny the effects of syntactic properties in agreement production. Rather, it allows semantic features to interact with syntactic processes. It may be the case that the effect of hierarchical distance illustrated by Hartsuiker et al. (2001) is modulated by semantic features that were not investigated. The study simply demonstrated that objects can indeed interfere with subject-verb agreement, but not to the same extent as nouns embedded within the subject NP. This finding leaves open the possibility that other semantic
features also have a role to play in determining the extent to which objects interfere with subject-verb agreement in these utterances.

More recently, three studies (Franck et al., 2006, 2007, 2010) have proposed a stronger syntactocentric account of object interference in subject-verb agreement, and of subject-verb agreement production overall, based in part on a comparison of the presence of attraction effects in object relative clauses with the apparent lack of attraction effects in complement clauses in French (e.g., *John parle aux patientes que le medicament guérissant *“John speaks to the patients whom the medicine cure” and John dit aux patientes que le medicament guérit “John tells the patients that the medicine cures”; Franck et al., 2010) These two sentence types have similar surface structure, but presumably different underlying representations, with the object (e.g., patientes) in the relative clause moving from a canonical position (e.g., after guérissant) to its surface position, leaving intermediate traces along the way. Franck et al. (2010) claim that the presence of the intermediate trace is what is responsible for the interference effects.

The explicit purpose of these studies was to bring a strong syntactic framing to the process of agreement production, with the authors explicitly “assuming a tight connection between the language processor and the grammar,” (Franck et al., 2006, p. 179). In each study, “the grammar” is defined as series of syntactic derivations within the Principles and Parameters/Minimalism framework (Franck et al., 2010; Chomsky, 1995, Zwart, 1993). Franck and colleagues (Franck et al., 2006, 2007, 2010) frame their syntactocentric model of agreement production within a strong modularist tradition defined by information encapsulation and domain specificity—agreement production is restricted to syntactic mechanisms that only make use of syntactic information. Semantic information has no role in object interference in the production of subject-verb agreement, either directly or indirectly. In this view, objects may interfere with subject-verb agreement if they carry features (e.g., grammatical plurality) that differ from the subject, and if they interfere with the
syntactic derivations occurring during the computation of the subject-verb agreement relationship (simply put, if they “get in the way” of the subject and the verb during mental derivations of the syntactic structure.) For interference to occur, the object must have been moved from its canonical post-verbal position and it must be produced in a linear order prior to the verb. This account is consistent with the results in both the Bock and Miller (1991) experiment, as well as the Hartsuiker et al. (2001) results, in that it allows for those results to be interpreted in a strictly syntactocentric approach to agreement production.

To summarize, the previous research on interference from non-subject nominals progressively presents a syntactocentric view of agreement production. The early study presented by Bock and Miller (1991) hints at the possibility that nominals outside of the subject noun phrase may interfere during the production of subject-verb agreement under particular syntactic and semantic influences. Their interpretation of their results, however, is consistent with the syntactocentric model that Bock and colleagues have developed, as discussed in Section 2.2.1. The Hartsuiker, et al. (2001) study did not investigate semantic influences, but only presented the role of syntactic information during the interference of non-subject nominals in agreement production. The Franck studies explicitly aim to support a modular model of agreement in which agreement production makes no reference to semantic information whatsoever, and non-subject nominals may only interfere within the confines of particular syntactic configurations. Overall, the current state of agreement research demonstrates that nominals outside of the subject noun phrase can interfere with subject-verb agreement, but only when appearing prior to the verb. Furthermore, it appears to be the working assumption that semantic information relevant to the object nominal has no role to play in the interference process at the positional processing level (at the very least, this issue has not
been addressed; the semantic number of the object has not been manipulated independently of grammatical number in any of these studies.  

The results of the corpus study presented in the previous chapter directly counter this syntactocentric view of agreement production. First of all, the results specifically demonstrate that post-verbal nominals can interfere with subject-verb agreement, countering the claim that interference from non-subject nominals can only occur in a particular syntactic structure. Second, they demonstrate that this interference occurs in a particular semantic context paired with a particular syntactic configuration—the equative construction. In equative constructions, a post-verbal nominal differing in number from the subject head noun was significantly correlated with agreement mismatch (such that the verb agreed with the post-verbal nominal rather than the subject). This finding leads to the second research question: Assuming that post-verbal nominals may exert interference effects on subject-verb agreement, can that effect be modulated by the construction in which they appear, and if so, to what extent?

4.2 Can interference effects from post-verbal nominals be mediated by constructions?

Experimental research examining the role of construction on interference effects in subject-verb agreement has treated “construction” as synonymous with different hierarchical syntactic structures (e.g., Franck et al., 2006, 2010). In such studies, if a noun interferes with subject-verb agreement to different degrees in different constructions, it is because of the structural differences between those constructions—not because of any semantic differences between them. Constructions as learned form-function pairings (as defined by Goldberg, 1995, 2006) have generally

30 Recall that the Bock and Miller (1991) study demonstrated that animacy appears to interfere with the agreement process, but that the syntactocentric explanation is that it does so indirectly by causing the speaker to assign the wrong noun to the subject grammatical function. According to this account, the features of the (incorrectly assigned) subject are still the features that control agreement, and animacy does not interfere with the agreement process itself.
not been investigated. In this view, linguistic constructions at any level of grammatical analysis (from morphemes to fully general phrasal patterns) are linked to particular functions or meanings in the mind of the language user. From this perspective, the choice of a particular syntactic form is highly motivated by its meaning or communicative function as well as its grammatical context. The implication for agreement production is that agreement cannot be a strictly syntactic process; meaning must be involved, and can be involved at various levels of linguistic analysis. In other words, the particular function or meaning of the sentence structure in which the verb appears has the potential to influence a speaker’s choice of verb agreement forms.

Constructions, defined as form-function pairings, provide the ideal environment in which to test whether or not syntax and semantics interact during subject-verb agreement production, because they provide an opportunity to see whether there is an interaction between agreement mechanisms and variables that do not independently encode agreement-related information. In other words, the presence of an element that does not by itself contribute information to agreement production (e.g., a particular construction) can instead affect the agreement process by promoting or suppressing a feature that does (e.g., grammatical number of a particular nominal). The semantic function of a particular construction may provide an environment in which the effect of a post-verbal nominal on subject-verb agreement is strengthened, without directly contributing any information about agreement processes per se.

Consider the function of the equative construction: to equate the referent of the subject with the post-verbal nominal. The function of the equative construction does not typically convey any information about agreement processes (e.g., directly calling for the verb to agree with the post-

31 In addition, it may be the case that information structure plays a role as well. In these constructions, the speaker may place new/focal information post-verbally in order to avoid introducing new information in the subject position (e.g., Duffield & Michaelis, 2011). However, as there was no information structure analysis done on the tokens used in this study, this aspect will remain unexamined here.
verbal nominal, as may be the case with THERE-existentials or locative inversion constructions, depending upon the analysis. But in a view of agreement production that allows a dynamic interaction between syntactic and semantic information, activating the subject head noun may be likely to increase the activation of the co-indexed post-verbal nominal, in turn increasing the interference effect that nominal may have on subject-verb agreement. In other words, a dynamic, interactive account allows for a significant interaction between construction type and post-verbal nominal number in predicting subject-verb agreement mismatch. A syntactocentric approach makes no such prediction; the function of the construction in which the post-verbal nominal is used should make no difference in whether or not it interferes in subject-verb agreement.

While there have been no studies on agreement from the constructionist point of view per se, one study briefly mentioned in Chapter 2 (Solomon & Pearlmutter, 2004) suggests that the conceptual relationship between the subject head noun and a local noun as expressed by the sentential context determines (at least in part) the degree to which the local noun may interfere with subject-verb agreement. They found that the more that two nouns are “semantically integrated,” the more likely the local noun is to interfere. Semantic integration refers to how tightly linked two nominals are, as defined by the relationship between the two expressed in the sentence. For example, the subject drawing and local noun flowers are more tightly semantically integrated in The drawing of the flowers than The drawing with the flowers. This is not the same as semantic overlap (e.g., the relationship between desk and table) or association (e.g., the relationship between mouse and cheese); it is defined by the phrase in which the two nouns appear (e.g., NP with NP or NP of NP). Solomon and Pearlmutter (2004) show that local nouns that are more tightly semantically integrated with subject head nouns have been shown to have larger interference effects; the role of semantic integration has not yet been investigated with nouns outside of the subject noun phrase.
Aside from the Solomon and Pearlmutter (2004) study, the possibility that the semantics associated with a particular syntactic form might affect how a speaker produces agreement remains relatively unexamined. The results of the corpus study in Chapter 3, however, suggest that speakers are more likely to produce agreement mismatch due to the interference of a post-verbal nominal when using a particular construction which actually conveys an extremely high level of semantic integration—the equative construction. The equative construction serves to equate the referent of the subject noun phrase with that of the post-verbal nominal as one-and-the-same, perhaps conveying the highest level of semantic integration possible (much more so than the integrated relationships depicted between two separate entities in the Solomon and Pearlmutter study). At the very least, the level of semantic integration is much higher than in, for example, a transitive construction, a construction that prototypically expresses an action involving two separate, distinct entities (Goldberg, 1995, pp. 117-119). If syntax and semantics interact during agreement production, and the meaning and/or function of the construction in which subject-verb agreement is produced affects speakers’ agreement productions, it stands to reason that the post-verbal nominal in an equative construction, being more highly semantically integrated with the subject, will be more likely to interfere with agreement than in the transitive construction.

This experiment is designed to investigate the processes by which speakers produce subject-verb agreement by examining variables that have not previously been included in experimental research on subject-verb agreement production: the nominal appearing after the verb and the constructional context in which subject-verb agreement is produced. These variables were suggested by the results of a careful corpus investigation of agreement patterns in spontaneous utterances. Results of this experiment will be interpreted as supporting either a modular approach or a constraint-based approach to agreement production.

32 With the exception of reflexives (e.g., John saw himself)
4.3 Experiment 1: New elements in design and paradigm

The purpose of Experiment 1 was to investigate two questions. First, could post-verbal elements that are outside of the subject noun phrase elicit attraction effects during the production of subject-verb agreement? Second, if so, would these effects be mediated by the constructional context in which agreement is produced? In the experiment, participants were asked to produce agreement in utterances containing both singular and plural nouns in a post-verbal position, in two constructions: the equative (which takes the form NP₁ COP NP₂, and has the function of equating two noun phrases) and the transitive (which takes the form NP₁ V NP₂, and typically express a scene in which one entity performs an action involving another).³³ ³⁴

Although the experimental design is based upon the methods and design used in a majority of the previous psycholinguistic research on the production of subject-verb agreement, several innovations have been made in order to strengthen the test of the effect of the post-verbal nominal, and also to create a more communicative environment for the participants. Rather than simply requiring participants to complete subject preambles that had been visually presented on a computer screen, participants were instructed that they were going to be finishing sentences in order to help the experimenter complete short stories as part of a “story-telling task”. Participants were told that during a “priming phase” they were to repeat visually- and orally-presented information that they should use to complete the story (during a “preamble completion phase”). Finally, after completing the subject preamble (and therefore completing the story), participants were asked to do a picture-

³³As mentioned above, the transitive construction need not involve two distinct entities, as in the case of reflexives. Furthermore, the transitive construction can be somewhat polysemous (e.g., referring to having objects, moving objects, acting upon objects, or involving psychological activities). Nonetheless, the transitive is a construction that typically conveys a situation involving two entities. See, for example, Sethuraman and Goodman (2004) and Casenhiser and Goldberg (2005) for evidence of children’s acquisition of the transitive constructional meaning involving actions with two separate entities.
³⁴ For this dissertation, I am setting aside the possible syntactic analyses that may or may not provide similar or different structural descriptions of the two constructions.
matching task. Participants were told that the purpose of this task was to test how well they understood the information in the story. Data were then omitted from participants who scored below 90% on the picture-matching task (incorrectly selecting more than 7 pictures during the experiment). Examples of the test trial procedure for both the Transitive-Plural and Equative-Plural conditions are illustrated in Figures 4.2 and 4.3.

**Figure 4.2.** Experiment 1: Illustration of the experimental procedure in the Transitive-Plural condition. The Transitive-Plural condition refers to the Priming phase, in which both a verb (in orthographic form) and a nominal (in picture form) are primed. In singular trials, only a single item (e.g., one worm instead of three) was presented in the picture to prime the nominal.
The departure from typical procedures in the experimental design accomplishes three specific goals. First, the use of primes allowed for the efficient collection of a substantial number of fluently produced tokens containing the desired construction types and post-verbal number types. Second, the use of pictures provided a controlled and consistent conceptual input, ensuring that all participants had at least some access to a specific conceptual number representation of the subject noun phrase referent. Third, the use of pictures and story context along with the cooperative sentence completion task put the participants in a more communicative situation than the typical read-repeat-complete paradigm. Results should therefore be more reflective of the type of processing that goes on during spontaneous, conversational language production than results from

Figure 4.3. Experiment 1: Illustration of the experimental procedure in the Equative-Plural condition. The Equative-Plural condition refers to the Priming phase, in which a nominal (in picture form) is primed. In singular trials, only a single item (e.g., one robin instead of three) was presented in the picture to prime the nominal.
the typical sentence completion tasks. These innovations will be briefly discussed prior to presenting the methods and results of the experiment.

4.3.1 Eliciting constructions using primed responses

To ensure that participants would produce the desired constructions and post-verbal nominals participants were primed with material that they were instructed to use to complete the subject preambles. In the equative condition, participants were primed only with a noun in either singular or plural form (to be used as the equative nominal), while in the transitive condition participants were primed with both a neutral (participial) form of the transitive verb and a visual representation of the noun in either singular or plural form (to be used as the object). The purpose of presenting the transitive verbs in participial form (e.g., losing) was because it was necessary to have a form that would both elicit a response in the present tense (such that the verb would be marked for number) and that would not prime for either singular or plural (e.g., lose-PL or loses-SG).

An example of the priming for each of the four conditions (equative with singular noun, equative with plural, transitive with a singular noun and transitive with plural) is presented in Table 4.1.

Table 4.1. Experiment 1. Example of priming conditions.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Prime 1</th>
<th>Prime 2</th>
<th>Preamble (to be completed by participant)</th>
<th>Possible completions</th>
</tr>
</thead>
<tbody>
<tr>
<td>EQUATIVE-SG</td>
<td>∅</td>
<td>a robin</td>
<td>IS/ARE a robin</td>
<td></td>
</tr>
<tr>
<td>EQUATIVE-PL</td>
<td>∅</td>
<td>robins</td>
<td>IS/ARE robins</td>
<td></td>
</tr>
<tr>
<td>TRANSITIVE-SG</td>
<td>eating</td>
<td>a worm</td>
<td>IS/ARE eating a worm</td>
<td></td>
</tr>
<tr>
<td>TRANSITIVE-PL</td>
<td>eating</td>
<td>worms</td>
<td>IS/ARE eating worms</td>
<td></td>
</tr>
</tbody>
</table>
This method, which resulted in an asymmetry across the equative and transitive conditions (i.e., there were two items primed in the transitive condition, and only one in the equative), was determined to be the most natural and comfortable for participants among several piloted versions, and it resulted in the most natural and effortless responses of all versions.

Such priming techniques have been previously used in experiments investigating predicate adjectival agreement in languages such as French and Italian (e.g., Franck et al., 2008; Vigliocco & Franck, 1999). In these experiments, participants are typically presented with a neutral form of the adjective prior to the presentation of the preamble, or all forms are presented at once, counterbalanced so that all forms are equally available to the participant during processing. Experimenters then look to see the gender form of the adjective that has been produced when the participant forms the complete sentence. Although the use of primes does remove some of the spontaneity that participants experience in free-response versions of the subject preamble completion task, it does aid participants in producing quick and fluent responses. It also allows for efficient and effective collection of the data points of interest, as a higher proportion of responses are of the response types of interest than in elicited production experiments that allow participants to freely produce any number of a variety of responses.

4.3.2 Controlling conceptual input with picture stimuli

A second adaptation to the experimental procedure is the use of pictures to provide a consistent conceptual representation for participants (to the extent that speaker-external sources can contribute to the speaker’s own conceptualization of referents). Pictures have occasionally been used in agreement production experiments as a way to influence participants’ conceptualizations of the referents being described. Eberhard (1999, Experiment 1) investigated the effects of concreteness and imageability of distributive noun phrases (grammatically singular noun phrases that refer to a
multitude of an identical item, e.g., *the label on the bottles, the picture on the postcards*) on the likelihood of speakers to produce agreement mismatch. In that experiment, pictures representing the distributive referents showed multiple identical copies of the items denoted by the subject head noun. In a similar fashion, the paradigm in this experiment matched pictures of multiple identical items that could be described by either grammatically singular or plural noun phrases—that is, by either a singular subject noun phrase referring to a single type (e.g., *the one sold by the eager salesman*), or a plural post-verbal equative noun referring to multiple tokens of that type (e.g., *convertibles*). This flexibility in conceptual-grammatical mapping allowed the same picture to be used for each item across all four conditions. In this way, the conceptual (visual) information provided to participants was held constant, although only the grammatical forms varied across conditions—unlike in Eberhard’s experiment, where pictures reinforced either a plural (distributive) or a singular conceptualization of the referents denoted by the subject noun phrase by varying in the number of objects being shown. It is possible that the presentation of these pictures may increase the overall rate of agreement mismatch produced by participants (although Eberhard 1999, Experiment 2 demonstrated that pictures do not contribute to a significant increase in rates of mismatch), but any increase would be to the same extent across all conditions.

4.3.3 Placing participants in a communicative situation

In most studies, participants are asked to repeat and complete subject noun phrase preambles that have been isolated from any contextual setting and from any communicative intent. But this may not be the best way to examine how speakers produce agreement in the natural course of speaking. As Goodwin (1979, pp. 97-98) notes, “Sentences emerge with conversation. However, in traditional linguistics it has been assumed that the analysis of sentences can be performed upon examples isolated from such an interactive process. In opposition to such a view…sentences in
natural conversation emerge as the products of a process of interaction between speaker and hearer."

In order to understand more about how speakers produce subject-verb agreement during spontaneous, natural use of language, the use of isolated sentences in a non-communicative task was abandoned, and participants completed sentences in a more communicative, yet still controlled setting.

Three changes have been made in order to fit the subject preamble completion paradigm to a more communicative setting. First, the subject preambles to be completed were situated within a short-story context. Second, pictures were included, both during the story context and during a picture-matching task at the end of each trial in order to both control the conceptual input (as described above) and to help the participants focus on the overall message being communicated rather than to treat it as a test-like sentence completion task.

In the third and most radical change, rather than repeating the subject preamble, participants were instructed to co-construct the sentence with the experimenter by completing the preamble that the experimenter produced as quickly and as naturally as possible. By using this method, not only was the flow of the story uninterrupted, but the experimenter and participant also engaged in a communicative behavior observed in spontaneous conversations, with one speaker finishing the other’s sentence. In Conversational Analysis, this behavior is known as co-creating “compound turn-constructional units (compound TCUs)” — a practice in which “two speakers engaged in conversation jointly produce a single syntactic unit such as a sentence,” (Lerner, 1991, p. 441). Co-creating compound TCUs is a widespread behavior. It has been demonstrated in speakers across languages (e.g., English and Japanese: Lerner & Takagi, 1999). It has also been shown to occur between family members and speakers with progressive neurological diseases and speech disorders.

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35 Conversation Analysis is a data-driven study of talk-in-interaction that aims to describe the interactional rule, procedures and conventions that make up the social organization of language in use (Goodwin & Heritage, 1990).
who use augmentative and alternative communication devices (Bloch, 2011). This method (as any experimental method) is far from being completely ecologically valid; it lacks several important features that characterize natural conversation in which turn-taking occurs (i.e., turn order and turn size are fixed, length of conversation, what parties say, and relative distribution of turns have been specified in advance; Sacks, Schegloff & Jefferson, 1974). Nonetheless, this adaptation is an attempt to move away from the non-communicative paradigm that has been typically used in agreement production research, and to come closer to understanding what speakers actually do when engaged in the type of linguistic behavior that we do most often—talk-in-interaction (Schegloff, 1999).

4.4 Methods

4.4.1 Participants

Twenty-four native English speakers between the ages of 18 and 45 years old participated. Two participants’ data were excluded because they were native bilingual speakers (one of Mandarin and the other of Spanish.) Participants were recruited from the University of Colorado Boulder community through the use of flyers and announcements, and received either a payment of $5.00 or course credit for their participation.

4.4.2 Materials

Test items. Twenty-four sets of experimental items were constructed. The experimental items are illustrated by the set in Table 4.1. A full list of test items for Experiment 1 is presented in the Appendix in Table A1. The variables manipulated in this experiment were the construction type (equative vs. transitive), and the number value of the predicate nominal (singular vs. plural) for a 2x2 crossed design. Each of the items consisted of: (1) primed material to be used to complete a sentence, and; (2) a subject noun phrase preamble for the sentence to be completed. Only singular
head nouns were used in the experiment; no plural head nouns were used. Test items were limited to singular head nouns because the clearest interference effects have been demonstrated in the experimental literature when the subject head is singular and the interfering noun is plural (e.g., Barker et al., 2001; Bock & Miller, 1991; Eberhard et al., 2005). As a result, each of the twenty-four test items appeared in four conditions: Equative-SG, Equative-PL, Transitive-SG, Transitive-PL, where “equative” and “transitive” refer to the construction type, and SG and PL refer to the number of the primed post-verbal nominal.

All primed materials were presented both visually and orally. Verb and nominal primes were presented in the transitive conditions, and nominal primes alone were presented in the equative conditions. In transitive conditions, the verb was presented in the present participle form (e.g., buying) to avoid priming participants for number. Verbs were presented in orthographic form in the middle of the computer screen while the experimenter read the word. Nominals were presented in picture form (to be described below in Picture design) while the experimenter named the picture. Singular nominals were presented in the singular conditions, and plural nominal were presented in the plural conditions.

All test item preambles contained the abstract, singular subject head nouns thing or one modified by a reduced relative clause seven syllables in length. The use of the reduced relative clause modifier was motivated by the significant effect of the modifier in the corpus study. The subject head noun (thing or one) for each test item was chosen in order to make the subject preambles as natural as possible, as judged by the experimenter and a research assistant. Reduced relative clause

Perhaps one of the most-well established findings that has been replicated time and time again in the experimental literature on agreement production is that in the sentence preamble completion paradigm, plural nouns are more likely to interfere with subject-verb agreement with singular subjects than vice versa (e.g., Barker et al., 2001; Bock & Miller, 1991; Bock & Eberhard, 1993; Eberhard et al., 2005; Vigliocco et al., 1995; Vigliocco et al., 1996; inter alia). See also the discussion of markedness of the plural feature, Chapter 2, Section 2.2.1.
modifiers (containing either transitive or intransitive verbs with prepositional complements) all contained a singular noun.

Test item preambles were designed to be unambiguously grammatically singular, containing only single nouns. Regarding conceptual number, the preambles were designed to be interpreted as conceptually singular (i.e., containing singular, non-collective head nouns with non-distributive interpretations) when isolated from context, but to allow for a flexible construal of the referent either as a single category (type) or as a plural group of multiple individual members of that category (tokens of that type). For example, the subject preamble, *The one nesting in the leafy tree* could be used to identify the type of bird (*a robin*), or the multiple identical animals depicted in the scene (*robins*). This flexibility allowed subject preambles to be paired with both singular and plural post-verbal nominals in the equative condition, as well as with pictures that depicted multiple objects (as described below.)

Preambles were presented orally, embedded in a short story context accompanied by pictures (to be described below in *Context design* and *Picture design*). The four versions of each of the twenty-four experimental items were counterbalanced across four experimental lists, with each list being used in forward and reverse order. Each of the lists contained six items in each of the four experimental conditions. An example of a test item in each of the four conditions is presented in Table 4.2.
Table 4.2. Experiment 1. Example of a test item in each of the four experimental conditions.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Prime 1</th>
<th>Prime 2</th>
<th>Context (identical across conditions)</th>
<th>Preamble</th>
<th>TEST: verb produced</th>
</tr>
</thead>
<tbody>
<tr>
<td>EQUATIVE-SG</td>
<td>Ø</td>
<td>a robin</td>
<td>Birds have begun singing this spring morning.</td>
<td>The one nesting in the leafy tree…</td>
<td>IS/ARE a robin</td>
</tr>
<tr>
<td>EQUATIVE-PL</td>
<td>Ø</td>
<td>robins</td>
<td>A sparrow hops through the tall grass.</td>
<td></td>
<td>IS/ARE robins</td>
</tr>
<tr>
<td>TRANSITIVE-SG</td>
<td>eating</td>
<td>a worm</td>
<td></td>
<td>IS/ARE eating a worm</td>
<td></td>
</tr>
<tr>
<td>TRANSITIVE-PL</td>
<td>eating</td>
<td>worms</td>
<td></td>
<td>IS/ARE eating worms</td>
<td></td>
</tr>
</tbody>
</table>

Fillers. In addition to the twenty-four experimental items, forty-eight filler items were included. Twenty-four of the filler preambles contained subject head nouns that were basic-level category nouns that could substitute for *thing* or *one* in the test trials37. For example, in the test item given in Table 4.2, the basic-level noun *bird* could replace *one* in the preamble. Each of the fillers that contained a basic-level noun corresponding to a test item appeared in the experimental list after the test item. An additional twenty-four filler items contained nouns that were unrelated to test items. Across all fillers, half (24 items) contained singular head nouns, and half (24) contained plural subject head nouns. Twenty-four filler subjects were modified by prepositional phrases, and 24 by relative clauses, distributed equally across singular and plural subjects. Relative clause modifiers for fillers were subject-gap relative clauses in the present tense (e.g., *The generator that __ is breaking down*), reinforcing the number value of the subject head noun and priming participants to produce grammatical subject-verb agreement. Filler primes were of three types: transitive, intransitive, and equative. Transitive fillers were primed with a verb and object (similar to transitive primes in test

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37 The basic-level category nouns used in filler items for Experiment 1 are used as test items in Experiment 2, whereas Experiment 2 contains filler items with the subject head noun *thing* or *one*. In this way, both experiments use the same subject head nouns across all items: 12 *thing*, 12 *one*, 24 basic-level category nouns, and 24 other filler nouns.
items), intransitive fillers were primed with a verb, and equatives were primed with a nominal. Half of equative fillers had plural primes, and half had singular primes. As with test items, each of the filler items was embedded in a short story context. Examples of each of the filler types (with story contexts omitted) are presented in Table 4.3. A full list of filler items is presented in Table A3 in the Appendix.

Table 4.3. Experiment 1. Example of a filler item. (Story contexts are omitted.)

<table>
<thead>
<tr>
<th>Filler type</th>
<th>Prime 1</th>
<th>Prime 2</th>
<th>Preamble</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANSITIVE</td>
<td>entertaining</td>
<td>children</td>
<td>The book in her lap…</td>
</tr>
<tr>
<td></td>
<td>depicting</td>
<td>presidents</td>
<td>The portraits that line the hallway…</td>
</tr>
<tr>
<td>INTRANSITIVE</td>
<td>basking</td>
<td>∅</td>
<td>The lizards on the rocks…</td>
</tr>
<tr>
<td></td>
<td>breaking</td>
<td>∅</td>
<td>The bracelet that falls to the floor…</td>
</tr>
<tr>
<td>EQUATIVE</td>
<td>∅</td>
<td>stars</td>
<td>The ornaments along the railing…</td>
</tr>
<tr>
<td></td>
<td>∅</td>
<td>an angel</td>
<td>The figurine that stands on the shelf…</td>
</tr>
</tbody>
</table>

Context design. Contexts for each of the trials consisted of two sentences. In test trials, the first sentence contained a plural subject and a verb in the present perfect (e.g., *The bosses have filled the office with supplies.*) The second sentence contained a singular subject and a verb in the simple present. An example context is presented in (59):

61. (Context) The bosses have filled the office with supplies. A photocopier runs in the corner.  
   (Preamble and primes) The thing passed out by the secretary…(a dictionary/covering a document)

In order to provide a somewhat natural communicative context for the elicited sentences, the discourse information presented by the context sentences was designed to establish a “contextually licensed” poset (partially ordered set) relation between elements in the context sentences and the post-verbal nominal elicited from the participant (Ward & Birner, 2008). For example, in (59) above, the partially ordered set is *office supplies*, of which the post-verbal nominals
dictionary and document are members. The two context sentences in test trials were overtly marked for number, thus ensuring that each participant was presented with examples of both singular and plural examples of grammatical, overtly marked, subject-verb agreement. Contexts were designed to elicit a stative reading, thereby encouraging participants to produce responses in the present tense, which is overtly marked for number. Contexts for filler sentences varied in terms of subject number but were all in present tense.

*Picture design.* Examples of images presented to participants can be seen in Figures 4.2 and 4.3 above. Images were presented in each of the three parts of a single trial: The priming stage, the story telling and preamble completion task, and the picture-matching task.

Primes (used during the priming stage). Verbs to be primed were presented in the center of the screen in Calibri size 60 font. Pictures of nominal primes were selected from non-copyrighted images found through a Google search, and were presented in PowerPoint. In the singular condition, one picture was presented. In the plural condition, three identical copies of the same picture were presented on the screen. Multiple copies of the same picture were presented in order to allow for a type/token reading such that the multiple objects could be interpreted as a singular type (e.g., three instances of a robin) or as individuals (e.g., robins).

Context pictures (used during the story telling and preamble completion task). Context pictures were sets of three images corresponding to the two context sentences and the preamble. The same picture was presented for each trial across all four conditions. Images were selected from non-copyrighted images found through a Google search. Images appeared on the screen using PowerPoint animation. During the preamble, images corresponding to both the nominal in the equative condition and the nominal in the transitive condition appeared simultaneously using entrance and/or emphasis effects. In test trials, the picture corresponding to the preamble always
contained three copies of the image for the primed nominal (regardless of the prime being singular or plural.)

Selection pictures (used during the picture matching task). Three picture sets were presented to participants in the picture-matching task: a matching set and two distractor sets. The correct (matching) set consisted of the images presented in the context pictures. In test trials, this set was an exact copy of the final presentation of context pictures. In filler trials, elements of the context pictures were sometimes presented in a slightly different arrangement. Distractor sets each contained two elements from the context and preamble descriptions, but could be distinguished from the matching set in that they contained one item not mentioned in the context and preamble. In all test trials, the matching picture was presented in the top center position.

4.4.3 Procedure

Materials were presented in PowerPoint on a 13-inch MacBook Pro. Participants were tested individually. Instructions were presented orally by the experimenter and included demonstrations of the procedure, as well as four practice trials. Each trial consisted of a priming phase, a sentence-completion task, and a picture selection task.

Participants were told that the experiment in which they were participating examined how speakers integrate information for purposes of communication. They were instructed that they would be engaging in two tasks during each trial: a story-telling task and a picture-matching task. The story-telling task consisted of two parts: a priming phase and a preamble-completion phase. In the priming phase, participants were presented with a verb in participial form ambiguous for number (e.g., singing), a picture of an item (e.g. a picture of a robin), or both (e.g. eating and the image of a worm). The experimenter read the word and/or named the item, and the participant was asked to repeat. Following the priming phase, the experimenter read the two context pictures and the
preamble while corresponding pictures appeared on the screen. Upon completion of the preamble, a star appeared in the center of the screen (simultaneously with the last word of the preamble), prompting the participant to complete the sentence. Participants were instructed to complete the sentence as quickly and as naturally as possible. Following the story-telling task, participants were presented with three sets of pictures, one of which corresponded to the pictures previously presented. Participants were instructed to select the set of pictures which best matched the story that had been told.

4.4.4 Scoring

All test trials (n=528) were transcribed and coded by the experimenter. Responses were assigned to one of three scoring categories, based on the following criteria. Responses in which participants completed the preamble with the primed construction and nominal (in either singular or plural form) and produced a singular verb were assigned to the Match category. These responses included variations in verb tense (e.g., eats or is eating). Responses were assigned to the Mismatch category if they met the criteria for the Match category but produced a plural, rather than singular, form of the verb. All other responses were assigned to the Other category, including responses which were ambiguous for verb number (e.g., where the verb was omitted or in the past tense), responses in which participants did not produce the primed construction or in which complex noun phrases were produced (e.g., The one played with by the little girl…is Barbies that are baking cakes), and responses in which the participant substituted a different lexical item for either the prompted verb or nominal. Responses which contained repairs (e.g., is…are russets) were also assigned to the Other category, but disfluencies (e.g., …are hiding, uh, uh, price tag) were not. Other responses were excluded from the analysis, resulting in 64 (12%) trials being excluded.
The remaining total 464 responses were included in the analysis. Examples of responses from each scoring category are given in Table 4.4.

*Table 4.4. Experiment 1. Examples of participant responses in each category.*

<table>
<thead>
<tr>
<th>Scoring Category</th>
<th>Primes</th>
<th>Preamble</th>
<th>Participant Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Match</td>
<td>lattés</td>
<td>The one ordered by the manager…</td>
<td>…is lattés</td>
</tr>
<tr>
<td></td>
<td>fedoras</td>
<td>The thing set by the tall mannequin…</td>
<td>…is a fedora</td>
</tr>
<tr>
<td></td>
<td>tying, shoes</td>
<td>The one featured in the oak cabinet…</td>
<td>…is tying shoes</td>
</tr>
<tr>
<td>Mismatch</td>
<td>russets</td>
<td>The one served hot by the prompt waiter…</td>
<td>…are russets</td>
</tr>
<tr>
<td></td>
<td>leaving, marks</td>
<td>The one ordered by the manager…</td>
<td>…are leaving marks</td>
</tr>
<tr>
<td>Other</td>
<td>an oreo</td>
<td>The one added at the last minute…</td>
<td>…an oreo</td>
</tr>
<tr>
<td></td>
<td>seating, visitors</td>
<td>The thing placed in the common room…</td>
<td>…is for seating visitors</td>
</tr>
<tr>
<td></td>
<td>cracking, eggs</td>
<td>The one quickly picked by one shopper…</td>
<td>…is the eggs cracked</td>
</tr>
<tr>
<td></td>
<td>teaspoons</td>
<td>The one chosen by the master chef…</td>
<td>…are cooking spoons</td>
</tr>
</tbody>
</table>

Percentages of responses in the categories included in the analysis (Match and Mismatch) by condition defined by construction type and prime number (EQU-SG, EQU-PL, TRANS-SG, TRANS-PL) and by the number of the produced post-verbal nominal are given in Table 4.5.
Table 4.5. Experiment 1. Numbers and percentages of responses in Match and Mismatch categories by condition and produced post-verbal nominal number.

<table>
<thead>
<tr>
<th>Experimental Condition</th>
<th>Response Category (Agreement Type)</th>
<th>MATCH</th>
<th>MISMATCH</th>
<th>GRAND TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Example response</td>
<td>Example response</td>
<td></td>
</tr>
<tr>
<td>Post-verbal Nominal Number: PLURAL</td>
<td>MATCH</td>
<td>EQU-SG</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>MISMATCH</td>
<td>EQU-PL</td>
<td>6</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td></td>
<td>7 (9.5%)</td>
<td>67 (90.5%)</td>
</tr>
<tr>
<td></td>
<td>MATCH</td>
<td>TRANS-SG</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>MISMATCH</td>
<td>TRANS-PL</td>
<td>64</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td></td>
<td>74 (69.8%)</td>
<td>32 (30.2%)</td>
</tr>
<tr>
<td>Post-verbal Nominal Number: SINGULAR</td>
<td>MATCH</td>
<td>EQU-SG</td>
<td>115</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>MISMATCH</td>
<td>EQU-PL</td>
<td>62</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td></td>
<td>177 (99.4%)</td>
<td>1 (0.6%)</td>
</tr>
<tr>
<td></td>
<td>MATCH</td>
<td>TRANS-SG</td>
<td>86</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>MISMATCH</td>
<td>TRANS-PL</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td></td>
<td>102 (96.2%)</td>
<td>4 (3.8%)</td>
</tr>
<tr>
<td>GRAND TOTAL</td>
<td>MATCH</td>
<td>TOTAL</td>
<td>360 (76.3%)</td>
<td>104 (23.7%)</td>
</tr>
</tbody>
</table>

The experimental condition is listed in Column 1, giving the construction type (EQU and TRANS) and the number of the primed nominal (SG and PL) (see Table 4.2 for examples). The upper half of the table provides proportions of participants’ responses (singular agreement, or MATCH, or plural agreement, MISMATCH) when they completed the preamble with a PLURAL nominal, irrespective of the number of the primed nominal. The lower half of the table provides this information for when participants produced a SINGULAR nominal (irrespective of primed nominal number). Examples of completions are provided within the table.

Visual presentations of percentages and counts of responses by participants based on the information in Table 4.5 are presented in Figures 4.4 and 4.5.
Figure 4.4: Percentages of response (match vs. mismatch) by production (construction type x post-verbal nominal number). Responses are presented irrespective of prime number.

Figure 4.5: Counts of response (match vs. mismatch) by production (construction type x post-verbal nominal number). Responses are presented irrespective of prime number.
4.4.5 Analysis

Because the dependent variable is a binomial, the likelihood of mismatch was modeled using a mixed-effect logistic regression model treating subjects and items as random factors (Baayen, 2008; Baayen, Davidson, & Bates, 2008; Jaeger, 2008). The analysis was performed using R statistical software, treating the verb agreement with the singular subject (Match or Mismatch) as the dependent variable. The main variables included the grammatical number value of the post-verbal nominal that the participant produced (plural vs. singular), the construction used (equative vs. transitive), and the interaction between the two. In addition to the main variables of interest, two additional control variables were included that may have contributed to speakers’ choices in verb number production. These two additional variables, which were a result of the experimental design, may have inadvertently contributed to participants’ choices in verb number marking: the lexical subject head noun (thing vs. one—which is considered to be “marked” for singular, and may have thus biased participants to produce a Match response); and subject head noun modifiers beginning with “s” (e.g. *The one sold by the eager salesman…*) which may have caused the participants to misinterpret the head noun as plural (e.g., *The oneS sold…*). The inclusion of the control variables in addition to the main variables of interest resulted in significant improvement to the model ($\chi^2=10.554, p=0.0051$).

4.6 Results

Results from Experiment 1 are presented in Table 4.6.

38 Because initial logistic regression analysis showed the number of the primed nominal and the produced nominal to be significantly correlated (β=3.33, z-value 11.34, p = 2e-16), prime number was not included in the analysis. This decision was confirmed by a likelihood ratio test demonstrating that the inclusion of the primed nominal number as a variable did not significantly improve the model ($\chi^2=0.375, p=0.54$).

39 A decrease in the AIC (Akaike Inclusion Criterion) (228.38 to 221.82) showed the addition of the control variables to improve the model, whereas a slight increase in the more conservative BIC (Bayesian Information Criterion) (253.22 to 254.94) suggests no improvement.
Table 4.6. Experiment 1. Analysis of Maximum Likelihood Estimates of Fixed Effects

| Parameter                                          | DF | Estimate | Standard Error | z value | Pr > (|z|)  |
|----------------------------------------------------|----|----------|----------------|---------|------------|
| Intercept                                          | 1  | -4.2499  | 0.6667         | -6.374  | 1.84e-10 ***|
| Post-verbal Nominal: Plural                        | 1  | 2.4940   | 0.6063         | 4.113   | 3.90e-05 ***|
| Construction: Equative                             | 1  | -1.9676  | 1.2215         | -1.611  | 0.10723    |
| Construction (Equative) * Post-verbal nominal (Plural) | 1  | 5.5659   | 1.3271         | 4.194   | 2.74e-05 ***|
| Subject head noun: Thing                           | 1  | 0.3550   | 0.4530         | 0.784   | 0.43326    |
| S-modifier: Yes                                     | 1  | 1.5513   | 0.4776         | 3.248   | 0.00116 ***|

Results demonstrate that speakers were more likely to produce agreement mismatch (i.e., plural agreement) when producing a plural post-verbal nominal in both equative and transitive constructions. This was shown by a significant positive main effect of produced post-verbal nominal number ($\beta=2.49$, $z$-value 4.113, $p < 0.0001$, 95% CI: 1.306, 3.682). Furthermore, speakers were even more likely to produce agreement mismatch with a plural post-verbal nominal in the equative condition, as demonstrated by a highly significant interaction between the number of the produced post-verbal nominal and the construction type ($\beta=5.57$, $z$-value 4.194, $p < 0.0001$, 95% CI: 2.965,

---

40 While the results of this analysis show that producing a plural post-verbal nominal was correlated with an increase in agreement mismatch in both construction types, because of the inclusion of the interaction between post-verbal nominal and construction type, the coefficient for the main effect of post-verbal nominal ($\beta=2.49$) can only be interpreted when the construction type was transitive (i.e., Construction=0). For an example of interpreting main effects in the presence of an interaction in logistic regression, see UCLA: Statistical Consulting Group (2013a, 2013b).
However, the construction type that speakers used, by itself, did not affect their likelihood of producing agreement mismatch; there was no main effect of construction type. Looking at the control variables, the type of subject head noun that was produced had no effect on the likelihood of a speaker to produce mismatch; there was no main effect of the type of subject head noun (thing or one). Modifier type, however, did matter. If subject modifiers began with /s/ or /z/, participants were more likely to produce agreement mismatch, as shown by a significant main effect ($\beta=1.55$, $z$-value $3.248$, $p = 0.001$, 95% CI: 0.615, 2.487).

4.6 Discussion

Results from Experiment 1 demonstrated a significant effect of post-verbal nominal number produced, such that when speakers produce a plural post-verbal nominal in the context of a transitive construction, they are more likely to produce agreement mismatch. Furthermore, there was a highly significant interaction between post-verbal nominal number and construction type such that this effect of post-verbal nominal number was even stronger in the context of an equative construction. Speakers were overwhelmingly more likely to produce agreement mismatch with a post-verbal plural nominal in the equative condition than they were in the transitive condition: 90.5% of the responses in which speakers produced a plural nominal in the context of an equative construction, displayed plural agreement (mismatch), compared to 30.2% of responses with plural nominals in the context of a transitive construction. Together, these results suggest that the

41 While the use of analysis of variance (ANOVA) with categorical outcome variables is problematic (Jaeger, 2008), it is still commonplace in agreement production research. For the sake of comparison, I performed an analysis of variance on these data, comparing the means of mismatch response proportions in experimental conditions defined by construction type and post-verbal nominal number (i.e., the data shown in Figure 4.4, along with the counts in Figure 4.5, above). This analysis demonstrated that speakers’ likelihood of producing agreement mismatch differed significantly across conditions [$F1(3,82)=93.625$, $p < 2.2e-16$; $F2(3,90)=99.596$, $p < 2.2e-16$]. Post-hoc pairwise comparisons (Tukey HSD) revealed differences between all conditions except between Transitive-SG and Equative-SG. Details are provided in the appendix.
grammatical number of the post-verbal nominal does not have the same effect across different construction types.

The results of Experiment 1 suggest that speakers are much more sensitive to the grammatical form of a post-verbal nominal when that nominal and the subject noun phrase share the same referent. Simply put, semantic information about the message to be communicated directly influences agreement production at the positional processing level by promoting or inhibiting the effects of particular grammatical forms within the construction. These results support a theory of agreement production, and of language production in general, in which semantic and syntactic information (and by extension, information at all levels of linguistic analysis) are deeply intertwined. This is counter to the syntactocentric, stage-based Bock and Levelt model of language production, in which semantic information only provides initial input to the grammatical encoding stage. More specifically, these results counter the syntactocentric models of agreement production, in which the only semantic information involved is the conceptual number of the subject noun phrase during the initial computation of the subject noun phrase number. In the dynamic, interactive approach to agreement production supported by the results of the current experiment, not only can semantic information make direct contributions to agreement processing through the conceptual number of the subject (as discussed in Chapter 2), but it can also contribute by promoting or inhibiting syntactic features that play a role in the agreement process. The semantic function of construction used should have no effect on agreement production, according to the syntactocentric approach. Yet in the current experiment, the semantics of the construction used serve to increase or decrease the influence of the grammatical number of the post-verbal nominal. Agreement production in this approach does not operate strictly within the confines of syntactic structure, nor solely on syntactic principles. Rather, speakers draw upon various sources on information in order to converge upon the form of the verb in the agreement relationship.
Addressing possible alternate explanations. There are a few possible counter-arguments to this explanation from the syntactocentric view, one concerning the role of the conceptual representation of the subject. It may in fact be argued that because the subject and the post-verbal nominal are co-indexed in the equative construction, it is actually the conceptual representation of the subject, and not the number (either grammatical or semantic) of the post-verbal nominal, that is responsible for these effects. How might this be the case? Recall that participants are primed for the number of the post-verbal nominal to be used. It may be the case that when participants are primed to use a plural post-verbal nominal in an equative construction that they then are biased toward a plural conceptual representation of the subject. This conceptualization of the subject as consisting of multiple items then biases the production of the verb toward a plural form. In this scenario, there is no on-line effect of the post-verbal nominal number, but rather, there is an effect of the prime on how the subject is construed.

Patterns in participants’ responses as shown in Table 4.4 suggest that priming is unlikely to be responsible for the results of Experiment 1. While results of a logistic regression analysis showed that prime number was highly correlated with produced number ($\beta =3.33$, $z$-value 11.34, $p = 2e-16$), speakers did not always choose to repeat the number of the primed nominal in their actual productions, that is, the number of the post-verbal nominal produced did not always correspond to the prime. In some cases, participants were primed with a singular nominal, but produced a plural, and vice versa. This resulted in an unequal number of responses of singular and plural post-verbal nominals. Participant responses by construction type and number of post-verbal nominal produced (regardless of the number of the prime) are illustrated in Figures 4.6 (mean counts of participants’ productions) and 4.7 (counts for individual participants).
Figure 4.6. Experiment 1: Mean counts of participants’ productions. Means are with respect to the number of the post-verbal nominal produced (regardless of priming condition). Equ-Pl = Equative construction, plural post-verbal nominal produced; Equ-Sg = Equative construction, singular post-verbal nominal produced; Trans-Pl = Transitive construction, plural post-verbal nominal produced; Trans-Sg = Transitive construction, singular post-verbal nominal produced. Because there were 6 items in each experimental condition, if participants produced a post-verbal nominal that was identical in number to the prime, the means should be equal across each category (6 in each). The asymmetries seen in the figure above indicate that participants sometimes chose to produce a post-verbal nominal with a number differing from the number value of the prime.
Figure 4.7. Experiment 1: Counts of participant productions. Counts are with respect to the number of the post-verbal nominal produced (regardless of priming condition). Equ-Pl = Equative construction, plural post-verbal nominal produced; Equ-Sg = Equative construction, singular post-verbal nominal produced; Trans-Pl = Transitive construction, plural post-verbal nominal produced; Trans-Sg = Transitive construction, singular post-verbal nominal produced. Because there were 6 items in each experimental condition, if participants produced a post-verbal nominal that was identical in number to the prime, the counts should be equal across each category (6 in each). The asymmetries seen in the figure above indicate that participants sometimes choose to produce a post-verbal nominal with a number differing from the number value of the prime.

Crucially, this “switching” from the plural to singular (plural prime $\rightarrow$ produced singular post-verbal nominal) in the context of an equative construction demonstrates that even when speakers are primed with a plural, they prefer to produce a singular post-verbal nominal—and when they do, they do not produce plural (mismatch) agreement.\textsuperscript{42} This trend of producing a singular post-verbal nominal even when primed with a plural nominal is reminiscent of the patterns seen in the corpus study; singular agreement tokens comprised a majority of the mismatch tokens observed. Taken

\textsuperscript{42} Results of a mixed effects logistic regression analysis modeling the likelihood of “switching” (i.e., producing a post-verbal nominal of a different number than the primed nominal) showed a significant interaction between construction type and prime number, such that speakers were likely to switch from a plural prime to a singular post-verbal nominal in the equative condition ($\chi^2=22.806, p = 4.433\times10^{-5}$).
together, these observations suggest an overall preference for speakers to produce singular agreement; this will be addressed briefly in Chapter 7, but is primarily a concern for future research.

If participants’ conceptual representations were being affected by the prime, then we would expect to see agreement mismatch significantly correlated with a plural prime—even if participants produced a singular post-verbal nominal. This did not happen. Nonetheless, questions about the influence of the prime may remain. For this reason, Experiment 3 will directly address the question of whether or not the agreement mismatch productions in this experiment are the result of priming.

Setting aside explanations from psycholinguistic approaches to agreement production, is it possible that the results of this experiment might due to cognitive processes involved during the experiment (i.e., that they are simply experimental artifacts)? In other words, could the difference across conditions be not the result of interactions between syntax and semantics, but rather the result of differences in working memory or attention or strategies across conditions? Two features of the experimental design allow this criticism: the participant’s completion of the subject preamble without the actual repetition of the preamble itself, and an asymmetry in the priming for the two construction type conditions (equative vs. transitive).

The first issue with the experimental design, specifically, not having participants repeat the subject preamble, invites criticism that any mismatch in subject-verb agreement may be due to the participant having misunderstood or forgotten the grammatical form of the subject noun phrase. Research from both Conversation Analysis (CA) and from psycholinguistics, however, suggests that this is unlikely. Recall that the experimental paradigm of having the experimenter produce the first part of the sentence, and then having the participant complete the sentence is designed as a compound turn construction unit (compound TCU, discussed in Section 4.c.) In the CA literature, compound TCUs are defined as having two parts: the preliminary component (the first part of the syntactic unit, produced by the first speaker) and the anticipatory completion (the second part,
produced by the second speaker). Preliminary components provide features that allow the second speaker to successfully produce the anticipatory completion—including features that indicate which form the anticipatory completion will take. Although subject-predicate constructions are not the prototypical examples of compound TCUs, they have been documented and analyzed (Lerner & Takagi, 1999), providing clear evidence that subject noun phrases do indeed provide the grammatical information necessary for speakers to produce anticipatory completions and to successfully produce the appropriate verbal agreement.

Psycholinguistic research also supports the claim that speakers are able to draw upon grammatical information in previously uttered phrases in order to produce grammatical forms. Although it is well-established that listeners/comprehenders quickly lose information about surface structure of sentences that they have heard, they do have a very high retention of structures immediately upon being presented with them (in linguistic stimuli: Anderson, 1974; Jarvella, 1970; Sachs, 1967; in non-linguistic stimuli, where participants are tested on structural left-to-right orientation of visual images: Gernsbacher, 1985), particularly when those structures have occurred within a sentence boundary (Jarvella, 1970). In addition, work by Kempen (2009) on coordinate ellipsis structures in Dutch and German (e.g., subject gapping structures Into the woods went the hunter and ___ shot a hare) suggests that speakers process and make use of all elements of a clause, even if they do not articulate them. In particular cases of ellipsis, speakers can process elided elements of the clause (e.g., elided subjects) during the conceptual and grammatical encoding stages, and draw upon such information to produce other elements of the clause—without actually articulating the elided elements.

43 Priming studies also suggest retention of syntactic form. For example, Levelt and Kelter (1982) show that a question’s surface form can affect the form of an immediate response (e.g., Dutch responders are more likely to use at as in At five o’clock when responding to the question, “At what time do you close?” than when asked “What time do you close?”), even when such forms are of little semantic consequence.
Not only does previous research suggest that it is unlikely that speakers are forgetting the subject preamble; response patterns seen in this experiment also make it unlikely. If speakers were merely forgetting the subject head noun number, they should do so in both equative and transitive conditions. This would make the effect of the interaction between construction and post-verbal nominal number nonsignificant. Furthermore, the switching pattern seen above in Figure 4.6 suggests that speakers are clearly sensitive to the form of the subject noun phrase. Participants specifically switch the number of the prime from plural to singular just in the case that the subject noun phrase is singular and they are using an equative construction. They do this much less in the transitive test conditions (and in the fillers, though the numbers are not reported here).

The second possible criticism that arises from the experimental design is that the significant interaction between post-verbal nominal and construction type is due to the asymmetry in the priming portion of the experiment. Recall that in the equative condition, participants are only primed with the post-verbal nominal that they are to produce. In the transitive condition, participants are primed with both the verb and the nominal. If may be the case that this experimental “priming asymmetry” is responsible for participants’ agreement mismatch patterns (e.g., due to a difference in attention, strategy or cognitive load), and not the on-line process of calculating agreement during the production of these two construction types. If this were the case, however, then we would expect a main effect of construction—speakers should be more likely to produce agreement mismatch in equative constructions overall, and not only when producing plural post-verbal nominals. This was not the case. Nonetheless, the priming asymmetry in the two construction-type conditions allows the possibility that the experimental paradigm may be responsible for the interaction effect. This asymmetry could lead to a difference in attention in the two conditions, a difference in strategy, or perhaps a difference in cognitive load. Each of these will be briefly addressed, and refuted, in turn.
First, the priming asymmetry may have led participants to pay more attention to their agreement production in the transitive condition than in the equative condition. Perhaps when participants are expected to remember two words rather than just one, they pay attention to the entire trial and therefore to the number value of the subject head noun, more than they do when they only have to recall a single primed word. But if speakers’ agreement mismatches were due to a lack of attention in the equative condition we would not expect them to (consciously or otherwise) produce a singular post-verbal nominal when primed with a plural. Presumably they make this switch in an attempt to overcome the competing pressures of the different number specifications of the subject and post-verbal nominal. As discussed above in reference to Figure 4.6, this switching did not occur randomly. Participants tended to switch in one direction (from plural to singular) and mainly in one condition (the equative condition.) This finding suggests that participants were actually paying more attention in the equative condition, recognizing that the plural prime did not match the singular subject head noun, and choosing to change the number of the post-verbal nominal that they produced in order to keep consistency among subject-verb-equative nominal.

Another possibility is that participants developed different strategies in each of the construction (priming) conditions, such that when primed with a verb and a nominal (in the transitive condition), participants decided to produce agreement with the subject head noun, whereas when primed with the nominal alone (in the equative condition), participants immediately calculated the agreement based upon that nominal number, essentially deciding to ignore the number of the subject head noun. Again, the switching from a primed plural nominal to the production of a singular post-verbal nominal suggests that participants’ use of different strategies across conditions is unlikely. This switching pattern suggests that participants were, if anything, more sensitive to the subject head noun number in the equative condition. When presented with a
plural prime nominal, speakers tended to change the number of that nominal to match that of the subject head noun when producing it in the equative condition.

Finally, it may be the case that some difference in cognitive load between the two construction (priming) conditions affected participants in such a way that resulted in the agreement mismatch patterns seen here. However, a difference in cognitive load is unlikely. First, let us assume that an increase in cognitive load results in an increase in likelihood to produce mismatch (an increase in “error” rate). If that were the case, than the results of Experiment 1 would indicate that the equative-plural condition provides a higher cognitive load than the transitive-plural condition (because the equative-plural condition elicits higher rates of mismatch). Essentially, this means that speakers experience a higher cognitive load when asked to recall only one item (the equative nominal) than when asked to recall two (the transitive verb and the object). This conclusion is rather counterintuitive.

In summary, results from Experiment 1 provide clear evidence that under certain conditions, the post-verbal nominal produced by speakers is able to elicit interference effects in subject-verb agreement, and that this effect is mediated by the constructional context in which the speaker produces that nominal element. Crucially, in the case that speakers produce a plural post-verbal nominal in the context of an equative construction, the effect of that plural nominal overrides the effect of the subject head noun on their agreement choices. These results support the claim that a post-verbal nominal can directly affect agreement patterns and that its features do not migrate to the subject NP node prior to being copied onto the verb. These data are consistent with the predictions of the constraint-based approach discussed above.

Following the results of Experiment 1, the question arises, why haven’t such significant effects of a post-verbal nominal been observed in other experimental studies of subject-verb agreement? To some extent, the effect of the post-verbal nominal has been amplified by the
controlled conditions of the experiment.\textsuperscript{44} The use of plural objects to interfere with singular subject head nouns, a technique that has been used in other experiments, helped to amplify the effect. The use of visual picture contexts that allowed for plural conceptualization, another technique that has been used in agreement experiments before (Eberhard, 1999) is also thought to assist in amplifying the effects seen here. The significant effect of post-verbal nominals in the context of equative constructions is still, however, many times larger than might be expected, even under these conditions. Is it possible that post-verbal nominals override subject head nouns in these sentences because the subject head noun itself is somehow “weak” or unable to maintain its number value in the face of the post-verbal noun? In the next experiment, we investigate the possibility that this effect size is due in part to the type of subject head noun—the abstract “thing” or “one”.

\textsuperscript{44} Please note that “amplification” of an effect under the conditions discussed here does not mean that the effect would be otherwise nonsignificant. The effects of the plural post-verbal nominal and the interaction between construction type and post-verbal nominal number produced still may very well be significant under different conditions, but the effect might be smaller, and a much higher number of participants would be necessary in order to demonstrate the significant effects. Consider that the interaction between the post-verbal nominal number and the construction type was still very strongly significant in the corpus study, although the overall rate of mismatch was quite low.
Chapter 5: Experiment 2—The Role of Subject Type

Both the corpus study presented in Chapter 3 and Experiment 1 presented in Chapter 4 demonstrated that speakers are significantly more likely to produce subject-verb agreement mismatch when using a construction with two specific properties: an equative BE-verb and a post-verbal nominal that differs from the subject in terms of the grammatical number feature. The corpus study also suggested an additional feature of the subject noun phrase (which trended toward, but did not reach, significance) that may contribute to the production of this mismatch: an abstract subject head noun, defined as the lexical items thing and one. Experiment 1 did not vary the features of the subject noun phrase, but only investigated the role of the construction type and the post-verbal nominal number. The purpose of Experiment 2, then, is to experimentally investigate the role of lexical semantic features of subject relative to those post-verbal nominal in determining the likelihood of speakers to produce agreement mismatch. In particular, this experiment asks if it is the case that speakers are more likely to produce verb agreement with a post-verbal nominal other than the subject when the subject head noun is less concrete and imageable in comparison to that post-verbal nominal. In other words, unlike previous work investigating the semantics of the subject, this experiment does not look at the semantic properties of the subject in isolation, but relative to other nominals in the context of the entire utterance.

The issue directly addressed by Experiment 2 is the effect on agreement production of the abstract property of the subject head noun. In other words, Experiment 2 investigates the effect of the use of non-concrete, non-imageable subject head nouns thing or one, as compared to more concrete, imageable nouns like flower or car, as in examples (62-63).

62. a. The thing planted under the window…
   b. The flower planted under the window…
63. a. The one sold by the eager salesman...
   b. The car sold by the eager salesman…

Why might the abstractness of the subject head noun influence speakers’ choices in agreement production? Several studies in both the syntactocentric and interactive approaches, reviewed in detail below, have demonstrated that semantic and conceptual information can, to varying degrees, influence agreement production. Types of semantic features that have been shown to influence agreement production include collectivity of subject head nouns (Bock, 1995; Bock et al., 2001; Bock et al., 1999; Humphreys & Bock, 2005), distributivity (Eberhard, 1999; Humphreys & Bock, 2005), animacy (Barker et al., 2001), and concreteness (Eberhard, 1999). If these properties can influence agreement production, it is reasonable to hypothesize that abstractness/concreteness may as well.

As with much of the research in agreement production, all of these studies have been limited to examining nouns within the subject noun phrase; to date, no study has considered conceptual properties in relation to nominals outside of the subject noun phrase. There is reason to believe, however, that the relative abstractness/concreteness of the subject head noun and the post-verbal nominal in equative constructions influence speakers’ choices of agreement morphology. Consider the attested utterances One thing I thought about the other day were batteries and The other one is…are the Saturns, taken from the corpus study. Intuitively, observers may sense that the vague subject head nouns thing and one are “not really what the speaker is talking about” and that speakers are drawn to produce agreement with the more concrete and imageable batteries and Saturns. In other words, when the subject and the post-verbal nominal are co-indexed, as in the equative construction, it may be

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45 Eberhard (1999) investigated the role of concreteness and imageability, but only across subject noun phrases (i.e., subject head nouns that were more imageable than other subject head nouns resulted in an increase in mismatch rates). She did not, however, manipulate the concreteness of subject head nouns relative to other nominals within the same sentence, as this experiment aims to do.
that speakers give greater weight to the grammatical features of the more concrete and imageable noun when producing the agreement morphology of the verb. When the subject head noun is a concrete, imageable noun, it may be more likely to “hold its own” against the pull of the grammatical features of the post-verbal nominal.

Experiment 2 addresses the role of the subject noun phrase in subject-verb agreement mismatch, specifically asking the research question, are post-verbal nominals more likely to override abstract subject head nouns than concrete, imageable ones? In this experiment, the lexical item in the subject head noun position will be varied, presenting participants with subject preambles containing either abstract items (thing and one), or more concrete, imageable lexical items (e.g., flower or car). If agreement production is a syntactocentric process, the relative concreteness or abstractness of the subject to interfering nouns should not affect the degree of interference from those nouns. If, however, agreement production is a dynamic, interactive process, it is possible (but not necessary) that the relative concreteness/abstractness of nouns may interact to determine the extent to which they contribute to subject-verb agreement.

5.1 Is agreement mismatch more likely to occur with abstract subject head nouns than with concrete subject head nouns?

A fair amount of research in the production of subject-verb agreement has addressed the role of semantic and conceptual features of the subject head noun or noun phrase in determining a speaker’s choice of agreement. Results from previous studies are reviewed here, and how the finding can be extended to the effects of post-verbal nominals will be discussed. Predictions will then be discussed regarding whether or not post-verbal nominals are more likely to influence agreement patterns in the presence of an abstract subject head noun than in the presence of a concrete, imageable one. This will be done within the frameworks of both syntactocentric and interactive approaches to agreement production.
5.1.1 Previous research of conceptual properties of subjects

Previous research on conceptual influences on agreement have focused on either properties of the subject noun phrase, including distributivity, imageability and collectivity, or on semantic relationships between nouns within the subject noun phrase. Generally, the syntactocentric approach to agreement production allows for effects of the former but not the latter. The interactive approach allows for both types of semantic information to influence agreement production.

*Distributivity, imageability, and collectivity effects.* The most direct evidence that concreteness and imageability play a role in agreement production has been shown in studies examining the rates of agreement mismatch in sentences containing distributive subject noun phrases. Distributive noun phrases are those containing lexically singular head nouns that indicate a single type distributed over multiple tokens, as in *the stamp on the letters* or *the label on the bottles*. The first study to investigate this issue was conducted by Bock and Miller (1991, Experiment 1), who found no effect of distributivity in English agreement production. Vigliocco et al. (1995) replicated this effect, finding no significant effects of distributivity in English. They did, however, find an effect in Italian. Vigliocco, Butterworth, and Garret (1996) once again replicated the lack of a distributivity effect in English, but found one in Spanish. Finally, Vigliocco, Hartsuiker, Jarema, and Kolk (1996) demonstrated significant effects of distributivity in Dutch and French. Vigliocco, Hartsuiker, Jarema, and Kolk (1996) explain these results in terms of cross-linguistic morphological systems. Because Spanish, Italian, Dutch and French have rich verbal inflection systems where person and/or number features are obligatorily marked on verbs, they claim that the speaker must have direct access to the conceptual as well as grammatical representation of the subject during the production of the verb. English, on the other hand, does not require person or number marking on the verb in many cases, and therefore speakers need only have access to the grammatical subject noun phrase representation.
Eberhard (1999) argues that the different results in cross-linguistic studies are due not to cross-linguistic morphological difference, but to differences in concreteness and imageability of the stimuli used in those studies. Eberhard found that when presenting English-speaking participants with distributive noun phrases that were rated as more concrete and imageable than those used in the Bock and Miller (1991), a significant effect of distributivity emerged. That is, participants were more likely to produce agreement mismatch (a plural verb) when completing a distributive subject noun phrase than a non-distributive one. This effect was consistent whether participants were presented with accompanying pictures (Experiment 1) or not (Experiment 2) and could not be attributed to differences in the instructions given to participants (Experiment 3). Furthermore, Eberhard used a rating task to demonstrate that the English stimuli used in Vigliocco, Hartsuiker, Jarema, and Kolk (1996) studies were considered less concrete and imageable than their Dutch and French stimuli. This finding suggests that Vigliocco, Hartsuiker, Jarema, and Kolk’s replication of the null effect of distributivity in English was not due to the morphological poverty of the English agreement system, but due to the lack of imageability in the stimuli.

In a later study, Humphreys and Bock (2005) revisited the effects of imageability and distributivity on rates of agreement mismatch in English. In their study, they investigate agreement patterns following collective subject noun phrases. Collectives are singular nouns such as gang, jury, and team that depict a group of individuals. Grammatically singular collective nouns are assumed to have both singular and plural conceptual number, and have often been used to examine the effects of conceptual plurality independent of grammatical plurality. Humphreys and Bock (2005) attempted to emphasize either the group (singular) conceptualization or the individual-members (plural) conceptualization by modifying these nouns with varying prepositional modifiers, illustrated by examples (64-65):

64. The gang by the motorcycles…
65. The gang on the motorcycles…
Humphreys and Bock claim that in utterances with collective subject head nouns modified by prepositional phrases like *by the motorcycles*, the collective ‘group’ interpretation is emphasized. When the same collective subject head noun is modified by a “distributive” prepositional modifier like *on the motorcycles*, the image of multiple individuals distributed across several objects is emphasized. This manipulation of subject modification resulted in a significant difference in rates of agreement mismatch, with speakers producing higher rates of (plural) mismatch following the distributive tokens.

The Eberhard (1999) and Humphreys and Bock (2005) findings may be extended to the patterns of mismatch being investigated in the present study, by considering the degree of concreteness/imageability of the subject relative to the post-verbal nominals: in *The thing planted under the window are roses* and *The one sold by the eager salesman are convertibles*, the subject head nouns *thing* and *one* are arguably less imageable than the post-verbal nominals *roses* and *convertibles*. It may be the case that the subject’s abstractness, or lack of concreteness and imageability, contributes to high rates of mismatch by allowing the more concrete post-verbal nominal to dominate the agreement process. If so, it may be the case that such mismatch rates would be diminished if more imageable and concrete nouns (e.g., *flower* and *car*) were used as subject head nouns.

**Semantic overlap effects.** In addition to distributivity and relative concreteness/imageability, another possibly relevant relationship between the subject head noun and the post-verbal nominal is that of semantic overlap—the degree to which the two nouns share semantic features. Barker et al. (2001) demonstrated that speakers are more likely to produce agreement mismatch when the subject head noun and local noun have a high degree of semantic overlap (defined as a “range from
synonyms to simply superordinate or subordinate category relations,” Barker et al., 2001, p. 101).46 For example, speakers produced more agreement errors following preambles similar to (66), where there is a high degree of semantic overlap between the two nouns, than in those similar to (67), where there is less semantic overlap.

66. The canoe by the sailboats…
67. The canoe by the cabins…

Extending these findings to the data examined in this study does not give clear predictions. In such utterances as The thing planted under the window were roses, there is arguably little semantic overlap between the lexical items thing and roses. Replacing the vague, abstract thing with the more concrete lexical item flower results in a higher degree of overlap. There are two possible ways in which such a substitution might affect rates of mismatch being produced. On the one hand, the high degree of semantic overlap could mean that the post-verbal nominal roses presents more competition for the subject head noun flower, which should result in an increase in mismatch rates over the rates in Experiment 1, just as the use of sailboats in (66) results in an increase of error rates as compared to the use of cabins in (67).47 However, it may be difficult to detect an increase over the high rates of mismatch observed in Experiment 1. On the other hand, if speakers are already treating the post-verbal nominal as the “controller” of agreement in the equative construction, then replacing thing with flower may actually present more competition for the plural roses. In other words, if speakers initially assume that the verb should agree with the post-verbal nominal (e.g., roses), then using the subject noun thing should not interfere, whereas the use of a semantically overlapping noun (e.g., flower) might increase the likelihood of producing a singular (i.e., “matching”) verb. This would result

46 The notion of semantic overlap is unfortunately not clearly defined by Barker et al. (2001), who appear to leave it to the reader to intuit “high” and “low” overlap, with no clear quantitative measure.
47 Given that the rates of mismatch in the equative-plural condition in Experiment 1 were quite high, it may be difficult to obtain a significant increase in mismatch rates.
in speakers being pulled to produce lower rates of mismatch (producing correct agreement with the subject *flower*). Despite the lack of clear implications, it is worth considering the role that semantic overlap may play in these tokens here if any change in mismatch rate is observed, because previous research suggests that it is a constraint that speakers are sensitive to during the agreement production process.

**Plausibility effects.** Both distributivity and semantic overlap deal with the type and degree to which lexical-level representations of the subject head noun and local nouns interact during agreement production. At the sentence-level, one semantic feature that has investigated is that of “plausibility”—the degree to which it is plausible that a local noun could be the subject of the verb. For example, in the sentence, “The man by the dog sits down,” both the subject head noun *man* and the local noun *dog* are plausible as subjects for the verb *sits*. If a local noun could possibly be interpreted as the subject for the verb in that sentence, it is possible that it may compete with the subject head noun during agreement production more than implausible local nouns would.

There is limited evidence that plausibility affects speakers’ choices in producing subject-verb agreement. Barker et al. (2001) found no effects of plausibility on agreement. However, they did not manipulate plausibility directly in their experiment, but evaluated its effects based on post-hoc plausibility ratings of the local nouns used in their stimuli. A stronger test comes from Thornton and MacDonald (2003), who experimentally manipulated the plausibility of local nouns embedded in subject noun phrases. They presented speakers with preambles in which either only the subject head noun

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48 As noted in Chapter 4, Section 2.2.2 fn 22, “The use of the term “plausibility” refers to the plausibility of a nominal appearing in a sentence to be the subject of the verb *as it appears in the sentence*, and not the plausibility of the nominal as the subject of the verb in any other form. For example, in *The child ate the apple*, the nominal *apple* is perfectly plausible as the subject of *eat* if the sentence is in the passive voice (e.g., *The apple was eaten by the child*). It is not, however, plausible as the subject of *eat* in the active voice, as it appears in the original sentence.
nour or both the head noun and local noun were a plausible subject for the verb (in the passive voice), as exemplified in (68-69):

68. Head noun plausible: The album by the composers… (PLAYED)
69. Both nouns plausible: The album by the composers… (PRAISED)

Speakers were more likely to produce agreement mismatch (agreeing with the local noun) in utterances in which both nouns were plausible subjects for the verb. These results suggest that speakers do take into account the semantic properties of nouns when producing agreement, and that plausibility as the subject is one such property.

Corroborating evidence comes from another study by Pittman and Smyth (2005), which examined participants’ choices in selecting additional adjectival predicates after already producing utterances similar to those in Thornton and MacDonald (2003). For example, participants were first asked to complete subject preambles in which only the head noun or both head and local noun were plausible subjects for the predicate. They were then asked to continue the sentence by selecting an additional adjectival predicate that would describe only one of the two nouns. Examples are given in (70) and (71):

70. Head noun plausible: The boy by the trees… (PLAYFUL) and (CHUBBY/GREEN)
71. Both nouns plausible: The boy by the trees… (TALL) and (CHUBBY/GREEN)

Results showed a main effect of plausibility in both agreement errors and in predicate selection: participants were more likely to produce errors (e.g., ARE tall) and to select the incorrect adjectival predicate (e.g., GREEN) after producing sentences in which both nouns were plausible subjects for the first predicate than when only the head noun was a plausible subject. They interpret their results to mean that agreement errors are not simply superficial errors in which the incorrect number feature is selected for the verb, but that the local noun is actually reanalyzed as the subject head when plausible.
The plausibility account from these studies does not directly apply to patterns in the data seen here; it is difficult to argue that an isolated lexical item such as *batteries* is a more plausible subject for the copula *BE* than the noun phrase *One thing I thought about the other day*—both are plausible as subjects for this particular verb. However, when combined in a single utterance, speakers may feel that *batteries* is more “subject-like” while the noun phrase *One thing I thought about the other day* is less so. In other words, the plausibility of each noun relative to the other may vary—and this plausibility-as-subject may be what motivates speakers to produce verbs that agree with the post-verbal nominal. If so, it may be the case that replacing *thing* with a more concrete lexical item may make it seem more similar to the post-verbal nominal, and therefore more “subject-like,” and in turn reduce the rates of agreement mismatch in such tokens.

5.1.2 Predictions framed within the syntactocentric and interactive approaches

Although most research in the syntactocentric approach (Bock & Miller, 1991; Humphreys & Bock, 2005) allows for semantic features of the subject referent to contribute to agreement, research in the interactive approach (Barker et al., 2001; Pittman & Smyth, 2005; Thornton & MacDonald, 2003) allows for a broader range of semantic effects. In these studies, the interaction of semantic features of various nouns within the subject noun phrase appears to affect speakers’ rates of agreement mismatch during production: Nouns that are more concrete/imageable than the subject head noun, or have semantic overlap with the subject head noun can interfere with subject-verb agreement, as can nouns that are relatively plausible as subjects of the verb. Given that the results of Experiment 1 demonstrate that the grammatical number of post-verbal nominals can

49 The description “subject-like” is a term that was used by several (non-linguist) native speakers who were asked to describe why these agreement patterns seemed more natural or more acceptable than other agreement errors. The defining properties of “subject-likeness” for these native speakers (e.g., in terms of information structure, topic, or focus) have not been analyzed.
interfere in the agreement process, it is reasonable to expect that the semantic and conceptual features of the post-verbal nominal may as well. In the stimulus items in Experiment 1, the subject head nouns *thing* and *one* are arguably less concrete/imageable than the post-verbal nominals (e.g., *roses* and *convertibles*), have little semantic overlap with them, and may seem less plausible as subjects. These conceptual factors may have been in part responsible for the strong interference effect of the post-verbal nominal on agreement production. Replacing these head nouns with more concrete lexical items that have semantic overlap with the post-verbal nominals (e.g., *flower* and *car*) could reasonably be expected to reduce the interference effect. Thus, in Experiment 2, a significant effect of manipulating the subject head noun type (abstract vs. concrete) would provide additional evidence for an interactive account of agreement production.

A lack of a significant effect of subject type would be more difficult to interpret. On the one hand, a syntactocentric approach predicts that a change in the lexical subject head from an abstract noun to a more concrete one (without a change in discourse reference and therefore conceptual number) in these tokens would have no effect on agreement patterns. Furthermore, syntactocentric approaches do not predict any reason for the semantic properties of the head noun to be measured against a noun outside of the subject noun phrase. Whether or not the subject head noun is more or less concrete, imageable, or plausible as subject than the post-verbal nominal, or whether it has any semantic overlap with the post-verbal nominal should make no difference.

On the other hand, it would be difficult to reconcile a syntactocentric account of null effects in Experiment 2 with the results of Experiment 1, which has already provided strong evidence against a syntactocentric account of agreement production. And although a null effect may be predicted by a syntactocentric approach, it does not rule out an interactive approach. A lack of significant results could simply mean that the semantic weight of the lexical subject head noun does not act as a strong constraint on agreement production in the context of the other constraints in the
utterances of interest to this study. Alternatively, it could be that abstractness is not the property of the subject head noun in these tokens that makes it seem intuitively “less subject like” than the post-verbal nominal to many observers; it may be that speakers are motivated to place less importance to the subject than the post-verbal nominal when producing agreement in these utterances for other reasons, including discourse-pragmatic factors, which cannot be addressed by the current experimental paradigm.

5.2 Experiment 2: Overview

Experiment 2 addresses the question of whether or not speakers are sensitive to the abstractness of the subject head noun relative to the post-verbal nominal when producing agreement in the context of an equative constructions, such that the influence of the post-verbal nominal is more likely to override abstract subject head nouns than concrete ones. Abstract head nouns thing and one in the test stimuli are replaced with more concrete nouns such as flower and car. Experiment 2 used only test items from the equative construction condition in Experiment 1, and not the transitive condition, for two reasons. First, because post-verbal nominals demonstrated a clear and strong effect on agreement patterns in the equative constructions in Experiment 1, it should be easier to see a manipulation of this effect from the subject head noun type, should there be one. Second, because the subject head noun and post-verbal noun are semantically integrated (by the definition in Solomon & Pearlmutter, 2004), it is expected that there should be a stronger interaction between the two than if they were less integrated. In other words, the relative plausibility-as-subject, concreteness/imageability, and semantic overlap of the subject head noun and post-verbal nominal should matter more when the two are conceptually related than when they are not. As an additional benefit, using the items from the equative construction condition in Experiment 1 offers an
opportunity to replicate the high rates of mismatch in equative constructions with plural post-verbal nominals seen in Experiment 1.

Two significant results are predicted. First, it is expected that the effects of post-verbal nominal number in the equative construction seen in Experiment 1 will be replicated such that speakers are more likely to produce agreement mismatch when producing a plural post-verbal nominal. Second, the effect of post-verbal nominal is expected to weaken when the subject head noun is the more concrete lexical item, rather than the abstract thing or one. In other words, there should be a significant interaction between post-verbal nominal number and subject type. There is no reason to expect a main effect of subject type—it is only when the number of the subject and the post-verbal nominal are in conflict (i.e., only in the plural condition) that the concrete subject head noun should reduce rates of mismatch.

5.3 Methods

5.3.1 Participants

Twenty-six native English speakers between the ages of 18 and 26 years old participated. Five participants’ data were excluded: two because they were native bilingual speakers (of Spanish), two because they had taken several courses in Linguistics, and one because of a high number of incorrect responses (10/72) on the picture matching task. Participants were recruited from the University of Colorado Boulder community through flyers and announcements, and received either a payment of $5.00 or course credit for their participation.

5.3.2 Materials

Test items. Twenty-four sets of experimental items were constructed, illustrated by the set in Table 5.1.
Table 5.1. Experiment 2. Example of a test item in each of the four experimental conditions (story context sentences omitted).

<table>
<thead>
<tr>
<th>Condition</th>
<th>Prime</th>
<th>Preamble</th>
<th>TEST: verb produced</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONCRETE-PL</td>
<td>roses</td>
<td>The flower planted under the window…</td>
<td>IS/ARE roses</td>
</tr>
<tr>
<td>CONCRETE-SG</td>
<td>a rose</td>
<td></td>
<td>IS/ARE a rose</td>
</tr>
<tr>
<td>ABSTRACT-PL</td>
<td>roses</td>
<td>The thing planted under the window…</td>
<td>IS/ARE roses</td>
</tr>
<tr>
<td>ABSTRACT-SG</td>
<td>a rose</td>
<td></td>
<td>IS/ARE a rose</td>
</tr>
</tbody>
</table>

The variables manipulated in this experiment were subject head noun type (abstract vs. concrete) and the number value of the post-verbal nominal (singular vs. plural) for a 2x2 crossed design. As a result, each of the twenty-four test items appeared in four conditions: Abstract-SG, Abstract-PL, Concrete-SG, Concrete-PL. Test items were identical to the equative construction items in Experiment 1 except for variations in the subject head noun; half (12) of the test items contained the abstract nouns *thing* (6 items) or *one* (6 items) and half contained concrete nouns. The concrete subject head nouns were the basic-level nouns used in the fillers in Experiment 1. Basic-level category nouns (e.g., *flower*) rather than more nouns naming individual types of objects (e.g., *rose*) were chosen in order to form appropriate subject noun phrases to be equated with the post-verbal nominal. Using individual types would have resulted in pragmatically odd sentences, as illustrated in (72-73):

72. The *flower* planted under the window = roses
73. ?? The *rose* planted under the window = roses
All other elements of the test items (priming materials, story contexts, grammatical number of subjects) were identical to the equative construction test items in Experiment 1. As in Experiment 1, the four versions of each of the 24 experimental items were counterbalanced across four experimental lists, with each list being used in forward and reverse order. Each of the lists contained six items in each of the four experimental conditions. Test items are presented in Table A2 in the Appendix.

_Filler items_. Filler items were identical to the filler items used in Experiment 1 except that the basic-level subject head nouns were replaced with the abstract _thing or one_ in half of the items in each list. Filler items containing _thing or one_ corresponded to the basic-level nouns in half of the test items in each list.\(^5^0\) For example, a filler item with the basic-level noun _bird_ in Experiment 1 would have the subject head noun _one_ in Experiment 2, in the list where _bird_ was used in a test item. Fillers that corresponded to test items in this way always appeared after the test item. Filler items are presented in Table A3 in the Appendix.

_Additional materials_. All other materials (pictures, story contexts, etc.) were identical to those in Experiment 1.

5.3.3 Procedure

The procedure was identical to the procedure in Experiment 1.

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\(^{50}\) As noted in Experiment 1, this design allowed the same basic level nouns to be used for fillers and test items across Experiments 1 and 2. The basic-level category nouns used in filler items for Experiment 1 were used as test items in Experiment 2, whereas Experiment 2 contained filler items with the subject head noun _thing or one_. In this way, both experiments use the same subject head nouns across all items: 12 _thing_, 12 _one_, 24 basic-level category nouns, and 24 other filler nouns. This design allowed for greater comparability across experiments.
5.3.4 Scoring

As in Experiment 1, all test trials (n=504) were transcribed and coded by the Experimenter. The three scoring categories were identical to those in Experiment 1. Of the three categories, *Match* had a total of 358 responses, *Mismatch* had a total of 114 responses, and *Other* had a total of 28 responses. As in Experiment 1, *Other* responses were excluded from the analysis. An additional 4 responses were excluded due to experimenter error.

A total of 472 responses remained. Examples of responses from each scoring category are given in Table 5.2.

<table>
<thead>
<tr>
<th>Scoring Category</th>
<th>Primes</th>
<th>Preamble</th>
<th>Participant response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Match</td>
<td>a teaspoon</td>
<td>The thing chosen by the master chef…</td>
<td>…is a teaspoon</td>
</tr>
<tr>
<td></td>
<td>ballerina</td>
<td>The one featured in the oak cabinet…</td>
<td>…is ballerinas</td>
</tr>
<tr>
<td>Mismatch</td>
<td>dictionaries</td>
<td>The thing passed out by the secretary…</td>
<td>…are dictionaries</td>
</tr>
<tr>
<td></td>
<td>convertibles</td>
<td>The car sold by the eager salesman…</td>
<td>…are convertibles</td>
</tr>
<tr>
<td>Other</td>
<td>an alternator</td>
<td>The generator stored in the back warehouse…</td>
<td>…have alternators</td>
</tr>
<tr>
<td></td>
<td>bells</td>
<td>The ornament joyfully hung on the branch…</td>
<td>…is ringing</td>
</tr>
</tbody>
</table>

Percentages of responses in the categories included in the analysis (Match and Mismatch) by condition (Concrete-SG, Concrete-PL, Abstract-SG, Abstract-PL) and by number of post-verbal nominal produced are given in Table 5.3.
Table 5.3. Experiment 2. Numbers and percentages of responses in Match and Mismatch categories by condition and produced post-verbal nominal number.

<table>
<thead>
<tr>
<th>Experimental Condition (Subject type x Prime Number)</th>
<th>Response Category (Agreement Type)</th>
<th>MATCH</th>
<th>Example response</th>
<th>MISMATCH</th>
<th>Example response</th>
<th>GRAND TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Post-verbal Nominal Number: PLURAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete-SG</td>
<td>MATCH</td>
<td>0</td>
<td></td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete-PL</td>
<td>Example response</td>
<td>2</td>
<td></td>
<td>41</td>
<td></td>
<td>52 (100%)</td>
</tr>
<tr>
<td>Total</td>
<td>2 (3.8%)</td>
<td>The bird …<strong>IS</strong> robins</td>
<td>50 (96.2%)</td>
<td>The bird …<strong>ARE</strong> robins</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstract-SG</td>
<td>MATCH</td>
<td>1</td>
<td></td>
<td>16</td>
<td></td>
<td>176 (100%)</td>
</tr>
<tr>
<td>Abstract-PL</td>
<td>Example response</td>
<td>4</td>
<td></td>
<td>48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5 (7.2%)</td>
<td>The one …<strong>IS</strong> robins</td>
<td>64 (92.8%)</td>
<td>The one …<strong>ARE</strong> robins</td>
<td>69 (100%)</td>
<td></td>
</tr>
<tr>
<td><strong>Post-verbal Nominal Number: SINGULAR</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete-SG</td>
<td>MATCH</td>
<td>105</td>
<td>The bird …<strong>IS</strong> a robin</td>
<td>0</td>
<td>The bird …<strong>ARE</strong> a robin</td>
<td>175 (100%)</td>
</tr>
<tr>
<td>Concrete-PL</td>
<td>Example response</td>
<td>70</td>
<td></td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>175 (100%)</td>
<td>The bird …<strong>IS</strong> a robin</td>
<td>0 (0%)</td>
<td>The bird …<strong>ARE</strong> a robin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstract-SG</td>
<td>MATCH</td>
<td>109</td>
<td></td>
<td>0</td>
<td></td>
<td>176 (100%)</td>
</tr>
<tr>
<td>Abstract-PL</td>
<td>Example response</td>
<td>67</td>
<td></td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>176 (100%)</td>
<td>The one …<strong>IS</strong> a robin</td>
<td>0 (0%)</td>
<td>The one …<strong>ARE</strong> a robin</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>GRAND TOTAL</strong></td>
<td></td>
<td>358 (75.8%)</td>
<td>The bird …<strong>IS</strong> a robin</td>
<td>114 (24.2%)</td>
<td></td>
<td>472 (100%)</td>
</tr>
</tbody>
</table>

The experimental condition is listed in column 1, giving the subject type and the number of the primed nominal (see Table 5.1 for examples). The upper half of the table provides proportions of participants’ responses (singular agreement, or MATCH, or plural agreement, MISMATCH) when they completed the preamble with a plural nominal, irrespective of the number of the primed nominal. The lower half of the table provides this information for when participants produced a singular nominal (irrespective of primed nominal number). Examples of completions are provided within the table.

Visual presentations of percentages and counts of responses by participants based on the information in Table 5.3 are presented in Figures 5.1 and 5.2.
Figure 5.1: Percentages of response (match vs. mismatch) by production (subject type x post-verbal nominal number). Responses are presented irrespective of prime number.

Figure 5.2: Counts of response (match vs. mismatch) by production (subject type x post-verbal nominal number). Responses are presented irrespective of prime number.
5.3.5 Analysis

As in Experiment 1, a mixed-effect logistic regression model treating subjects and items as random factors was performed using R statistical software, treating category (Match or Mismatch) as the dependent variable. The model used in the analysis of Experiment 2 was much simpler than in Experiment 1. Visual inspection of the data suggests that there is no interaction between subject type and number of post-verbal nominal produced (mismatch rates were similar across subject type in both the singular and plural conditions), though there are too few data points of mismatch in the singular post-verbal nominal condition to conduct a reliable analysis. In addition, because participants produced no mismatch responses when producing a singular post-verbal nominal in the concrete subject condition, analysis was limited to those responses in which participants produced a plural post-verbal nominal (n=121).

The only variable of interest was the type of subject head noun (concrete vs. abstract). As in Experiment 1, a likelihood ratio test revealed that inclusion of the number of the primed nominal did not significantly improve the model ($\chi^2=0.696, p=0.7919$). Primed number was therefore not included in the analysis. The control variable of subject head noun modifiers beginning with “s” as in The one sold by the eager salesman… was also omitted from the analysis, as a likelihood ratio test revealed that it did not significantly improve the model ($\chi^2=0.145, p=0.9042$).

5.4 Results

Results from Experiment 2 are presented in Table 5.4.
Results showed that participants were not more likely to produce mismatch when the subject head noun was more abstract relative to the post-verbal nominal. This was shown by a lack of significant effect of subject type (p = .673).\textsuperscript{51}

5.5 Discussion

Results from Experiment 2 replicated the effect of the post-verbal nominal on agreement in equative constructions. As in Experiment 1, speakers were highly likely to produce agreement mismatch (i.e., produce a plural verb) if they produced a plural post-verbal nominal. In Experiment 2, speakers produced agreement mismatch when producing a plural post-verbal nominal 96.2\% of the time in the concrete subject condition, and 92.8\% of the time in the abstract subject condition. When participants produced a singular post-verbal nominal (which matched the subject in number), they never produced agreement mismatch, regardless of the subject type. This replication of the high rates of mismatch with plural post-verbal nominals seen in Experiment 1 supports the interactive...

\textsuperscript{51}As in Experiment 1, I performed an analysis of variance on these data for the purpose of presenting results in a format comparable to other studies in agreement production, despite problems with using ANOVAs to analyze categorical outcome variables (Jaeger, 2008). The ANOVA compared the means of mismatch response proportions in experimental conditions defined by subject type within the plural post-verbal nominal completion (i.e., the data shown in the top half of Table 5.3, above). This analysis demonstrated no significant difference across conditions [F1(1,28)=0.2151, p =.6464; F2(1,40)=0.7357, p =.3962]. Details are provided in the appendix.
approach to agreement production in which the grammatical number of the post-verbal nominal has a strong effect on agreement production in the context of an equative construction.\footnote{It is worth noting that while the rates of mismatch produced in conjunction with a plural post-verbal nominal were comparable to those in Experiment 1, the tendency for speakers to produce a singular nominal (and a matching verb) even when primed with a plural (but not the reverse) was also replicated (speakers produced a singular post-verbal nominal despite being primed with a plural in 137 trials, while producing a plural post-verbal nominal following a singular prime in only 26 trials; see Table 5.3).} Subject type, however, did not matter. In other words, the grammatical number of the post-verbal nominal appears to have a strong effect on agreement regardless of whether it is relatively more or less concrete and imageable than the subject head noun.

The results of Experiment 2, both in terms of visual inspection of the data and the statistical analysis, show a complete lack of effect of subject type. In other words, providing participants with subject preambles containing subject head nouns (e.g., \textit{bird, car}) that were more concrete and imageable relative to the abstract \textit{thing} and \textit{one} did not decrease the likelihood of producing agreement mismatch in general, nor did it decrease the likelihood of producing mismatch in the presence of a plural post-verbal nominal. What does this mean for models of agreement production? As discussed in Section 5.1.2, a significant effect of subject type would have provided further support for an interactive approach to agreement prediction. The lack of effect is in line with predictions from a syntactocentric approach; however, it is difficult to reconcile a syntactocentric account of the null effect of subject type with the very significant effect of post-verbal nominal number in both Experiment 1 and Experiment 2.

In light of the lack of significance of the subject type in Experiment 2, the possibility that information structure contributes to speakers’ preferences to produce agreement with the post-verbal nominal is worth revisiting. The hypothesis that the subject head noun’s concreteness or abstractness would be a significant factor in agreement production was motivated by the intuition that the abstract subject is less salient (less relevant, or perhaps less activated) than the concrete,
imageable post-verbal nominal. It may still be the case that the post-verbal nominals in these utterances are more salient than the subjects during agreement production, but that salience is better captured in terms of information structure than lexical semantics. Information structure, however, was not manipulated in this experiment. Future experimental work is necessary in order to determine the extent to which information structure may play a role in the agreement pattern being investigated here.

Setting aside the possible role of information structure in agreement production, a more immediate, straightforward explanation for the lack of significance of subject type emerges from the experimental design. Experiment 2 was designed to test whether or not singular concrete subject head nouns (e.g., car and flower) were more likely to resist interference effects from plural post-verbal nominals than more abstract head nouns (e.g., thing or one). The experimental paradigm, however, was designed to be a communicative setting in which participants’ conceptualizations of the sentences to be uttered could be strongly influenced through the use of imagery. In this context, the subject preambles were always fairly imageable. Furthermore, the post-verbal nominals were primed using images, making them highly concrete and imageable. These items may have been imageable to such a degree that the relative concreteness or imageability of the subject lexical head noun may not have mattered.

To summarize the experimental work thus far, Experiment 1 demonstrated that post-verbal nominals can, under particular conditions, interfere with subject-verb agreement production, contrary to the claims of previous experimental investigations (e.g., Franck et al., 2006, 2010). Experiment 2 replicated the findings of Experiment 1. Experiment 2 also provided no evidence that the effect of the post-verbal nominal depends upon its conceptual properties as compared to the subject head noun. The lack of an effect of subject head noun type, however, may be due in part to
information structure properties of agreement constructions and in part to the experimental design, specifically the priming of the post-verbal nominal which makes it highly imageable and concrete.

This issue of priming leads to another concern that must be addressed. Given that previous experimental research demonstrated no effect of post-verbal nominals (Franck et al., 2006, 2010) but required that a non-subject nominal be produced prior to the verb in order to interfere, and given that the post-verbal nominals are presented as primed material before the participants’ production of the verb, is it possible that the effects of the post-verbal nominal seen in Experiments 1 and 2 are not the on-line effects of the post-verbal nominal produced, but rather, of the plural prime? Experiment 3 will address this issue.
Chapter 6: Experiment 3—The Role of Priming

The studies presented in this thesis thus far have demonstrated that speakers producing subject-verb agreement are sensitive to number information from a non-subject nominal element in a canonical post-verbal position. Furthermore, the effect of the post-verbal nominal can be strengthened by the semantic function of the construction in which the nominal occurs. When the post-verbal nominal is equated with the subject referent, as in the equative construction, its grammatical features contribute to agreement more than in other constructional contexts. These effects have not been seen before in psycholinguistic research on subject-verb agreement production, and they cannot be explained by the current dominant syntactocentric models of agreement production.

These claims rest on the assumption that the post-verbal nominal interferes with grammatical agreement production on-line—that is, while the speakers are actually producing the utterance and the post-verbal nominal. But in the experimental paradigm, speakers are primed with the item that they are to use to complete the sentence. Speakers have seen, heard, and actually produced the nominal that they will use to complete the utterance prior to even hearing the subject noun phrase preamble. It could be the case, then, that the patterns of agreement mismatch being produced are not due to the on-line contribution of the post-nominal produced. Instead, the rates of agreement mismatch could be due to a priming effect.

6.1 Priming effects in language processing

Priming may be defined as the increased activation of a particular feature (Bock & Loebell, 1990; Branigan, Pickering & Cleland, 2000; Dell, 1985), although in language production (and in syntactic production in particular) it is often discussed in terms of its effect—the increased
likelihood in repeating a particular feature (e.g., syntactic priming is defined as speakers’ tendency to reuse previously encountered structures, without necessarily referencing the psychological mechanisms behind that tendency: Bock, 1986b; Bock, Dell, Chang, & Onishi, 2007; Ferreira & Dell, 2000; Loebell & Bock, 2003; Pickering & Branigan, 1998). Strong evidence for priming in language processing comes from a large number of comprehension and production studies at the lexical level (e.g., Gow Jr. & Gordon, 1995; Hodgson, 1991; Swinney, 1979; Zwitserlood, 1989) as well as at phrasal and clausal levels (e.g., Branigan, Pickering & McClean, 2005; Potter & Lombardi, 1998; Thothathiri & Snedeker, 2008; Traxler, 2008) and across levels (e.g., lexical priming of phrasal structure: Arai et al., 2007; Santesteban, Pickering & McClean, 2010). Lexical and syntactic priming effects are also well documented in psycholinguistic studies of language production, (e.g., Bock, 1986a; Dell & O'Seaghdha, 1991). There is also evidence that priming can occur across comprehension and production (Bock, Dell, Chang & Onishi, 2007; Branigan et al., 2000; Haywood, Pickering & Branigan, 2005) and even across cognitive domains (structural priming from math to language, Scheepers et al., 2011; priming in music, Justus & Bharucha, 2001, see also Patel, 2003).

The question of whether priming is responsible for the effects seen in these studies was previously discussed in Chapter 4, Section 7 but it was addressed indirectly. This final experiment was conducted in order to directly establish whether the effect of the post-verbal nominal number in equative constructions in Experiments 1 and 2 were due to priming or due to the on-line production of the grammatically plural nominal.

6.2 Experiment 3: Overview

Experiment 3 is designed to investigate whether or not the significant likelihood of speakers to produce agreement mismatch when using equative constructions with plural post-verbal nominals, as seen in Experiments 1 and 2, is the result of the priming element in the experimental paradigm.
This was done by continuing to prime participants while adding a condition in which participants do not actually produce the primed nominal. In Experiment 3, just as in the first two experiments, participants were presented with plural and singular primes, but were allowed to complete the subject preamble using either the primed nominal or a predicate adjective (which is not marked for number). If participants produced agreement mismatch in conditions where they complete the utterance with a predicate adjective at rates equal to those in trials in which they complete the subject preamble with the primed nominal, then the results from Experiment 1 and 2 can be attributed to a priming effect. If, however, there was a significant effect of the on-line production of the nominal, then the agreement mismatch patterns seen in the earlier experiments can be attributed to the interaction of semantic and syntactic information during the on-line production of subject-verb agreement.

6.2.1 Changes to the stimuli

Subject noun phrase preambles were identical to those used in Experiments 1 (using the abstract thing/one subject head noun), but changes were made to three primed nominals in test trials and to several of the story context sentences in both filler and test trials. Three of the primed nominals were changed from the specific type names of the object (bangle, russet, and gala) to the basic-level category names that were used as subject head nouns in Experiment 2 (bracelet, potato and apple). This was based on comments from participants in Experiments 1 and 2 that the specific type names were unfamiliar. Adjective primes were also added to each trial. Story context sentences were altered in order to provide a context in which participants could naturally complete the preambles with either a noun or an adjective. Stimuli for Experiment 3 are listed in Tables A4 and A5 in the Appendix.
6.2.2 Changes to the procedure

The basic procedure for Experiment 3 was the same as the procedure used in Experiments 1 and 2, with two changes. First, in each trial, participants saw both an adjective prime and a noun prime, but were asked to use only one of the primes in completing the sentence following the subject preamble. In Experiments 1 and 2, participants used all primed material in the completion task; in Experiment 3, using only one of the primes and disregarding the other may have added some complexity to the task. The second change was that participants were allowed to freely choose which of the primes they could use to complete the sentence. This free-completion procedure was selected as the best method of several piloted procedures. These changes were understood to not affect the results of the experiment, and will be addressed in Section 6.6 (Discussion).

6.3 Methods

6.3.1 Participants

Twenty-eight native English speakers between the ages of 18 and 22 years old participated. Three participants’ data were excluded because they were native bilingual speakers (one of Korean and the other of Spanish), or had extensive immersion in a second language during childhood. An additional participant’s data were excluded due to experimenter error. Participants were recruited from the University of Colorado Boulder community through flyers and announcements, and received either a payment of $5.00 or course credit for their participation.

6.3.2 Materials

Test items. Twenty-four sets of experimental items were constructed, illustrated by the set in Table 6.1.
Table 6.1. Experiment 3. Example of a test item in each of the four experimental conditions (story context sentences omitted).

<table>
<thead>
<tr>
<th>Condition</th>
<th>Prime 1</th>
<th>Prime 2</th>
<th>Preamble</th>
<th>TEST: verb produced along with post-verbal element</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOUN-PL</td>
<td>roses</td>
<td>pink</td>
<td>The thing planted under the window…</td>
<td>IS/ARE roses</td>
</tr>
<tr>
<td>NOUN-SG</td>
<td>a rose</td>
<td>pink</td>
<td></td>
<td>IS/ARE a rose</td>
</tr>
<tr>
<td>ADJ-PL</td>
<td>pink</td>
<td>roses</td>
<td></td>
<td>IS/ARE pink</td>
</tr>
<tr>
<td>ADJ-SG</td>
<td>pink</td>
<td>a rose</td>
<td></td>
<td>IS/ARE pink</td>
</tr>
</tbody>
</table>

The variables manipulated in this experiment were prime order (adjective-first vs. noun-first) and the number value of the noun prime (singular vs. plural) for a 2x2 crossed design. As a result, each of the twenty-four test items appeared in four conditions: Adjective-SG, Adjective-PL, Noun-SG, Noun-PL. Subject noun phrase preambles in test items were identical to the equative construction items in Experiment 1. Story contexts were adapted to allow participants to complete subject preambles naturally with either the noun or adjective prime.

The presentation order of adjectives and nouns was counterbalanced across four experimental lists, with each list being used in forward and reverse order. Each of the lists contained six items in each of the four experimental conditions.

**Filler items.** Filler item subject preambles were identical to those used in Experiments 1 and 2. New primes for filler items were constructed such that all items had one noun prime and one adjective prime. Adjective primes included typical adjectives (e.g., *wild, vicious, precise*) and participial adjectives (e.g., *brewed, sizzling, charred, overflowing*) in order to maintain many of the primes used in Experiments 1 and 2. Half of the noun primes were singular, and half were plural. Order of prime presentation (adjective-first or noun-first) was balanced, with half of the items displaying the
adjective-first order. Story contexts for the filler items were adapted to bias the completions to either an adjective or noun completion, with half biased toward noun completions.

Additional materials. Picture contexts were adapted as necessary to fit the new story contexts, following the same criteria described in Experiment 1. As in Experiment 1, in test trials, the picture corresponding to the preamble always contained three copies of the image for the primed nominal (regardless of the prime being singular or plural.)

6.3.3 Procedure

The procedure was identical to the procedure in Experiment 1, with the exception that participants were instructed to complete the subject preambles using only one, and not both, of the primes. Participants were instructed to complete the preambles as quickly and naturally as possible, and were told that both responses were equally acceptable.

6.3.4 Scoring

As in Experiments 1 and 2, all test trials (n=600) were transcribed and coded by the Experimenter. The three scoring categories were identical to those in Experiment 1. Of the three categories, Match had a total of 407 responses, Mismatch had a total of 152 responses, and Other had a total of 37 responses. As in Experiments 1 and 2, Other responses were excluded from the analysis. An additional 4 responses were omitted due to experimenter or technical error. Examples of responses from each scoring category are given in Table 6.2.
Table 6.2. Experiment 3. Examples of participant responses in each category.

<table>
<thead>
<tr>
<th>Scoring Category</th>
<th>Primes</th>
<th>Preamble</th>
<th>Participant response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Match</td>
<td>dull, teaspoons</td>
<td>The thing chosen by the master chef…</td>
<td>…is a teaspoon</td>
</tr>
<tr>
<td></td>
<td>a bracelet, expensive</td>
<td>The thing worn by the fashion model…</td>
<td>…is expensive</td>
</tr>
<tr>
<td>Mismatch</td>
<td>shiny, bells</td>
<td>The thing joyfully hung on the branch…</td>
<td>…are bells</td>
</tr>
<tr>
<td></td>
<td>outdated, a dictionary</td>
<td>The thing passed out by the secretary…</td>
<td>…are outdated</td>
</tr>
<tr>
<td>Other</td>
<td>comfortable, a recliner</td>
<td>The thing placed in the common room…</td>
<td>…is co-…is a</td>
</tr>
<tr>
<td></td>
<td>a latté, cold</td>
<td>The one ordered by the manager…</td>
<td>recliner.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>…is coffee.</td>
</tr>
</tbody>
</table>

Responses were first coded according to completion type: adjective completion or noun completion. Proportions of response completions are given in Table 6.3 (total responses across participants) and illustrated in Figure 6.1 (response counts by participant).

Table 6.3. Experiment 3. Numbers and percentages of response by completion type.

<table>
<thead>
<tr>
<th>Completion Type</th>
<th>MATCH</th>
<th>Example response (Agreement Type)</th>
<th>MISMATCH</th>
<th>Example response (Agreement Type)</th>
<th>GRAND TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADJ</td>
<td></td>
<td>100 (75.8%)</td>
<td>32 (24.2%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>...IS</td>
<td>pink</td>
<td>...ARE</td>
<td>pink</td>
<td></td>
</tr>
<tr>
<td>NOM</td>
<td></td>
<td>307 (71.9%)</td>
<td>120 (28.1%)</td>
<td>(a) rose(s)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>...IS</td>
<td>(a) rose(s)</td>
<td>...ARE</td>
<td>(a) rose(s)</td>
<td></td>
</tr>
<tr>
<td>GRAND TOTAL</td>
<td>407 (72.8%)</td>
<td></td>
<td>152 (27.2%)</td>
<td></td>
<td>572 (100%)</td>
</tr>
</tbody>
</table>
Figure 6.1. Experiment 3: Counts of adjectival and nominal responses by participant. Counts are with respect to the item (adjective or nominal) used to complete the utterance in each test trial (Completion type).

Percentages of responses in the categories included in the analysis (Match and Mismatch) are given in Tables 6.4 and 6.5 based on completion type.

Table 6.4. Experiment 3. Numbers and percentages of responses for ADJECTIVE completions (by PRIME number).

<table>
<thead>
<tr>
<th>Prime Number</th>
<th>Example Prime</th>
<th>MATCH</th>
<th>Example response</th>
<th>MISMATCH</th>
<th>Example response</th>
<th>GRAND TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>SG</td>
<td>pink…a rose</td>
<td>52 (83.9%)</td>
<td>…IS</td>
<td>10 (16.1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>pink…roses</td>
<td>48 (68.6%)</td>
<td>pink</td>
<td>22 (31.4%)</td>
<td>pink</td>
<td></td>
</tr>
<tr>
<td>PL.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GRAND TOTAL</td>
<td></td>
<td>100 (75.8%)</td>
<td>32 (24.2%)</td>
<td>132 (100%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 6.5. Experiment 3. Numbers and percentages of responses for NOMINAL completions (by PRIME and PRODUCED number).

<table>
<thead>
<tr>
<th>Prime Number</th>
<th>Example Prime</th>
<th>Response Category (Agreement Type)</th>
<th>Example response</th>
<th>Example response</th>
<th>GRAND TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MATCH</td>
<td>MISMATCH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-verbal Nominal Number: PLURAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SG</td>
<td>pink…a rose</td>
<td>0</td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PL</td>
<td>pink…roses</td>
<td>6</td>
<td>96</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TOTAL 6 (4.8%) …IS roses 120 (95.2%) …ARE roses 126 (100%)

Post-verbal Nominal Number: SINGULAR

<table>
<thead>
<tr>
<th>Prime Number</th>
<th>Example Prime</th>
<th>Response Category (Agreement Type)</th>
<th>Example response</th>
<th>Example response</th>
<th>GRAND TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MATCH</td>
<td>MISMATCH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SG</td>
<td>pink…a rose</td>
<td>192</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PL</td>
<td>pink…roses</td>
<td>109</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TOTAL 301 (100%) …IS a rose 0 (0%) …ARE a rose 301 (100%)

GRAND TOTAL 307 (71.9%) 120 (28.1%) 427 (100%)

As in Experiments 1 and 2, participants did not always produce a nominal with a grammatical number matching that of the prime. In some cases, participants were primed with a singular nominal, but produced a plural, and vice versa. This resulted in an unequal number of responses of singular and plural post-verbal nominals, in the trials where participants used a nominal to complete the utterance. Participant responses by number of primed and post-verbal nominal produced are illustrated in Figure 6.2.
For the final analysis, trials were excluded in which the grammatical number of the produced nominal differed from that of the primed nominal. This was because adjective completions cannot be coded for grammatical number, so there is no possible coding for “grammatical number of the produced item.” The only items included in the analysis from the noun completions are those in which the grammatical number of the completion matched that of the prime. Total numbers are given in Table 6.6, and these were the items that were used in the analysis.
Table 6.6. Experiment 3. Numbers and percentages of responses in which the number of the prime nominal matched the number of the produced nominal.

<table>
<thead>
<tr>
<th>Prime Number</th>
<th>Example Prime</th>
<th>MATCH</th>
<th>Example response</th>
<th>MISMATCH</th>
<th>Example response</th>
<th>GRAND TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Response Category (Agreement Type)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Adjective</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SG</td>
<td>pink…a rose</td>
<td>52 (83.9%)</td>
<td>10 (16.1%)</td>
<td>62 (100%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PL</td>
<td>pink…roses</td>
<td>48 (68.6%)</td>
<td>22 (31.4%)</td>
<td>70 (100%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>100 (75.8%)</td>
<td>32 (24.2%)</td>
<td>132 (100%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Nominal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SG</td>
<td>pink…a rose</td>
<td>192 (100%)</td>
<td>0 (0%)</td>
<td>192 (100%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PL</td>
<td>pink…roses</td>
<td>6 (5.9%)</td>
<td>96 (94.1%)</td>
<td>112 (100%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>198 (67.3%)</td>
<td>96 (32.7%)</td>
<td>294 (100%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GRAND TOTAL</td>
<td>298 (70.0%)</td>
<td>128 (30.0%)</td>
<td>426 (100%)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Visual presentations of percentages and counts of responses by participants based on the information in Table 6.6 are presented in Figures 6.3 and 6.4.

Figure 6.3: Percentages of response (match vs. mismatch) by production (completion type x prime nominal number). Prime nominal number corresponds to post-verbal nominal number in this analysis.
Figure 6.4: Counts of response (match vs. mismatch) by production (completion type x prime nominal number). Prime nominal number corresponds to post-verbal nominal number in this analysis.

6.3.5 Analysis

Due to the zero-count of mismatch responses in the nominal singular condition (where participants were primed with a singular nominal and completed the subject preamble with a singular nominal), the problem of “complete separation” exists in the data (see Allison, 2008; SAS Institute Inc., 2010; UCLA Statistical Consulting Group, 2013c; Webb, Wilson, & Chong, 2004). This is a problem that is said to often occur with small data sets when one level of a predictor variable or combination of predictor variables predicts the outcome variable completely. In this case, a singular prime in the nominal condition perfectly predicts a failure to produce mismatch. Because of the lack of responses in the singular nominal condition, it is impossible to compute a maximum likelihood estimate for the variables involved. Strategies for dealing with complete separation of the data include omitting the variable involved, or collapsing categories within the variable if it makes sense.
to do so. Because the variable of interest here is the interaction between response type and primed number, these strategies are not ideal. Nonetheless, two mixed effects logistic regression analyses were conducted. The first was an analysis of the main effect of prime number (SG vs PL), collapsing across response type (NOM vs. ADJ). The second was an analysis of response type (NOM vs. ADJ) within the plural prime categories. Patterns observed by visual inspection of the data will also be discussed.\textsuperscript{53}

6.4 Results

Collapsing across response type, there was a main effect of prime number ($\beta =4.58$, $z$-value $10.484$, $p < 0.0001$, 95% CI: 3.724, 5.437), as shown in Table 6.7. These results suggest a priming effect; speakers are overall more likely to produce agreement mismatch when primed with a plural nominal.

Table 6.7. Experiment 3. Analysis of Maximum Likelihood Estimates of Fixed Effects (Main effect of prime number)

| Parameter              | DF | Estimate | Standard Error | z value | Pr > (|z|) |
|------------------------|----|----------|----------------|---------|----------|
| Intercept              | 1  | -3.8198  | 0.4800         | -7.958  | 1.75e-15 *** |
| Prime number: Plural   | 1  | 4.5807   | 0.4369         | 10.484  | <2e-16 *** |

Within plural prime categories, there was a main effect of response type ($\beta =4.45$, $z$-value 6.379, $p < 0.0001$, 95% CI: 3.158, 5.748), as shown in Table 6.8. These results suggest that mismatch is not due solely to priming; speakers are more likely to produce agreement mismatch when

\textsuperscript{53} It is worth noting that even one response in the nominal singular condition would allow for a mixed-effects logistic regression analysis, and would reveal a marginally significant positive effect of prime number=PL, a significant negative effect for completion type = NOM, and a highly significant positive interaction between prime number and completion type.
producing a plural post-verbal nominal than when producing an adjective to complete the subject preamble, despite being primed with a plural in both cases.

Table 6.8. Experiment 3. Analysis of Maximum Likelihood Estimates of Fixed Effects (Main effect of response type within plural prime categories)

| Parameter             | DF | Estimate | Standard Error | z value | Pr > (|z|)   |
|-----------------------|----|----------|----------------|---------|------------|
| Intercept             | 1  | -1.1613  | 0.4302         | -2.699  | 0.00695 ** |
| Response type: Nominal| 1  | 4.4529   | 0.6607         | 6.379   | 1.59e-11 ***|

Visual inspection of the data supports these claims. The percentages reported in Table 6.6 suggest that the agreement patterns that speakers produce when primed with singular or plural nominals depends on how they complete the utterance (with an adjective or a nominal.) This is shown by the difference in proportions of mismatch following singular and plural primes corresponding to the completion type. Following a plural prime, nominal completions had a much higher rate of mismatch than in the adjective completion (94.1% in nominals compared to 31.4% in adjectives); this suggests a positive interaction between prime=PL and completion type=Nominal. Following a singular prime, however, the opposite pattern occurred: participants produced fewer cases of mismatch in the nominal completions than in adjective completions (0% in nominals compared to 16.1% in adjectives, suggesting a negative main effect of completion type). In both adjective and nominal completions, participants were more likely to produce mismatch following a plural prime than a singular prime (Adjectives: 31.4% vs. 16.1%, Nominals: 94.1% vs. 0%, suggesting a main effect of prime number=PL).
6.5 Discussion

First, it is worth noting that the rates of mismatch in the noun completion condition were similar to those in Experiments 1 and 2, once again replicating those results.

Results from Experiment 3 support the claim that the grammatical number of the post-verbal nominal in equative constructions affects agreement production on-line, and not just as a matter of priming in the experimental paradigm. This is demonstrated by what appears to be an interaction between the completion type and the number of the primed nominal: participants produce much higher rates of (plural) agreement mismatch following a plural primed nominal when actually producing a nominal in the completion of the sentence than when producing an adjective. A logistic regression analysis of response type further supports this claim.

There is, however, some evidence of a priming effect over and above the effect of the interaction between completion type and primed number, demonstrated by the overall increase in mismatch following plural primed nominals, and further supported by a logistic regression analysis of prime number, collapsing across adjective and nominal completions. In other words, even when completing the subject preamble with an adjective, speakers are more likely to produce agreement mismatch than when primed with a singular nominal—even though there are no plural nouns in the constructed sentence to exert an attraction effect. The exact locus of this priming effect is unclear. It could be that the plural prime somehow biases the speaker toward a plural conceptualization of the subject referent, and that in turn, this conceptual plurality is responsible for the increase in mismatch rates in the adjective completion. Alternatively, it could be the case that the plural prime nominal activates a plural grammatical feature that interferes with the agreement production process. This would be akin to a speech error—all nouns in the sentence are singular, so any influence from grammatical plurality must come from an outside source, and cannot be explained in terms of the
normal agreement production process. In any case, whether the source of the priming effect is grammatical or conceptual is a matter for future investigation, and will not be discussed further here.

Results indicate one more effect worth considering—an effect of completion type. Following a plural prime, participants were much more likely to produce mismatch in the nominal completion, but following a singular prime, the opposite occurred. Participants actually produced fewer agreement mismatches in the nominal completion than in the adjective condition. In other words, it’s not just the case that only the influence of the plural prime gets an extra boost in the nominal condition. Actually producing the noun, which is overtly marked for grammatical number, strongly influences participants to produce agreement with that number—both singular and plural.54 This is challenging to the syntactocentric approach. In that approach, the material produced outside of the subject noun phrase should have little to no effect—particularly if the material has no plural number feature to pass along the syntactic hierarchy (i.e., producing a singular nominal shouldn’t matter more than producing an adjective that isn’t marked for number). This effect is, however, predicted by the interactive approach, and is consistent with the accounts of results in Experiments 1 and 2. The equative construction, which serves to equate the subject with the post-verbal nominal, boosts the grammatical features of the post-verbal nominal, allowing it to contribute to the agreement process.

There may be some concern that the changes in the experimental paradigm may be responsible, at least in part, for the results of Experiment 3. It is possible that the adapted procedure, in which participants are presented with two primes but are asked to use only one in the completion of the sentence, may add cognitive load to the task, which may indirectly contribute to error rate.

54 It should be noted that when completing the subject preamble using a nominal, participants did not always produce a nominal with the same number value as that of the prime. As in Experiments 1 and 2, when primed with a plural nominal, participants occasionally chose to produce a singular (109 of 301 response) and (less frequently) vice versa (24 of 126 responses) as illustrated in Table 6.5.
This concern is entirely reasonable. Using only one of the primes requires suppressing or inhibiting the other. The difficulty of inhibiting one of the primes may be increased by the decision process; Participants are not explicitly instructed to use one prime or the other, but must independently select the prime to use.

If cognitive load is responsible for mismatch in this experiment, there should be a comparable rate of mismatch across all conditions. But the apparent interaction between prime (produced) nominal number and completion type suggests that the effect of the on-line production of plural nominals in the equative construction is over and above any effects of cognitive load. In addition, there was an absence of any mismatch in the nominal singular condition. Finally, the comparability of agreement mismatch rates with plural nominals in equative construction across all three experiments (Experiment 1: 90.5%, Experiment 2: 96.2%, Experiment 3: 94.1%) suggests that the cognitive load has had very little effect on the rates of mismatch in this particular version of the experiment.

In summary, the results of Experiment 3 corroborate the results of the corpus study and Experiments 1 and 2 to support an interactive account of agreement production, in which semantic properties of the utterance that are not directly related to agreement features can interact with syntactic processing to promote or inhibit the contribution of relevant grammatical features. In the next and final chapter, the implications of these results for models of agreement production and for grammatical encoding in general, will be discussed.
Chapter 7: General Discussion and Conclusion

When describing a language, we are describing what speakers actually produce. The inventory of a language system—its sounds, its grammatical forms, its syntax—are all productions of the speakers creating the language. Understanding the psychological mechanisms by which speakers create that language is a key part of understanding the language itself. Such an understanding includes explaining not only how speakers produce canonical forms, but also speech errors, and patterns in-between—variations that appear to break prescriptive rules, but that are produced systematically and predictably.

The corpus and experimental studies reported in this dissertation investigated the role of elements outside of the subject noun phrase in subject-verb agreement production, and in particular, the production of agreement mismatch: cases in which the grammatical number of the verb does not match that of the subject. The major findings can be summarized as follows: first, in spontaneous language use, speakers are more likely to produce agreement mismatch when the subject noun phrase and another noun phrase that has a different grammatical number from the subject refer to the same discourse item, as in the example, [One thing I thought about the other day]-SG were-PL batteries-PL (Chapter 3, the corpus study). Second, experimental studies were able to replicate this effect; this type of mismatch seen in spontaneous, natural language use was reliably elicited in a controlled experimental setting. In the experimental setting, however, speakers were shown to demonstrate sensitivity to the grammatical number of a post-verbal nominal whether or not that post-verbal nominal referred to the same discourse item as the subject noun phrase. For example, producing the plural nominal robins led speakers to produce a plural verb are after the subject noun phrase The one nesting in the leafy tree (…are robins), but so did the plural nominal in the verb phrase eating worms (e.g., The one nesting in the leafy tree are eating worms). Nonetheless, speakers were much more likely to produce agreement mismatch when the subject noun phrase and the post-verbal nominal were equated in the
discourse (e.g., *The one nesting in the leafy tree = robins*) (Chapter 4, Experiment 1). This sensitivity that speakers displayed to the grammatical number of post-verbal nouns did not appear to be because the subject nouns were more abstract than those post-verbal nouns. In other words, the plural noun *robins* did not lead speakers to produce a plural verb following *The one nesting in the leafy tree…* just because “robins” is more imageable and concrete than the subject noun “one”; it was just as likely to do so following a more concrete subject noun (e.g., *The bird nesting in the leafy tree…*) (Chapter 5, Experiment 2). Finally, the agreement mismatch that speakers produced in the experimental setting were not the result of priming the speakers with plural nouns during the experimental procedure (Chapter 6, Experiment 3).

The remainder of this chapter will be devoted to briefly discussing these findings and their implications for psycholinguistic approaches to agreement production, grammatical encoding, and language production in general. I will also briefly discuss the implications of the innovative experimental paradigm used in the experimental studies presented in this thesis, and will suggesting future avenues of research investigating the interaction of different types of information during language production.

### 7.1 Implications for psycholinguistic approaches to agreement production

The major findings of this dissertation have several implications for psycholinguistic approaches to agreement production. The first and most important is that the production of subject-verb agreement involves integrating a greater amount of information than only that which is encoded in the subject noun phrase. Even though the grammatical dependency that is being produced is that of subject-verb agreement, speakers demonstrate sensitivity to the syntactic and semantic number of nominals outside of the subject noun phrase, and to the semantic functions of the constructions used when the grammatical dependency is produced.
The finding that constructional semantics plays a role in determining which nominal may have more or less influence in agreement production highlights a second implication for agreement production: semantic information other than that directly related to number can impact number agreement. Previous research has demonstrated that nominal elements within the noun phrase that are closely semantically related to the subject head noun (e.g., being semantically integrated with or having overlap of semantic features with the subject head noun; Barker, Nicol, & Garrett, 2001; Solomon & Pearlmutter, 2004) are more likely to contribute to agreement. This is the first study to show (to the best of my knowledge) that the semantic relationship between the subject and a nominal outside of the subject noun phrase can affect the likelihood of producing agreement mismatch. These studies have shown that constructional semantics interact with the syntactic properties of nominals in the utterance by allowing the properties of one nominal (here, the post-verbal nominal) to play a larger role in agreement than those of another (in this case, the subject noun phrase).

Although this research has demonstrated that constructional semantics can influence the grammatical encoding processes of agreement production, the agreement mismatch patterns observed and elicited in the studies presented here may not necessarily be constructional features per se. In other words, it may or may not be the case that the effect of the post-verbal nominal on the production of verb agreement morphology is the result of a construction that specifically licenses the verb to agree with the post-verbal nominal. It may be the case that the agreement patterns observed here are licensed by the construction, in a fashion similar to the post-verbal agreement licensed by locative inversion and THERE-existential constructions. On the other hand, it could be the case that a conceptual relationship between nominals increases the likelihood that grammatical information about the post-verbal nominal will be processed in parallel with that of the subject, and therefore interfere with agreement. The extent of the work presented here simply demonstrates that
speakers are sensitive to, and can be influenced by, information outside of the subject noun phrase when producing agreement. This finding in and of itself makes an important contribution to psycholinguistic research in production; but it does not offer conclusive evidence for the existence of a unique agreement construction. If the effects seen in this study are the result of constructional licensing (rather than general processing mechanisms whereby grammatical forms that are simultaneously activated are more likely to compete), is a matter for future research, and would require a much more careful and detailed description of the construction at work—including constraints on argument structure, information structure, and motivation for the production of mismatch patterns (see Bresnan, 1994, for an example of such analysis of locative inversion constructions).

The investigation of the lexical semantic property of abstractness/concreteness of the subject head noun relative to that of the post-verbal noun showed no effect on speakers’ likelihood of producing agreement mismatch. This finding led to a discussion of what other linguistic properties may account for native speaker intuitions that agreement mismatch seems more acceptable following abstract subject head nouns like *thing* or *one*. Information structure features such as topic and focus were briefly considered, and although the corpus and experimental studies of this dissertation did not fully investigate these features, it was suggested that future research in this area would be worthwhile in improving our understanding of how speakers produce agreement. It may be possible that the information structure properties of the utterance being produced lead to some nominal elements (and hence the relevant grammatical and semantic properties of those nominal elements) to be more or less activated during agreement production.
7.1.1 Activation-based accounts of agreement production

Given this picture of agreement production as an interactive process in which various types of activated information contribute to a particular production choice, it does not make much sense to treat agreement as a “feature copy” process, during which information about the subject is copied onto the verb. A more appropriate metaphor might be that of a “converging” process, where all information that is relevant to the subject-verb relationship converges during the production of the verb to determine its form. This metaphor of “information converging” rather than “feature copying” allows us to more easily think of agreement as a process in terms of spreading activation in production (e.g., Dell, 1986, inter alia): various sources of information that are activated (e.g., semantic plurality of the subject, grammatical singularity of the subject, the plural grammatical number of a post-verbal nominal that is co-indexed with the subject referent) spread that activation to the number of the verb to be produced.

Activation-based accounts of agreement production have been proposed before, in various formats. Eberhard (1997, pp. 161-162) discusses the effect of the plural number feature of local nouns in terms of its being present or absent (activated or not). Eberhard et al.’s (2005) the quantitative version of the Marking and Morphing Model describes the effects of the semantic and syntactic features on agreement production in terms of their activation strength. Haskell and McDonald (2003) describe agreement mismatch in terms of competition between two activated verb forms (plural and singular). These models are still limited, however, in their assumptions that the information activated during the agreement production process is primarily limited to information about the subject referent. The studies presented in this dissertation illustrate that the grammatical (and possibly semantic) features of nominals outside of the subject noun phrase can also be activated during agreement production, and that their activation can be strengthened or weakened.
by their semantic relationship with the subject referent, as determined by the construction in which they appear.

7.1.2 Scaling up

An important characteristic of any successful model of production that has been tested using a few particular production phenomena is whether or not it can scale up to explain the wider variety of forms produced throughout the language. I have argued here that an interactive account of agreement production is the best possible explanation for the production of the agreement mismatches investigated here. But is it the best possible explanation for the variety of agreement phenomenon seen throughout languages of the world? A wide variety of agreement patterns remain to be examined experimentally, not just in terms of controller-target relationships (e.g., subject-verb, noun-determiner, noun-adjective), but also in terms of features (number and gender have been addressed experimentally, person has not, and the less understood features of case, definiteness, respect, and tense/aspect/mood as discussed in Corbett, 2006, pp. 133-138 have not even been considered).

Most certainly, research on agreement production must be expanded to include more languages. But for now, a future course of research may simply involve a more thorough understanding of the variation of agreement patterns observed in English. This thesis has presented effects not seen before by starting from observations about agreement patterns seen in spontaneous language use that have not been observed in experimental studies; there are still many contradictions between agreement produced in the lab and agreement produced “in the wild” that remain to be addressed. One contradiction hinted at in the studies presented here concerns an asymmetry between plural and singular mismatch. In experimental studies, the strongest interference effects have come from plural nominals. Plural nouns have been shown time and again to be more likely to
interfere with subject-verb agreement with singular subjects than vice versa (e.g., Barker et al., 2001; Bock & Miller, 1991; Bock & Eberhard, 1993; Eberhard et al., 2005; Vigliocco et al., 1995; Vigliocco et al., 1996; inter alia). Yet in the corpus study presented in Chapter 3, it was noted that a majority of mismatch cases were instances of singular agreement. The experiments also demonstrated, indirectly, a preference for singular agreement. While there was a strong effect of post-verbal nominal number, such that speakers overwhelmingly produced a plural verb when producing a plural post-verbal nominal, there was a preference for singular agreement in the equative condition, which speakers maintained by choosing to produce a singular post-verbal nominal even when primed with a plural (see Section 4.6, Figures 4.6 and 4.7, and fn 43). Thus, whereas experimental accounts of agreement claim that the plural is a “marked” form (see Section 2.2.1 for discussion), which easily interferes with unmarked singular forms, the studies presented here suggest that singular agreement is in some cases preferred, perhaps being an entrenched, default form of agreement (see Corbett, 2006, pp. 147-151 for a discussion of default agreement in various languages.)

We must be careful not to be building models that account primarily for language produced in an experimental setting (consider, for example, that the Marking and Morphing model is evaluated solely on the basis of experimental data, and not observations of distributional properties of agreement mismatch in spontaneous language use; see Eberhard et al., 2005, pp. 545-552.) While well-controlled experiments based on carefully constructed (if unnatural) stimuli are absolutely necessary for developing accounts of language processing, we must constantly check those accounts against the language that speakers actually produce in spontaneous use. Scaling agreement models up is going to require both an increase in breadth (considering a wider range of languages) and depth (looking more carefully at variation within languages that are currently being examined.)

It may be the case that a more developed model in the syntactocentric approach can handle discrepancies between agreement in spontaneous language and experimentally-elicited language, as
well as variation in agreement production cross-linguistically, eliminating the need for an interactive approach. It could do so by simply expanding the types of features, controllers, and targets, within the model (essentially taking a general, “Copy Feature X from Controller Y to Target Z” approach).

A larger challenge to syntactocentricism comes from variation in domains and conditions of agreement. Domains—the syntactic conditions under which agreement is produced—may be non-canonical, for example, in cases where the verb agrees partially with the subject head noun, and partially with a possessive in certain cases (Corbett 2006, pp. 59-70). Conditions—factors which affect agreement, but are not reflected by agreement (e.g., animacy and other properties; see Corbett, 2006, Ch. 6) also would seem difficult for syntactocentric accounts, as they include semantic or pragmatic constraints on the application of agreement procedures to a syntactic form. Given the wide variation of agreement patterns across languages, as well as the increasing amount of evidence for dynamic interaction of information sources in language processing in general, an interactive approach holds the most promise for explaining how agreement, and language in general, is produced. This, of course, remains a topic for future research.

7.1.3 Alternate explanations

I have argued that the findings presented here present a significant challenge to the syntactocentric approach to agreement production, but naturally, the question arises: Is there a way that the syntactocentric approach can account for these results? To counter the claims of this dissertation, a syntactocentric approach would have to demonstrate that the interaction of the construction type with plural post-verbal nominal number is not responsible for the increased rates of mismatch in the equative condition over the transitive condition. One possible explanation would be that the grammatical form (and possibly semantic number) of the post-verbal nominal has nothing to do with agreement mismatch rates; instead, the construal of the subject referent or the
incorrect assignment of nominals to the subject role must be responsible. This has been a common counter-argument to evidence of interactive processes involved in language production (e.g., Bock & Miller’s, 1991, p. 74 discussion of animacy effects, addressed above in Section 2.2, and Brehm & Bock’s 2013 response to Solomon & Pearlmutter, 2004). Applied to the findings here, a syntactocentric approach would conjecture that speakers are more likely to produce agreement mismatch in the equative condition because they construe the subject as plural. The production of the plural post-verbal nominal in such an account would have no effect on the verb (or no more than in the transitive condition); it is merely a reflection of the conceptual number of the subject. After all, the subject and post-verbal nominal are co-indexical in the equative construction, so the claim that the post-verbal nominal merely reflects the construal of the subject—and does not actually affect agreement production—seems to make sense.

But a closer look reveals that this claim is a virtual Pandora’s box for the syntactocentric approach. Results of the studies presented here show a very strong interaction between post-verbal nominal number and construction type. In the equative condition, the verb agreement marking almost always coincides with the number of the post-verbal nominal. To claim that in all of these cases agreement is actually driven by the conceptual representation of the subject (of which the post-verbal nominal number is simply a reflection) is to claim, essentially, that agreement in the equative construction is semantically driven. That is an interactive explanation: It says that subject-verb agreement is a primarily syntactic process in most declarative constructions, except in the case of an equative, when suddenly semantic information becomes the primary determinant of agreement. Whether or not this is actually the case needs to be addressed by future experimental work. Such research would require holding the grammatical form of the post-verbal nominal constant while
conceptual information is varied by some means other than manipulation of grammatical or lexical form.\footnote{In almost all previous experimental studies on subject-verb agreement production, conceptual and grammatical/lexical number have been conflated. That is, the lexical item is assumed to have a particular conceptual number—either expressed by the number features of the noun, or by the lexical type (e.g., collective nouns, mass nouns, pluralia tantum). Conceptual number has not been measured independently of the assumptions of what the lexical item itself expresses. (The only exception is perhaps Eberhard, 1999, who used picture stimuli in one of her experiments.)}

For now, a more elegant and straightforward explanation emerges from the interactive approach. The strong interaction between post-verbal nominal number and the equative construction suggests that the semantic function of the construction (to equate two nominals) allows the post-verbal nominal number to play a greater role in subject-verb agreement than it would in other constructions. This finding provides evidence in favor of an interactive approach to subject-verb agreement production, in which semantic and syntactic information from both nominal elements and the construction used when the agreement is produced interact to determine the production of agreement morphology of the verb. Semantic information from the construction at the message level can permeate the grammatical encoding process, influencing which grammatical elements will have more or less influence during the agreement production process.

The interactive approach is not, however, a semantically-driven one. Perhaps ironically, the interactive approach actually allows syntax more freedom than the syntactocentric approach does in accounting for variations in agreement production. A syntactocentric approach can only explain the semantic influences seen in agreement variation through the construal of the subject referent. As more and more such examples of variation are presented to the syntactocentric approach, more and more power has to be given to semantic construal of the referent. In other words, when semantics and syntax diverge, verb agreement appears to follow semantic information; when semantics and syntax coincide, it may as well be said that semantics is still the driving force (since the two are
confounded). In the face of agreement mismatch that cannot be explained by interference from local grammatical nouns, the syntactocentric approach appears to be actually moving toward a semantic account of agreement production. An interactive account, on the other hand, allows semantics to contribute directly to agreement (in cases where agreement actually reflects the construal of the subject) but does not place the full burden on semantics to account for such a wide variation in agreement patterns. In such utterances as One thing I thought about the other day were batteries, semantic information actually allows a greater range of syntactic features to contribute to agreement production—in this case by promoting the grammatical number of the post-verbal nominal.

7.2 Implications for models of grammatical encoding and language production: Interaction, incrementality and parallelism, and scope of planning

Taking a step back from agreement production and considering the implications of the findings presented in this thesis for models of grammatical encoding and language production at large, it would seem that the stages of grammatical encoding, and language production in general, are not as encapsulated or specialized as the syntactocentric approach claims. Syntax and semantics appear to be deeply intertwined. Not only does grammatical encoding make use of semantic information as input for form retrieval (for example, integrating semantic number during agreement production, or more generally, mapping concepts to lexical items during lexical retrieval); grammatical encoding may also make reference to semantic information as a guide for syntactic processes, where semantic forces may promote or inhibit the influence of various grammatical features.

The interactive account blurs the strong divisions between conceptual and grammatical encoding (and presumably between grammatical and phonological encoding as well). This is not to say, however, that there are not “stages” of production, at least in the sense that some elements of an utterance to be produced may be processed earlier than others. Far too much evidence from
speech error research and elicited production experiments has been put forth in favor of stage-based production to dismiss the basic 3-stage skeletal architecture of language production in the name of interactivity. This blurring between stages and strong interaction between semantics and syntax does, however, bring us to the issues of incrementality and scope of planning during language production (see Bock, 1995, p. 198; Brown-Schmidt & Tanenhaus, 2006, p. 593), both of which are intimately tied to the timing of processing during production.

Incrementality refers to the piecemeal nature of language production and the order in which units are planned at each stage of processing; we need not plan an entire utterance before initiating speech. Rather, the production mechanism can begin processing information as soon as it becomes available (Bock, 1995; Kempen & Hoenkamp, 1987; Rohde, 2002). Scope of planning refers to the size of the unit being planned, or roughly, how far ahead the speaker is planning. A variety of factors may affect how large of a unit speakers are able to plan before onset of speech (Allum & Wheeldon, 2007; Brown-Schmidt & Tanenhaus, 2006). Studies of incrementality and scope of planning in production have typically used elicitation of speech errors (e.g., Coppock, 2010), word order, measurements of onset latency (e.g., Allum & Wheeldon 2007; Levelt & Maasen, 1981), or more recently, tracking of eye movements (Brown-Schmidt & Tanenhaus, 2006) as methods of investigating the timing, order, and size of units involved in conceptual and grammatical encoding.

Incrementality and scope of planning are also reflected in agreement production. Essentially, the semantic integration effects on agreement production reviewed in Chapter 5 (Solomon & Pearlmutter, 2004), in which local nouns that are more tightly integrated semantically with subject head noun are more likely to cause agreement mismatch (e.g., flowers in the drawing of the flowers as compared to the drawing with the flowers), can be explained in terms of incrementality & scope of planning. According to Solomon and Pearlmutter, semantically integrated nominals within the subject noun phrase (i.e., within the scope of planning for that unit in the utterance) are likely to be
processed within a similar timeframe (which relates to incrementality). The timing and scope of processing results in competition between the two nominals during the production of agreement. This competition between nominals and their agreement features is responsible for an increase in error rates in agreement production (but see Brehm and Bock, 2013, for an alternate account of the effects of semantic integration).

What do the current findings presented in this thesis have to say about scope of planning and incrementality? First, plural post-verbal nominals were shown to significantly increase the likelihood of speakers to produce agreement mismatch. This effect of the post-verbal nominal suggests that when speakers are producing the verb with its agreement features, the elements of the verb phrase are within the scope of planning, and affect the production of the verb. Although this conclusion may seem obvious, it is something that has been neglected in the subject-verb agreement production literature. Previous studies have focused almost solely on elements within the scope of the subject noun phrase. Second, post-verbal nominals in equative constructions, which are very highly semantically integrated with the subject referent, are more likely to influence agreement than post-verbal nominals in transitive constructions, which are typically less semantically integrated with subject. If, as Solomon and Pearlmutter (2004) claim, nominal elements that are semantically integrated with the subject are likely to be processed in parallel with the subject, as reflected by agreement mismatch, then it follows that the subject and the post-verbal nominal are simultaneously activated, being processed in parallel.

In a final comment regarding the implications of the findings of this thesis for language production at large, it must be noted that only one side of the story has been told. Although the findings presented in this thesis have been discussed in support of an interactive approach to agreement production, and to language production in general, they only demonstrate how semantic

56 Except, perhaps, in cases of reflexives, e.g., *He calmed himself.*
information interacts with syntactic processes. The reverse, how syntactic information can feedback into semantic processes, has not been discussed. The role of syntactic information in semantic processing is beyond the scope of the corpus and experimental studies here. The results do, however, raise questions for future investigation. For example, is it possible that marking the post-verbal nominal as plural early in grammatical encoding (during functional processing) feeds back to the conceptualization of the subject referent, causing it to be construed as a plural? Could the singular subject head noun influence speakers to construe the post-verbal nominal as singular, because speakers overwhelmingly preferred to produce singular post-verbal nominals in the equative condition, as indicate by the “switching” preferences discussed in Chapter 4, Section 7? Or do speakers simply prefer to produce nominals with matching grammatical forms when using the equative construction? These questions remain to be addressed using careful experimental methods that can detect differences in conceptual processing independently of grammatical form during online production.

7.3 Concluding remarks and future directions

This thesis has examined a particular instance of agreement mismatch, non-canonical grammatical dependency in English: cases of non-subject agreement in equative constructions. I have argued here that a language production architecture that allows a dynamic interaction of syntactic and semantic information is better equipped to explain variation in agreement production than an architecture that constrains the use of a limited amount semantic information to only the very early functional processing stage of grammatical encoding. The greater implication is that any

57 Recall that while the syntactocentric allows for conceptual plurality of the subject referent to influence agreement production, a plural construal of the subject referent that results from interaction with syntactic information is still counter to the syntactocentric approach.
production model based on the investigation of a narrow scope of grammatical forms may not have a full picture of how speakers produce language in spontaneous, natural communicative contexts.

It is worth noting that these findings presented and the implications for psycholinguistic models of agreement production emerged from a somewhat unconventional approach. Rather than starting from the theoretical models of agreement production and designing stimuli to test the models based on previous examined linguistic forms, I began by exploring the agreement that speakers actually produce in spontaneous language use. Following the corpus study, I used an innovative adaptation of a well-established experimental paradigm, working with participants in a situation that was more communicative than the simpler preamble-completion paradigm typically used in agreement production experiments. The strong interaction of syntax and semantics that emerged through the use of this communicative paradigm naturally leads to the question of whether or not the lack of effects of semantic information in previous studies has been due to task effects: when participants are essentially asked to make good sentences in a test-like environment, they may be more focused on producing grammatically acceptable utterances than they would in a natural, communicative situation. This is a question for future research. In any case, the future of agreement production research must include a wider range of methods in order to more clearly investigate the separate role of semantic and syntactic information. In order to fully understand the role of semantic and conceptual information, methods that can tease apart semantic concepts from grammatical forms (such as the use of images rather than linguistic forms) will be necessary. The work here has contributed to the development of agreement production research not only by establishing new methods, but also by presenting results that can only be further addressed through new methods.

Taken together, these findings point toward a dynamic view of agreement production in which various sources of information interact and converge upon an appropriate linguistic form, joining a large body of research in the interactive (or constraint-based) approach to language
processing. But the question still remains as to whether these findings can be unified into a coherent, falsifiable model of agreement production. Agreement may be the result of interacting features of the utterance being produced, but do we have a principled way of determining which features will interact, and how they will interact. I believe that the research presented and reviewed in this dissertation suggests fruitful directions for future research.

We have seen syntactocentric studies demonstrating that structural distance determines the strength of effects of grammatical features of local and object nouns. It is this structural distance that provides the syntactocentric Marking and Morphing model with a way to quantify these effects. In that model, semantic or conceptual effects are limited to a single variable representing the construal of the subject referent.

Research in the interactive approach, however, suggests that the strength of the effect of nominal grammatical features in the utterance on agreement production is not just determined by their syntactic distance from the subject referent, but also by their semantic relationship with it. The more closely related a nominal is to the subject referent, the more likely it is to interfere. Semantic distance is unfortunately much more difficult to quantify than syntactic distance. Lexical production research would seem to provide some hope. A fair number of studies demonstrate that lexical items that are semantically related are more likely to activate each other at various points in time in the course of production, as reflected by reaction times and priming studies (e.g., Belke, Meyer, & Damian, 2005; Levelt et al., 1991, Levelt et al., 1999; Schriefers et al., 1990) or semantic substitution errors (e.g., Caramazza & Hillis, 1990; Dell, 1985, 1986; Harley & MacAndrew, 2001; see also Dell et

As Eberhard et al. (2005, p. 543) note, “The model treats number information like a source of activation in activation-based cognitive models. When a source of number information is bound to a temporary structural network for an utterance, it transmits its information to the structure. Within the structure, the information moves or spreads according to principles of structural organization, assembly, and dissolution. Because these principles are at best poorly understood, only one of them, structural distance, is represented in the model.”
al., 2008; Oppenheim, Dell, & Schwartz, 2010). But semantic relationships between items in utterances are defined by more than lexical semantics—they are defined by the semantics of the message. How then can an interactive approach to agreement production begin to put semantics in some sort of measurable framework and move toward a quantifiable, falsifiable model of agreement production?

The answer may lie in examining the constructional semantics of the utterances in which agreement is produced. Exactly how the semantic relationships expressed in constructions might be quantified and framed within an activation-based model of production to the same degree that has been done with structural relationships is not yet entirely clear, but the directions in which we should go are a bit more so. Psycholinguistic research has turned to formal linguistic theoretical work in syntax before, but that work has been mostly in the Chomskyan tradition, which does not recognize constructions as idiosyncratic and conventionalize form-function pairings. There is, however, formal work in construction-based grammars (for example, Sign Based Construction Grammar: Michaelis, 2013; Sag, 2012), and this may provide some answers regarding how to formalize semantic relationships such that they can be described within an activation-based framework of agreement production.

The work presented in this dissertation has not made use of formal construction-based grammars in describing the constructional semantics. But it has engaged in a discussion of how the basic meaning conveyed by a construction can interact with grammatical forms to affect agreement production. Even this initial investigation of the use of constructions in production has been illuminating. This dissertation has shown that by widening the scope of investigation in subject-verb agreement production to go beyond the subject and consider a broader range of syntactic and semantic influences, we may gain a better understanding of how speakers produce this grammatical dependency. It has also suggested that examining how syntactic and semantic features interact in
other constructional contexts may lead to a better understanding of how speakers produce the range of grammatical forms that comprise their languages. Future work in this area must now be concerned with more precisely defining those features and examining their influence on speakers’ productions in both naturalistic and experimental settings.


Ferreira, V. S., & Dell, G. S. (2000). Effect of ambiguity and lexical availability on syntactic and


dissertation.


### Appendix

**Table A1: Experimental stimuli for Experiment 1: Test items**

<table>
<thead>
<tr>
<th>Item</th>
<th>Equative Prime (SG/PL)</th>
<th>Transitive Prime (V + SG/PL)</th>
<th>Context</th>
<th>Preamble</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>a russet/russets</td>
<td>accompanying a steak/steaks</td>
<td>The customers have selected their preferred entrées. The vegetable prepared by the chef completes the hearty meal.</td>
<td>The one served hot by the prompt waiter…</td>
</tr>
<tr>
<td>2</td>
<td>an Oreo/Oreos</td>
<td>squishing a sandwich/sandwiches</td>
<td>Turkey sandwiches have been packed for the children's lunches. Mom carelessly tosses in a treat for dessert.</td>
<td>The one added at the last minute…</td>
</tr>
<tr>
<td>3</td>
<td>a fedora/fedoras</td>
<td>hiding a price tag/price tags</td>
<td>Men's vintage clothing and apparel have been displayed around the store. A bow tie sits out by the register.</td>
<td>The thing set by the tall mannequin…</td>
</tr>
<tr>
<td>4</td>
<td>a convertible/convertibles</td>
<td>displaying a license plate/license plates</td>
<td>The auto industry's consumer reports have been released. A particular vehicle ranks highly among the younger generation this year.</td>
<td>The one sold by the eager salesman…</td>
</tr>
<tr>
<td>5</td>
<td>a teaspoon/teaspoons</td>
<td>measuring a spice/spices</td>
<td>Cooking classes have started. A knife slices onions on the cutting board.</td>
<td>The thing chosen by the master chef…</td>
</tr>
<tr>
<td>6</td>
<td>a rose/roses</td>
<td>losing a petal/petals</td>
<td>The neighbors have been working in their gardens all summer. The old oak tree shows off its autumn color.</td>
<td>The thing planted under the window…</td>
</tr>
<tr>
<td>7</td>
<td>a robin/robins</td>
<td>eating a worm/worms</td>
<td>Birds have begun singing this spring morning. A sparrow hops through the tall grass.</td>
<td>The one nesting in the leafy tree…</td>
</tr>
<tr>
<td>8</td>
<td>a gala/galas</td>
<td>cracking an egg/eggs</td>
<td>The women have dropped their produce into their baskets. The fruit looks ripe and sweet.</td>
<td>The one quickly picked by one shopper…</td>
</tr>
<tr>
<td>9</td>
<td>a monarch/monarchs</td>
<td>pollinating a blossom/blossoms</td>
<td>Winged insects have come to the garden. A chrysalis hangs from one leaf.</td>
<td>The one resting gently on a twig…</td>
</tr>
<tr>
<td>10</td>
<td>a Barbie/Barbies</td>
<td>baking a cake/cakes</td>
<td>The children have gotten out their toys. A Transformer action figure stands on the boy's desk.</td>
<td>The one played with by the little girl…</td>
</tr>
<tr>
<td>11</td>
<td>a recliner/recliners</td>
<td>seating a visitor/visitors</td>
<td>The retirement home's rooms have been comfortably furnished. A radio plays old-time music in a resident's room.</td>
<td>The thing placed in the common room…</td>
</tr>
<tr>
<td>12</td>
<td>a gecko/geckos</td>
<td>scaring a dog/dogs</td>
<td>Small pests have invaded these hills. A garter snake basks in the sun on the path.</td>
<td>The one staring at the young hiker…</td>
</tr>
<tr>
<td>13</td>
<td>a latté/lattés</td>
<td>leaving a mark/marks</td>
<td>Morning meetings have begun in the offices. A secretary hurriedly hands out each drink from the café.</td>
<td>The one ordered by the manager…</td>
</tr>
<tr>
<td>14</td>
<td>a thoroughbred/thoroughbreds</td>
<td>swatting a fly/flies</td>
<td>The millionaire's pastures have been mowed. A stable stores riding gear and hay in the middle of the property.</td>
<td>The thing grazing in the green pasture…</td>
</tr>
<tr>
<td>15</td>
<td>a dictionary/dictionaries</td>
<td>covering a document/documents</td>
<td>The bosses have filled the office with supplies. A photocopier runs in the corner.</td>
<td>The thing passed out by the secretary…</td>
</tr>
<tr>
<td>16</td>
<td>an alternator/alternator</td>
<td>powering a conveyor belt/conveyor belts</td>
<td>The workers have arrived at the sites. A forklift drives around in the parking lot.</td>
<td>The thing safely stored in the back warehouse…</td>
</tr>
<tr>
<td>17</td>
<td>a bangle/bangles</td>
<td>flashing a diamond/diamonds</td>
<td>The paparazzi have started photographing the celebrities. A designer cape covers the movie star's shoulder.</td>
<td>The thing worn by the fashion model…</td>
</tr>
<tr>
<td>18</td>
<td>a ballerina/ballerinas</td>
<td>tying a shoe/shoes</td>
<td>The artists have depicted women in various activities. The woman in the painting brushes her hair.</td>
<td>The one featured in the oak cabinet…</td>
</tr>
<tr>
<td>19</td>
<td>a black widow/black widows</td>
<td>spinning a web/webs</td>
<td>These abandoned houses have fallen into disrepair. A rat lurks near the floorboard.</td>
<td>The thing waiting in the dark corner…</td>
</tr>
<tr>
<td>20</td>
<td>a bell/bells</td>
<td>touching a pinecone/pinecones</td>
<td>The holidays have arrived. A decorated Christmas tree lights up the room.</td>
<td>The thing joyfully hung on the branch…</td>
</tr>
<tr>
<td>21</td>
<td>a terrier/terriers</td>
<td>chasing a squirrel/squirrels</td>
<td>Dogs have become the most common pets in this area. A Labrador waits outside the neighborhood café.</td>
<td>The one barking loudly in the yard…</td>
</tr>
<tr>
<td>22</td>
<td>an alarm/alarms</td>
<td>waking a guest/guests</td>
<td>The tourists have spent the night in luxurious hotel rooms. A down comforter lays across the bed.</td>
<td>The thing set on the short nightstand…</td>
</tr>
<tr>
<td>23</td>
<td>a rifle/rifles</td>
<td>startling a horse/horses</td>
<td>The actors have re-enacted a scene from the Wild West. A bonnet hides one woman's face.</td>
<td>The thing packed in the cowboy's wagon…</td>
</tr>
<tr>
<td>24</td>
<td>a Picasso/Picassos</td>
<td>delighting a curator/curators</td>
<td>The museums have displayed the works of art. A pedestal holds a famous sculpture.</td>
<td>The one shown on the gallery wall…</td>
</tr>
</tbody>
</table>
Table A2: Experimental stimuli for Experiment 2: Test items. Only equative primes were used. Context sentences (omitted here) were identical to those used in Experiment 1.

<table>
<thead>
<tr>
<th>Item</th>
<th>Prime (SG/PL)</th>
<th>Concrete subject</th>
<th>Abstract subject</th>
<th>Preamble</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>a russet / russets</td>
<td>The potato</td>
<td>The one</td>
<td>...served hot by the prompt waiter…</td>
</tr>
<tr>
<td>2</td>
<td>an Oreo / Oreos</td>
<td>The cookie</td>
<td>The one</td>
<td>...added at the last minute..</td>
</tr>
<tr>
<td>3</td>
<td>a fedora / fedoras</td>
<td>The hat</td>
<td>The thing</td>
<td>...set by the tall mannequin…</td>
</tr>
<tr>
<td>4</td>
<td>a convertible / convertibles</td>
<td>The car</td>
<td>The one</td>
<td>...sold by the eager salesman…</td>
</tr>
<tr>
<td>5</td>
<td>a teaspoon / teaspoons</td>
<td>The spoon</td>
<td>The thing</td>
<td>...chosen by the master chef…</td>
</tr>
<tr>
<td>6</td>
<td>a rose / roses</td>
<td>The flower</td>
<td>The thing</td>
<td>...planted under the window…</td>
</tr>
<tr>
<td>7</td>
<td>a robin / robins</td>
<td>The bird</td>
<td>The one</td>
<td>...nesting in the leafy tree…</td>
</tr>
<tr>
<td>8</td>
<td>a gala / galas</td>
<td>The apple</td>
<td>The one</td>
<td>...quickly picked by one shopper…</td>
</tr>
<tr>
<td>9</td>
<td>a monarch / monarchs</td>
<td>The butterfly</td>
<td>The one</td>
<td>...resting gently on a twig…</td>
</tr>
<tr>
<td>10</td>
<td>a Barbie / Barbies</td>
<td>The doll</td>
<td>The one</td>
<td>...played with by the little girl…</td>
</tr>
<tr>
<td>11</td>
<td>a recliner / recliners</td>
<td>The chair</td>
<td>The thing</td>
<td>...placed in the common room…</td>
</tr>
<tr>
<td>12</td>
<td>a gecko / geckos</td>
<td>The lizard</td>
<td>The one</td>
<td>...staring at the young hiker…</td>
</tr>
<tr>
<td>13</td>
<td>a latte / lattes</td>
<td>The coffee</td>
<td>The one</td>
<td>...ordered by the manager…</td>
</tr>
<tr>
<td>14</td>
<td>a thoroughbred / thoroughbreds</td>
<td>The horse</td>
<td>The thing</td>
<td>...grazing in the green pasture…</td>
</tr>
<tr>
<td>15</td>
<td>a dictionary / dictionaries</td>
<td>The book</td>
<td>The thing</td>
<td>...passed out by the secretary…</td>
</tr>
<tr>
<td>16</td>
<td>an alternator / alternators</td>
<td>The generator</td>
<td>The thing</td>
<td>...stored in the back warehouse…</td>
</tr>
<tr>
<td>17</td>
<td>a bangle / bangles</td>
<td>The bracelet</td>
<td>The thing</td>
<td>...worn by the fashion model…</td>
</tr>
<tr>
<td>18</td>
<td>a ballerina / ballerinas</td>
<td>The figurine</td>
<td>The one</td>
<td>...featured in the oak cabinet…</td>
</tr>
<tr>
<td>19</td>
<td>a black widow / black widows</td>
<td>The spider</td>
<td>The thing</td>
<td>...waiting in the dark corner…</td>
</tr>
</tbody>
</table>
20 a bell / bells The ornament The thing ...joyfully hung on the branch…
21 a terrier / terriers The dog The one ...barking loudly in the yard…
22 an alarm / alarms The clock The thing ...set on the short nightstand…
23 a rifle / rifles The gun The thing ...packed in the cowboy's wagon…
24 a Picasso / Picassos The portrait The one ...shown on the gallery wall…
Table A3: Experimental stimuli for Experiments 1 and 2: Filler items. In Experiment 1, all preambles used concrete lexical head nouns. In Experiment 2, half of the filler items in each list had the subject head abstract noun *thing* or *one* when the concrete noun matched that of a test item. For example, filler item (25) would use the abstract noun *one* when it appeared in a list where test item (5) displayed the concrete subject noun *spoon*.

<table>
<thead>
<tr>
<th>Item</th>
<th>Prime 1</th>
<th>Prime 2</th>
<th>Context</th>
<th>Preamble</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>a bell</td>
<td>ringing</td>
<td>The siblings are playing at making music. The baby bangs on pots and pans with a stick.</td>
<td>The spoon (one) in the toddler's hand…</td>
</tr>
<tr>
<td>26</td>
<td>∅</td>
<td>roasting</td>
<td>The campers are cooking up a great meal with lots of vegetables. The soup in the pot is boiling.</td>
<td>The potato (one) in the fire…</td>
</tr>
<tr>
<td>27</td>
<td>a top hat</td>
<td>∅</td>
<td>The magician has set up all of his props. A deck of cards and a wand are on the table.</td>
<td>The hat (thing) next to the cape…</td>
</tr>
<tr>
<td>28</td>
<td>smoke</td>
<td>emitting</td>
<td>The factory is in disrepair. The machines are quite old.</td>
<td>The generator (one) that is breaking down…</td>
</tr>
<tr>
<td>29</td>
<td>∅</td>
<td>waving</td>
<td>The nursery is filled with interesting toys. One of the wind-up toys plays music.</td>
<td>The doll (one) that runs on batteries…</td>
</tr>
<tr>
<td>30</td>
<td>an espresso</td>
<td>∅</td>
<td>Snacks and beverages are set out. The hot drink in the mug is peppermint tea.</td>
<td>The coffee (one) that is steaming…</td>
</tr>
<tr>
<td>31</td>
<td>children</td>
<td>entertaining</td>
<td>The librarian has lots of activities planned for the reading hour. Displays of books are on every shelf.</td>
<td>The book (one) in her lap…</td>
</tr>
<tr>
<td>32</td>
<td>∅</td>
<td>floating</td>
<td>Professional landscapers have designed the local park. Benches line the path.</td>
<td>The flower (thing) in the fish pond…</td>
</tr>
<tr>
<td>33</td>
<td>a mustang</td>
<td>∅</td>
<td>From the ranch, you can see the wild west. A hawk soars in the deep blue sky.</td>
<td>The horse (thing) beyond the river…</td>
</tr>
<tr>
<td>34</td>
<td>bridesmaids</td>
<td>carrying</td>
<td>The wedding party is traveling to the reception. The bride and groom are going in a horse-drawn carriage.</td>
<td>The car (thing) that is driven by the chauffer…</td>
</tr>
<tr>
<td>35</td>
<td>∅</td>
<td>breaking</td>
<td>The jewelry box has tipped over. The earrings are all mixed up.</td>
<td>The bracelet (thing) that falls to the floor…</td>
</tr>
<tr>
<td>36</td>
<td>an angel</td>
<td>∅</td>
<td>Grandmother has many knick-knacks. Thimbles line the kitchen cabinet.</td>
<td>The figurine (thing) that stands on the shelf…</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>berries</td>
<td>picking</td>
<td>Animals are fattening up for the fall. Squirrels are gathering nuts. The birds (ones) in the bushes…</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>∅</td>
<td>warming</td>
<td>Mom prepares after-school snacks. Muffins sit on a plate on the counter. The cookies (ones) in the oven…</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>cats</td>
<td>∅</td>
<td>The boutique sells appliances that look like animals. The alarms on the counter are ducks. The clocks (ones) on the wall…</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>wings</td>
<td>flapping</td>
<td>The garden is buzzing with insects. The birds collect pollen. The butterflies (ones) that land on the fence…</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>∅</td>
<td>falling</td>
<td>Dirty bowls crowd the counter. Old pieces of fruit sit here and there. The apples (ones) that were knocked by her elbow…</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>stools</td>
<td>∅</td>
<td>The lounge is decorated in a classic style. A leather sofa is placed in the corner. The chairs (things) that are at the bar…</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>pillows</td>
<td>damaging</td>
<td>The bored pets are getting into trouble. The cats are scratching the curtains. The dogs (ones) in the living room…</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>∅</td>
<td>basking</td>
<td>The dessert is filled with creatures. A rattlesnake is coiled beside its den. The lizards (things) on the rocks…</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>stars</td>
<td>∅</td>
<td>The house has been brightly decorated for the party. Flowers are on the table. The ornaments (things) on the railing…</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>presidents</td>
<td>depicting</td>
<td>The history museum exhibit is honoring famous political figures. A movie tells of congressional history. The portraits (things) that line the hallway…</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>∅</td>
<td>gathering</td>
<td>What a storm! The wind blows the door open. The spiders that seek shelter…</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>pistols</td>
<td>∅</td>
<td>The policemen patrol the street. They carry handcuffs. The guns that are in their holsters…</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>a door</td>
<td>unlocking</td>
<td>The sign to the stockroom says, &quot;Staff only. &quot;The secretaries need to get supplies. The key in the boss' drawer…</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>a target</td>
<td>striking</td>
<td>Each marksman hopes to hit a bull’s eye. The judges watch each trial closely. The arrow from one archer's quiver…</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>∅</td>
<td>soaring</td>
<td>A child kicks up the sand. Clouds race by. The kite on the windy beach…</td>
<td></td>
</tr>
<tr>
<td>Line</td>
<td>Word(s)</td>
<td>Action(s)</td>
<td>Description(s)</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>---------</td>
<td>-----------</td>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>⊙ shining</td>
<td>A winter storm brings snowdrifts. Leaves fly through the air in autumn.</td>
<td>The sun on a summer day…</td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>a janitor ⊙</td>
<td>Children run around the playground. The woman inside the office is the principal.</td>
<td>The man in one of the classrooms…</td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>a wine bottle ⊙</td>
<td>The staff is getting ready for the big toast. Most waiters are serving champagne.</td>
<td>The bottle on one waiter's tray…</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>a pancake flipping</td>
<td>The servants of the manor are preparing breakfast. The maid sets the table.</td>
<td>The cook that makes every meal…</td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>a dam building</td>
<td>The owl lines its nest. The rabbits dig a burrow.</td>
<td>The beaver that gnaws on every log…</td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>⊙ swimming</td>
<td>Anglerfish lure their prey. The octopus crawls toward its dinner.</td>
<td>The shark that hunts all the fish…</td>
<td></td>
</tr>
<tr>
<td>58</td>
<td>⊙ rolling</td>
<td>The golfer gets ready to swing. The caddies stand nearby.</td>
<td>The ball that falls off the tee…</td>
<td></td>
</tr>
<tr>
<td>59</td>
<td>a dentist ⊙</td>
<td>The hostess introduces you to the guests. The men that are wearing ties are doctors.</td>
<td>The woman that smiles brightly…</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>a Tiffany lamp ⊙</td>
<td>The room is richly decorated. Oak cabinets are against the walls.</td>
<td>The lamp that sits in a corner…</td>
<td></td>
</tr>
<tr>
<td>61</td>
<td>candies holding</td>
<td>Grandma's kitchen is always filled with treats. Cookies are on a plate on the table.</td>
<td>The mugs on some of the shelves…</td>
<td></td>
</tr>
<tr>
<td>62</td>
<td>paperclips attracting</td>
<td>In the school science lab, a petri dish contains specimens. The chemicals in the test tubes are smoking.</td>
<td>The magnets in both of the boxes…</td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>⊙ walking</td>
<td>The technological advancements of this decade are amazing. Phones can talk to people.</td>
<td>The robots from some of the laboratories…</td>
<td></td>
</tr>
<tr>
<td>64</td>
<td>⊙ sinking</td>
<td>The typhoon has hit this community hard. Houses are destroyed.</td>
<td>The boats at every pier…</td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>antiques ⊙</td>
<td>She has a beautifully furnished house. The vases in the entryway are imports.</td>
<td>The mirrors in each hallway…</td>
<td></td>
</tr>
<tr>
<td>66</td>
<td>all-beef patties ⊙</td>
<td>This diner serves great food. The salad is filled with fresh spring greens.</td>
<td>The burgers on the griddle…</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
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<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>67</td>
<td>prizes</td>
<td>winning</td>
<td>The host explains the game. The tasks are difficult. The contestants that finish all the challenges…</td>
<td></td>
</tr>
<tr>
<td>68</td>
<td>muffins</td>
<td>burning</td>
<td>The roommates aren't paying attention to dinner. The soup has boiled over. The toasters that sit on the kitchen counter…</td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>Ø</td>
<td>overflowing</td>
<td>This apartment is a wreck! The doors are falling off the hinges. The sinks that have silver faucets…</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>Ø</td>
<td>crawling</td>
<td>Bees fly around. A grasshopper jumps. The beetles that munch on the leaf…</td>
<td></td>
</tr>
<tr>
<td>71</td>
<td>criminals</td>
<td>Ø</td>
<td>Policemen patrol the neighborhood. A guard dog is barking. The thieves that break into all the houses…</td>
<td></td>
</tr>
<tr>
<td>72</td>
<td>claw hammers</td>
<td>Ø</td>
<td>This builder is very proud of his work. He always chooses the best equipment. The hammers that the builder prefers…</td>
<td></td>
</tr>
</tbody>
</table>
Table A4 Experimental stimuli used in Experiment 3

<table>
<thead>
<tr>
<th>Item</th>
<th>Adj Prime</th>
<th>Nom Prime (SG/PL)</th>
<th>Context</th>
<th>Preamble</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>baked</td>
<td>a potato/</td>
<td>The customers have selected their preferred side dishes. The steamed</td>
<td>The one servedhot by the prompt waiter…</td>
</tr>
<tr>
<td></td>
<td></td>
<td>potatoes</td>
<td>broccoli remains in the center of the table.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>stale</td>
<td>an Oreo/</td>
<td>Fresh turkey sandwiches have been packed for the children's lunches.</td>
<td>The one added at the last minute…</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oreos</td>
<td>Mom carelessly tosses in a treat for dessert.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>stylish</td>
<td>a fedora/</td>
<td>Men's vintage clothing and apparel have been displayed around the store.</td>
<td>The thing set by the tall mannequin…</td>
</tr>
<tr>
<td></td>
<td></td>
<td>fedoras</td>
<td>An attractive bow tie sits out by the register.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>popular</td>
<td>a convertible/</td>
<td>The auto industry's consumer reports have been released. A particular</td>
<td>The one sold by the eager salesman…</td>
</tr>
<tr>
<td></td>
<td></td>
<td>convertibles</td>
<td>vehicle ranks highly among the younger generation this year.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>dull</td>
<td>a teaspoon/</td>
<td>The cooking class students have chosen the appropriate utensils. A</td>
<td>The thing chosen by the master chef…</td>
</tr>
<tr>
<td></td>
<td></td>
<td>teaspoons</td>
<td>sharp knife slices onions on the cutting board.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>pink</td>
<td>a rose/</td>
<td>The neighbors have been working in their gardens all summer. The old</td>
<td>The thing planted under the window…</td>
</tr>
<tr>
<td></td>
<td></td>
<td>roses</td>
<td>oak tree shows off its autumn color.</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>cheerful</td>
<td>a robin/</td>
<td>Small creatures have come out to greet the spring morning. A tiny</td>
<td>The one nesting in the leafy tree…</td>
</tr>
<tr>
<td></td>
<td></td>
<td>robins</td>
<td>sparrow hops through the tall grass.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>juicy</td>
<td>an apple/</td>
<td>The women have selected the freshest produce. The fruit looks ripe and</td>
<td>The one quickly picked by one shopper…</td>
</tr>
<tr>
<td></td>
<td></td>
<td>apples</td>
<td>sweet.</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>delicate</td>
<td>a butterfly/</td>
<td>Winged insects have come to the garden. A fragile chrysalis hangs from</td>
<td>The one resting gently on a twig…</td>
</tr>
<tr>
<td></td>
<td></td>
<td>butterflies</td>
<td>one leaf.</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>cute</td>
<td>a Barbie/</td>
<td>The children have gotten out their toys. A tough action figure stands</td>
<td>The one played with by the little girl…</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Barbies</td>
<td>in the boy's desk.</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>comfortable</td>
<td>a recliner/</td>
<td>The retirement home's rooms have been thoughtfully furnished. An old-</td>
<td>The thing placed in the common room…</td>
</tr>
<tr>
<td></td>
<td></td>
<td>recliners</td>
<td>time radio plays familiar music in a resident's room.</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>scared</td>
<td>a gecko/</td>
<td>Many pests have invaded these hills. A fierce snake basks in the sun</td>
<td>The one staring at the young hiker…</td>
</tr>
<tr>
<td></td>
<td></td>
<td>geckos</td>
<td>on the path.</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>cold</td>
<td>a latte/</td>
<td>Morning meetings have begun in the offices. A secretary hurriedly</td>
<td>The one ordered by the manager…</td>
</tr>
<tr>
<td></td>
<td></td>
<td>lattes</td>
<td>hands out each drink from the café.</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>groomed</td>
<td>a thoroughbred/</td>
<td>The millionaire's pastures have been mowed. A man in the stable organizes</td>
<td>The thing walking in the green pasture…</td>
</tr>
<tr>
<td></td>
<td></td>
<td>thoroughbreds</td>
<td>riding gear.</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>outdated</td>
<td>a dictionary/</td>
<td>The bosses have ordered new supplies. The photocopier in the corner</td>
<td>The thing passed out by the secretary…</td>
</tr>
<tr>
<td></td>
<td></td>
<td>dictionaries</td>
<td>needs paper.</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>powerful</td>
<td>an alternator/</td>
<td>The workers have arrived at the sites. A strong forklift drives</td>
<td>The thing safely stored in the back</td>
</tr>
<tr>
<td></td>
<td></td>
<td>alternators</td>
<td>around in the parking lot.</td>
<td>warehouse…</td>
</tr>
<tr>
<td>17</td>
<td>expensive</td>
<td>a bracelet/</td>
<td>The magazines have reported on all the celebrities' outfits. A</td>
<td>The thing worn by the fashion model…</td>
</tr>
<tr>
<td></td>
<td></td>
<td>bracelets</td>
<td>designer cape covers the movie star's shoulder.</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>poised</td>
<td>a ballerina/</td>
<td>The artists have depicted women in various activities. The woman in</td>
<td>The one featured in the oak cabinet…</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ballerinas</td>
<td>the painting brushes her hair.</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>poisonous</td>
<td>a black widow/</td>
<td>These abandoned houses have fallen into disrepair. A dirty rat lurks</td>
<td>The thing waiting in the dark</td>
</tr>
<tr>
<td></td>
<td></td>
<td>black widows</td>
<td>near the floorboard.</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>shiny</td>
<td>a bell/ bells</td>
<td>The holidays have arrived! A sparkling Christmas tree lights up the room.</td>
<td>The thing joyfully hung on the branch…</td>
</tr>
<tr>
<td>21</td>
<td>obnoxious</td>
<td>a terrier/ terriers</td>
<td>Dogs have become problem pets in this area. A German Shepard marks his territory on the neighbor's tree.</td>
<td>The one barking loudly in the yard…</td>
</tr>
<tr>
<td>22</td>
<td>musical</td>
<td>an alarm/ alarms</td>
<td>The tourists have spent the night in luxurious hotel rooms. A down comforter keeps the guest warm.</td>
<td>The thing set on the short nightstand…</td>
</tr>
<tr>
<td>23</td>
<td>heavy</td>
<td>a rifle/ rifles</td>
<td>The actors have gathered their props for the Wild West scene. A light bonnet hides one woman's face.</td>
<td>The thing packed in the cowboy's wagon…</td>
</tr>
<tr>
<td>24</td>
<td>valuable</td>
<td>a Picasso/ Picassos</td>
<td>The museums have displayed the works of art. A famous sculpture rests on a pedestal.</td>
<td>The one shown on the gallery wall…</td>
</tr>
<tr>
<td>Item</td>
<td>Prime 1</td>
<td>Prime 2</td>
<td>Context</td>
<td>Preamble</td>
</tr>
<tr>
<td>------</td>
<td>-----------</td>
<td>-----------</td>
<td>-------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>25</td>
<td>wooden</td>
<td>a utensil</td>
<td>The siblings are playing in the kitchen. The baby's forks are plastic.</td>
<td>The spoon in the toddler's hand…</td>
</tr>
<tr>
<td>26</td>
<td>roasting</td>
<td>a russet</td>
<td>The campers are cooking up a great meal with lots of vegetables. The soup in the pot is boiling</td>
<td>The potato in the fire…</td>
</tr>
<tr>
<td>27</td>
<td>a top hat</td>
<td>felt</td>
<td>The magician has set up all of his props. A deck of cards and a wand are on the table.</td>
<td>That hat next to the cape…</td>
</tr>
<tr>
<td>28</td>
<td>battered</td>
<td>a machine</td>
<td>The factory is in disrepair. The machines are quite old.</td>
<td>The generator that is breaking down…</td>
</tr>
<tr>
<td>29</td>
<td>waving</td>
<td>a doll</td>
<td>The nursery is filled with interesting toys. One of the wind-up toys plays music.</td>
<td>The doll that runs on batteries…</td>
</tr>
<tr>
<td>30</td>
<td>an espresso</td>
<td>brewed</td>
<td>Snacks and beverages are set out. The hot drink in the mug is peppermint tea.</td>
<td>The coffee that is steaming…</td>
</tr>
<tr>
<td>31</td>
<td>illustrated</td>
<td>a comic</td>
<td>The librarian has lots of activities planned for the reading hour. The reading material should keep the children interested.</td>
<td>The book in her lap…</td>
</tr>
<tr>
<td>32</td>
<td>a water lily</td>
<td>floating</td>
<td>Professional landscapers have designed the local park. Benches line the path.</td>
<td>The flower in the fish pond…</td>
</tr>
<tr>
<td>33</td>
<td>a mustang</td>
<td>wild</td>
<td>From the ranch, you can see the wild west. Soaring in the deep blue sky is a hawk.</td>
<td>The horse beyond the river…</td>
</tr>
<tr>
<td>34</td>
<td>a limousine</td>
<td>rented</td>
<td>The wedding party is traveling to the reception. The bride and groom are going in a horse-drawn carriage.</td>
<td>The car that is driven by the chauffeur…</td>
</tr>
<tr>
<td>35</td>
<td>broken</td>
<td>an accessory</td>
<td>The jewelry box has tipped over. The earrings are all mixed up.</td>
<td>The bracelet that falls to the floor…</td>
</tr>
<tr>
<td>36</td>
<td>an angel</td>
<td>porcelain</td>
<td>Grandmother has many knick-knacks. Thimbles line the kitchen cabinet.</td>
<td>The figurine that stands on the shelf…</td>
</tr>
<tr>
<td>37</td>
<td>chirping</td>
<td>bluebirds</td>
<td>Animals are fattening up for the fall. Squirrels are gathering nuts.</td>
<td>The birds in the bushes...</td>
</tr>
<tr>
<td>38</td>
<td>snickerdoodles</td>
<td>cooked</td>
<td>Mom prepares after-school snacks. Blueberry muffins sit on a plate on the counter.</td>
<td>The cookies in the oven...</td>
</tr>
<tr>
<td>39</td>
<td>cats</td>
<td>mechanical</td>
<td>The boutique sells appliances that look like animals. The alarms on the counter are ducks.</td>
<td>The clocks on the wall...</td>
</tr>
<tr>
<td>40</td>
<td>monarchs</td>
<td>spotted</td>
<td>The garden is buzzing with insects. The bees collect pollen.</td>
<td>The butterflies that land on the fence...</td>
</tr>
<tr>
<td>41</td>
<td>rotten</td>
<td>galas</td>
<td>Dirty bowls crowd the counter. Old pieces of fruit sit here and there.</td>
<td>The apples that were knocked by her elbow...</td>
</tr>
<tr>
<td>42</td>
<td>stools</td>
<td>covered</td>
<td>The lounge is decorated in a classic style. A leather sofa is placed in the corner.</td>
<td>The chairs that are at the bar...</td>
</tr>
<tr>
<td>43</td>
<td>vicious</td>
<td>purebreds</td>
<td>The bored pets are getting into trouble. The cats scratching the curtains are out of control.</td>
<td>The dogs in the living room...</td>
</tr>
<tr>
<td>44</td>
<td>basking</td>
<td>iguanas</td>
<td>The dessert is filled with creatures. A rattlesnake is coiled beside its den.</td>
<td>The lizards on the rocks...</td>
</tr>
<tr>
<td>45</td>
<td>stars</td>
<td>hand-crafted</td>
<td>The house has been brightly decorated for the party. Flowers are on the table.</td>
<td>The ornaments on the railing...</td>
</tr>
<tr>
<td>46</td>
<td>commissioned</td>
<td>paintings</td>
<td>The history museum exhibit is honoring famous political figures. A movie tells of congressional history.</td>
<td>The portraits that line the hallway...</td>
</tr>
<tr>
<td>47</td>
<td>frightened</td>
<td>arachnids</td>
<td>What a storm! The wind blows the door open.</td>
<td>The spiders that seek shelter...</td>
</tr>
<tr>
<td>48</td>
<td>pistols</td>
<td>polished</td>
<td>The policemen patrol the street. They carry handcuffs.</td>
<td>The guns that are in their holsters...</td>
</tr>
<tr>
<td>49</td>
<td>hidden</td>
<td>keys</td>
<td>The intern has no access to the supplies. The sign on stockroom says, &quot;Staff Only. &quot;</td>
<td>The keys in the boss' drawer...</td>
</tr>
<tr>
<td>50</td>
<td>precise</td>
<td>an arrow</td>
<td>Each marksman hopes to hit a bull's eye. The judges watch the competition closely.</td>
<td>The arrow from one archer's quiver…</td>
</tr>
<tr>
<td>51</td>
<td>a kite</td>
<td>soaring</td>
<td>A child kicks up the sand. Clouds race by.</td>
<td>The shape in the windy sky…</td>
</tr>
<tr>
<td>52</td>
<td>blazing</td>
<td>sunshine</td>
<td>A winter storm brings snowdrifts. Leaves fly through the air in autumn.</td>
<td>The heat of the summer day…</td>
</tr>
<tr>
<td>53</td>
<td>a janitor</td>
<td>tall</td>
<td>Children run around the playground. The woman inside the office is the principal.</td>
<td>The man in one of the classrooms…</td>
</tr>
<tr>
<td>54</td>
<td>wine</td>
<td>aged</td>
<td>The staff is getting ready for the big toast. Most waiters are serving champagne.</td>
<td>The bottle on one waiter's tray…</td>
</tr>
<tr>
<td>55</td>
<td>skilled</td>
<td>a chef</td>
<td>The servants of the manor are preparing breakfast. The maid setting the table is meticulous.</td>
<td>The cook that makes every meal…</td>
</tr>
<tr>
<td>56</td>
<td>beavers</td>
<td>busy</td>
<td>The owl lines its nest. The rabbits dig a burrow.</td>
<td>The critters that gnaws on all the logs…</td>
</tr>
<tr>
<td>57</td>
<td>a blue shark</td>
<td>swimming</td>
<td>The spiny fish is an anglerfish. This crawling cephalopod is an octopus.</td>
<td>The shark that hunts all the fish…</td>
</tr>
<tr>
<td>58</td>
<td>dented</td>
<td>a golf ball</td>
<td>The golfer gets ready to swing. The caddies stand nearby.</td>
<td>The ball that falls off the tee…</td>
</tr>
<tr>
<td>59</td>
<td>a dentist</td>
<td>intelligent</td>
<td>The hostess introduces you to the guests. The men that are wearing ties are doctors.</td>
<td>The woman that smiles brightly…</td>
</tr>
<tr>
<td>60</td>
<td>colorful</td>
<td>glass</td>
<td>The room is richly decorated. Oak cabinets are against the walls.</td>
<td>The lamp that sits in a corner…</td>
</tr>
<tr>
<td>61</td>
<td>candies</td>
<td>striped</td>
<td>Grandma's kitchen is always filled with treats. Cookies are on a plate on the table.</td>
<td>The sweets in some of the mugs…</td>
</tr>
<tr>
<td>62</td>
<td>effective</td>
<td>magnets</td>
<td>The school science lab has reliable equipment. The glass test tubes are sturdy</td>
<td>The magnets in both of the boxes…</td>
</tr>
</tbody>
</table>
New products are on display at the technology convention. The phones from all of the companies are smartphones. The creations from some of the laboratories…

The typhoon has hit this community hard. Houses are destroyed. The boats at every pier…

She has a beautifully furnished house. The vases in the entryway are imports. The mirrors in each hallway…

This diner serves great food. The salad is filled with fresh spring greens. The burgers on the griddle…

The host explains the game. The tasks are difficult. The contestants that finish all the challenges…

The roommates aren't paying attention to dinner. The soup has boiled over. The muffins that sit in the toaster ovens…

This apartment is a wreck! The doors are falling off the hinges. The sink that have silver faucets…

Bees fly around. A grasshopper jumps. The beetle that munches on the leaf…

Policemen patrol the neighborhood. A guard dog is barking. The thieves that break into all the houses…

This builder is very proud of his work. He always chooses the best equipment. The hammers that the builder prefers…
### Tables A.6: ANOVAs of mean rates of Mismatch for Experiment 1

#### F1 Analysis

<table>
<thead>
<tr>
<th></th>
<th>Exp1_F1$Condition</th>
<th>Residuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum of Squares</td>
<td>9.485521</td>
<td>2.810409</td>
</tr>
<tr>
<td>Deg. of Freedom</td>
<td>3</td>
<td>82</td>
</tr>
</tbody>
</table>

Residual standard error: 0.1851304

<table>
<thead>
<tr>
<th>Df</th>
<th>Sum Sq</th>
<th>Mean Sq</th>
<th>F value</th>
<th>Pr(&gt;F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>9.486</td>
<td>3.1618</td>
<td>92.25</td>
<td>&lt;2e-16***</td>
</tr>
<tr>
<td>82</td>
<td>2.81</td>
<td>0.0343</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Tukey multiple comparison of means for Experiment 1, F1

<table>
<thead>
<tr>
<th>diff</th>
<th>lwr</th>
<th>upr</th>
<th>p adj</th>
</tr>
</thead>
<tbody>
<tr>
<td>EquSg-EquPl</td>
<td>-0.84590909</td>
<td>-0.9959096</td>
<td>0</td>
</tr>
<tr>
<td>TransPl-EquPl</td>
<td>-0.55954545</td>
<td>-0.7095459</td>
<td>0</td>
</tr>
<tr>
<td>TransSg-EquPl</td>
<td>-0.81409091</td>
<td>-0.9640914</td>
<td>0</td>
</tr>
<tr>
<td>TransPl-EquSg</td>
<td>0.28636364</td>
<td>0.1399782</td>
<td>0.4327491</td>
</tr>
<tr>
<td>TransSg-EquSg</td>
<td>0.03181818</td>
<td>-0.1145673</td>
<td>0.1782037</td>
</tr>
<tr>
<td>TransSg-TransPl</td>
<td>-0.25454545</td>
<td>-0.4009309</td>
<td>-0.10816</td>
</tr>
</tbody>
</table>

#### F2 Analysis

<table>
<thead>
<tr>
<th></th>
<th>Exp1_F2$Condition</th>
<th>Residuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum of Squares</td>
<td>11.166768</td>
<td>3.363606</td>
</tr>
<tr>
<td>Deg. of Freedom</td>
<td>3</td>
<td>90</td>
</tr>
</tbody>
</table>

Residual standard error: 0.193322

<table>
<thead>
<tr>
<th>Df</th>
<th>Sum Sq</th>
<th>Mean Sq</th>
<th>F value</th>
<th>Pr(&gt;F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>11.167</td>
<td>3.722</td>
<td>99.6</td>
<td>&lt;2e-16***</td>
</tr>
<tr>
<td>90</td>
<td>3.364</td>
<td>0.037</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Tukey multiple comparison of means for Experiment 1, F1

<table>
<thead>
<tr>
<th></th>
<th>diff</th>
<th>lwr</th>
<th>upr</th>
<th>p adj</th>
</tr>
</thead>
<tbody>
<tr>
<td>EquSg-EquPl</td>
<td>-0.8790152</td>
<td>-1.0283843</td>
<td>-0.72964597</td>
<td>0</td>
</tr>
<tr>
<td>TransPl-EquPl</td>
<td>-0.5956818</td>
<td>-0.745051</td>
<td>-0.44631263</td>
<td>0</td>
</tr>
<tr>
<td>TransSg-EquPl</td>
<td>-0.8402652</td>
<td>-0.9896343</td>
<td>-0.69089597</td>
<td>0</td>
</tr>
<tr>
<td>TransPl-EquSg</td>
<td>0.2833333</td>
<td>0.1372474</td>
<td>0.42941928</td>
<td>0.0000121</td>
</tr>
<tr>
<td>TransSg-EquSg</td>
<td>0.03875</td>
<td>-0.1073359</td>
<td>0.18483595</td>
<td>0.8990011</td>
</tr>
<tr>
<td>TransSg-TransPl</td>
<td>-0.2445833</td>
<td>-0.3906693</td>
<td>-0.09849739</td>
<td>0.0001834</td>
</tr>
</tbody>
</table>
Tables A.7: ANOVAs of mean rates of Mismatch for Experiment 2

F1 Analysis

<table>
<thead>
<tr>
<th></th>
<th>Exp2_F1$Condition</th>
<th>Residuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum of Squares</td>
<td>0.0046459</td>
<td>0.6049041</td>
</tr>
<tr>
<td>Deg. of Freedom</td>
<td>1</td>
<td>28</td>
</tr>
<tr>
<td>Residual standard error:</td>
<td></td>
<td>0.146982</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Df</th>
<th>Sum Sq</th>
<th>Mean Sq</th>
<th>F value</th>
<th>Pr(&gt;F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exp1_F1$Condition</td>
<td>1</td>
<td>0.00465</td>
<td>0.0046459</td>
<td>0.2151</td>
</tr>
<tr>
<td>Residuals</td>
<td>28</td>
<td>0.6049</td>
<td>0.0216037</td>
<td></td>
</tr>
</tbody>
</table>

F2 Analysis

<table>
<thead>
<tr>
<th></th>
<th>Exp2_F2$Condition</th>
<th>Residuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum of Squares</td>
<td>0.0145826</td>
<td>0.7928650</td>
</tr>
<tr>
<td>Deg. of Freedom</td>
<td>1</td>
<td>40</td>
</tr>
<tr>
<td>Residual standard error:</td>
<td></td>
<td>0.1407893</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Df</th>
<th>Sum Sq</th>
<th>Mean Sq</th>
<th>F value</th>
<th>Pr(&gt;F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exp2_F2$Condition</td>
<td>1</td>
<td>0.01458</td>
<td>0.014583</td>
<td>0.7357</td>
</tr>
<tr>
<td>Residuals</td>
<td>40</td>
<td>0.79286</td>
<td>0.019822</td>
<td></td>
</tr>
</tbody>
</table>