Spring 2022

Lexical and Syntactic Priming in Dialogue

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LEXICAL AND SYNTACTIC PRIMING IN DIALOGUE

By

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Bachelor of Arts
The University of Tennessee, 2018

Submitted in Partial Fulfillment of the Requirements

For the Degree of Master of Arts in

Linguistics

College of Arts and Sciences

The University of South Carolina

2022

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DEDICATION

Above all, I praise and thank God for His saving grace and for blessing me with so many amazing and supportive people during the most difficult years of my life. I also dedicate this thesis to my late grandfather, who saw something within me that I could not and still cannot see. His gentle energy and unwavering belief kept me from giving up countless times. Although he departed from us shortly before I began this thesis project, I know that he would be proud of the hard work I have put into my studies. Finally, but no less deservedly, I dedicate this work to my mother and father for their endless support, admirable faith, and love. Thank you for sacrificing so much so that I would be able to follow this path.

ACKNOWLEDGEMENTS

I extend my sincerest gratitude to my advisor Dr. Amit Almor and my reader Dr. Dirk den Ouden for their mindful guidance and patience aiding me through every stage of this educational process. Without their generous investment of time and energy, this thesis would not have been possible.

Thank you to the members of the *a*Lab reading group, the Graduate Students of Linguistics (GSLING), and the attendees of the GSLING Student Research Symposium (Fall 2019) for their comments and suggestions on the early stages of this project. Thank you also to my colleagues and supervisors on the Aging Brain Cohort at UofSC for their support and encouragement in my research endeavors. I would also like to thanks to Dr. Anne Bezuidenhout, Dawson Peterson, and Caleb Reid for their various roles and support.

And I give a very special thank you to my undergraduate assistants, Bel Shields and Kalil Warren, for volunteering their time and willingness to help test so many participants. I wish them both the best of luck on their bright academic journeys.

This research was funded in part by the Linguistics Department COVID-REALS Summer Research Award and by a Graduate Research Scholarship from the Alpha Kappa Alpha Educational Advancement Foundation.

ABSTRACT

Speakers engaged in dialogue align with one another across multiple linguistic levels to ensure effective communication. The Interactive Alignment Model (Pickering & Garrod, 2004) suggests speakers align due to automatic priming mechanisms at individual linguistic levels. Syntactic priming is the tendency to repeat a syntactic structure that has been recently comprehended or produced. Although syntactic priming is regarded as an automatic, abstract structural phenomenon, other linguistic factors can influence a syntactic structure's priming strength. Lexical repetition between structures has been shown to enhance syntactic priming, an effect termed "lexical boost" (Branigan et al., 2000; Healey, Purvery, & Howes., 2014). Another lexical factor is a verb's bias for a particular argument structure, which makes some verbs more resistant to syntactic priming (Gries, 2005; Bernolet & Hartsuiker, 2010). The present study extends upon Bernolet and Hartsuiker's (2010) study of verb bias effects in syntactic priming in two ways: first, by replicating verb bias effects in syntactic priming in English, and second, by introducing verb repetition in addition to the overlap of verb structure bias to investigate lexical boost effects. The current study investigates whether lexical factors such as verb bias and lexical repetition distinctly modulate syntactic priming between speakers engaged in interactive dialogue, considers the results within two accounts of syntactic priming and discusses the implications and future directions for psycholinguistic models of syntactic priming and alignment during dialogue.

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CHAPTER 1

INTRODUCTION

Dialogue is an intricate act of linguistic exchange between two or more speakers. People engaged in a dialogue often subconsciously imitate one another in gesture, body posture, speech rate, and many other ways. It is well known that we begin to resemble those we interact with on a daily basis, but there are many types of adaptation and synchronous behavior that people are not consciously aware of in everyday conversation. In spoken language, speakers can align across multiple linguistic levels (Pickering & Garrod, 2004). Phonologically, they might begin to use similar pronunciation, prosody, or stress patterns. At the word level, people often settle upon using the same words or phrases to refer to objects or actions. This study examines how speakers align at the level of syntax to produce similar argument structures they have recently heard or produced.

Syntactic priming (also referred to as "structural priming" or "syntactic persistence") occurs when speakers subconsciously repeat a structure that has been recently activated, even if this means using a less preferred, alternative structure (Bock, 1986; Branigan, Pickering, & Cleland, 2000; Pickering & Branigan, 1998). For example, upon hearing a sentence with the double-object (DO) dative structure (1a), a speaker will be more likely to produce another sentence using the DO structure than the alternative prepositional-object (PO) dative structure with the preposition *to* (1b):

(1a) The officer handed the dancer the ticket.

(1b) The officer handed the ticket to the dancer.

Syntactic priming effects have been found for both sentence comprehension and production across different grammatical constructions, including the dative alternation as shown above (Bock, 1986; Branigan et al., 2000; Bernolet & Hartsuiker, 2010; Ziegler & Snedeker, 2019), active versus passive voice (Bock, 1986; Hartsuiker, Bernolet, Schoonbaert, Speybroeck & Vanderelst, 2008), and relative clauses (Cleland & Pickering, 2003). Bock (1986) was the first to investigate syntactic priming in sentence production in a controlled experimental setting. She found that participants were significantly more likely to produce a PO structure following a PO prime, and to produce DO structure following a DO prime (Bock, 1986, p. 364). Bock declared this "syntactic persistence" as evidence that abstract structural forms are isolable from linguistic content and conceptual features. Critically, this was the first study among many to demonstrate that syntactic priming occurs in the absence of lexical or conceptual overlap (Arai, van Gompel & Scheepers, 2007; Bernolet & Hartsuiker, 2010; Bock, 1986; Branigan et al., 2000; Chang, Dell & Bock, 2006; Pickering & Branigan, 1998; Segaert, 2018; Ziegler & Snedeker, 2019).

During sentence comprehension, syntactic priming leads to processing advantages, such as shorter response times when reading and shorter fixations during eye-tracking (Arai et al., 2007; Traxler, 2008). Syntactic priming has also been found in studies on young children (Peter, Chang, Blything, & Rowland, 2015), second language learners (Kim & McDonough, 2008), and persons with aphasia (Cho-Reyes, Mack & Thompson, 2016; Lee, Man, Ferreira & Gruberg, 2019). Overall, syntactic priming is a robust phenomenon in both sentence production and comprehension and allows for tests of implicit knowledge of language structure.

Until the turn of the twenty-first century, experimental research on syntactic priming effects focused on either sentence comprehension or production in isolated contexts. Branigan, Pickering and Cleland (2000) were the first to use a novel, scripted confederate paradigm to study syntactic priming effects during interactive dialogue under controlled conditions. Participants were paired with a confederate experimenter – acting as a second participant – and were tasked with describing and sorting picture cards depicting transitive and intransitive actions. Unknown to the participants, the confederate experimenter possessed a carefully constructed script of priming sentences which presented the dative alternation structures (DO vs. PO) at regular intervals between baseline and filler sentences. They found that participants produced significantly more PO structures following the PO primes than a DO or baseline prime, and more DO structures following DO primes (Branigan et al., 2000). This paradigm has since been replicated and adapted across multiple studies to investigate priming during interactive discourse tasks between two speakers.

One theory of dialogue that emerged from psycholinguistic evidence of priming between speakers is the Interactive Alignment Model (IAM), which claims that the more speakers prime one another and produce similar linguistic representations, the more they are said to "align" with one another (Pickering & Garrod, 2004). The main goal of the IAM is to model how interlocutors coordinate or align their linguistic representations during dialogue to achieve effective communication. One critical assumption of the IAM is that parity exists between the primed representations used in both production and in comprehension, which allows for the same priming mechanisms to affect within- and between-speaker alignment. That is, a speaker can be primed by their own previous

utterances (production-to-production), or they can be primed by their conversational partner's utterances (comprehension-to-production). Several neuroimaging studies have found support for this claim at the level of syntactic priming. Segaert and colleagues (2013) report that syntactic priming during both comprehension and production tasks activated similar areas in the brain. In a later neuroimaging study on narrative processing, Silbert and colleagues (2014) again found activation in overlapping brain regions of speakers producing a naturalistic narrative and listeners comprehending the same narrative. These studies seem to suggest that both sentence comprehension and sentence production share at least some neural substrates in the brain. However, it remains unclear whether these areas perform the same processes for both modalities of language and should not be claimed as evidence for the IAM's assumption of parity between comprehension and production in interactive dialogue.

The IAM also predicts that priming will be stronger in interactive contexts than in isolated, monologic contexts. Studies using interactive discourse tasks have largely supported this prediction: rates of priming are indeed greater when another interlocutor is present than in monologic contexts (Schoot, Hagoort & Segaert, 2019). Pickering and Garrod (2004) further claim that speakers need not consciously align their mental models nor negotiate common ground with the other speaker when aligning their linguistic representations during conversation. Instead, speakers are believed to automatically prime one another to produce similar messages in order to align their situation models, or the information relevant to a current situation. Branigan, Nass and Pickering (2003) report that "[syntactic] alignment occurred whether naïve participants believed they were interacting with another human participant in another room or with an unintelligent

computer" (2003, p. 190). This suggests that speakers align automatically across multiple linguistic levels to achieve more efficient communication, even if the other interlocutor is not another human being.

Much less support has been found for Pickering and Garrod's (2004) hypothesis that speakers will align most strongly in spontaneous, naturalistic dialogue. Corpus studies have revealed that between-speaker priming is actually stronger in task-oriented discourse than in spontaneous, naturalistic conversation (Reitter & Moore, 2014). In some natural conversations, speakers have even been shown to diverge – rather than align – in their linguistic representations and syntactic priming could be no more likely to occur than as if by chance (Healey et al., 2014; Howes et al., 2010). Fusaroli and colleagues (2017) suggest that "different contexts of conversation are likely to afford different degrees of explication as well as different processes and mechanism for the establishment of common ground" (p. 2056). In the case of task-oriented discourse, speakers need to align the information in their situation models in order to achieve the goal of the task in which they are engaged, and aligning their linguistic representations often aids in expediting communication transfer and ensuring task success (Reitter & Moore, 2014). However, computational models trained on corpora of naturalistic dialogue have revealed promising evidence of "a structural, though weak fingerprint left by alignment in networks of linguistic items" (Mehler, Luecking, Menke, 2012, p. 9).

The IAM is ambitious in its goal to model linguistic alignment between speakers but has received rather mixed support. Additionally, the mechanisms responsible for syntactic priming remain a point of debate in psycholinguistics, and more empirical investigation is needed to understand how priming mechanisms support coordinated

communication and dialogue (Karpiński, 2014). For the purposes of the current study, it is assumed that the same priming mechanisms serve both sentence comprehension and production (Pickering & Garrod, 2004). We expect that syntactic priming will be stronger in an experimental setting than in a spontaneous, naturalistic dialogue, allowing for a finer manipulation and examination of specific linguistic factors which facilitate syntactic priming. The current study uses an interactive sentence production task to investigate the role of individual lexical items on syntactic priming between two speakers and compare abstract syntactic priming effects alongside lexically driven priming effects.

The next section introduces two prominent mechanistic accounts of syntactic priming, discusses support for each account in the previous literature, and the compatibility of each within a larger framework of linguistic alignment. The third chapter explains two lexical factors, lexical overlap and verb alternation bias, and their distinct effects on syntactic priming. The fourth through sixth chapters present the current study, including one preliminary grammatical preference survey and two syntactic priming experiments. The final chapter considers the results under the two mechanistic accounts of syntactic priming, discusses the role of lexical factors underlying broader syntactic alignment during interactive dialogue, and proposes directions for future research.

CHAPTER 2

MECHANISTIC ACCOUNTS

.....Two leading theories which seek to explain the mechanisms underlying syntactic priming effects are Pickering and Branigan's (1998) residual activation account and Chang, Dell and Bock's (2006) error-based learning account. The first account posits that syntactic priming is a result of prior, temporary activation in the lemma stratum and associated combinatorial nodes, making the activated information easier to access and produce. The second account claims that priming is a form of implicit, error-based learning, where the strength of syntactic connections is weighted based upon previous experience, surprisal, and likelihood of occurrence. This section summarizes the basic assumptions of each theory and reviews each account's predictions for syntactic priming during interactive discourse.

2.1 RESIDUAL ACTIVATION

Pickering and Branigan (1998) support a lexicalist view (Levelt, 1993) of syntactic priming where the lexical features of a verb, such as person and number, are stored in separate nodes at the lemma stratum and connect to syntactic structures via combinatorial nodes. Activation of the prime structure is temporarily more accessible than alternatives during language retrieval and production. In several written sentence production priming experiments, Pickering and Branigan found that morphological factors, such as "tense, aspect, or number of the verb" do not affect structural priming,

suggesting that syntactic information is stored at another level and can be activated independently of these other features (1998, p. 633). The residual activation account captures the basic facilitative nature of syntactic priming and predicts that repeated lexical content between prime and target structures will strengthen priming effects. However, the residual activation account does not predict stronger priming effects due to verb bias, since it assumes that activation at the verb's lemma will co-activate all relevant grammatical structures and select for the most recently activated syntactic structure in the input. Additionally, the residual activation account fails to explain cumulative syntactic priming (also called "syntactic adaptation") effects, where priming persists over time, even as more linguistic material intervenes (Hartsuiker et al., 2008; Jaeger & Snider, 2007; Kaan & Chun, 2018).

The IAM assumes the same lexicalist perspective as the residual activation account (Pickering & Branigan, 1998), but further claims automatic priming mechanisms drive alignment between speakers engaged in interactive discourse. Priming is not restricted to operating at one linguistic level, but can "percolate" to other linguistic levels, such that "aligned representations at one level lead to aligned representations at other levels" (Pickering & Garrod, 2004, p. 174). For example, overlap at the lexical level can percolate up to the syntactic level, leading to greater syntactic priming, and vice-versa, with syntactic alignment percolating down to activate lexical representations (Pickering & Branigan, 1998). However, Pickering and Garrod (2004) assert that under the IAM not all linguistic alignment is driven by transient residual activation mechanisms, but that "different tasks and sentence types lead to very different time-courses of priming" (p. 213). As such, the IAM predicts that some language routines, such as phatic (i.e., "How

are you?") and idioms, might be drawn from memory by a different, implicit priming mechanism than the priming mechanism that spreads activation from recently encountered linguistic input.

2.2 ERROR-BASED IMPLICIT LEARNING

The second mechanistic account, proposed by Chang, Dell and Bock, claims that "structural priming is a form of error-based implicit learning" (2006, p. 245). Their connectionist model of speech production is a revised version of Chang's (2002) dual-path model which employs independent yet simultaneous routes for meaning and sequencing. According to this connectionist-type model, a speaker predicts upcoming linguistic representations from prior comprehension and production experience and adjusts the relative weights depending upon the difference found between the prediction and the input. If the prediction is correct and matches the input, the system updates and adds weight to that form; if the prediction deviates from the input, the weights of that form are adjusted accordingly[1]. When trained on several different types of syntactic structures – including the dative alternation – the model was able to fit the human data from psycholinguistic studies of syntactic priming. The error-based implicit learning mechanism therefore predicts both immediate (aka transient) priming effects and longer-lasting cumulative priming effects. However, since the error-based implicit learning account is designed for sentence production in particular, it is unclear how this account might extend to predicting syntactic priming in comprehension and consequently also predict alignment across discourse (cf. Tooley, 2020).

[1] The training period of adjusting weights is called an epoch.

The literature on syntactic priming is robust, yet the mechanisms responsible for priming are still widely debated. Recent studies examining the cumulative adaptation effects of priming support the error-based implicit learning account (Bernolet et al., 2016; Kaan & Chun, 2018; Peter et al., 2015; Tooley & Traxler, 2017). However, the residual activation and the error-based implicit learning accounts make very different predictions regarding other linguistic and non-linguistic factors which have been shown to strongly influence syntactic priming. According to the residual activation account, "combinatorial information is specified over phrasal categories, such that combinatorial nodes specify the phrases that combine with the verb" (Pickering & Branigan, 1998, p. 646), but factors such as frequency and strength of existing representations are not stored in these nodes. In other words, the grammatical information connected with lexical items via the lemma is static; alternate structures are therefore expected to be primed equally, so long as the verbs share the same syntactic phrasal categories. However, the error-based implicit learning account predicts different rates of syntactic priming, given frequency and prediction based upon prior linguistic exposure. The next chapter describes how two lexical factors – lexical overlap and verb bias – have been shown to modulate the strength of syntactic priming and discusses how the residual activation and error-based learning accounts differ in accommodating these lexical factors.

CHAPTER 3

LEXICAL FACTORS

Although lexical overlap is not necessary for syntactic priming to occur, "there are good reasons to expect syntactic knowledge to be closely linked to lexical items" (Chang et al., 2006, p. 251). Two lexical factors shown to modulate priming at the level of syntax are lexical boost and verb bias. The first factor, lexical boost, emerges from lexical overlap or repetition of an open-class lexeme[2] – such as the head verb or noun – between a prime and target sentence, which enhances or "boosts" the syntactic priming effect (Branigan et al., 2000; Cleland & Pickering, 2003). The second lexical factor of interest is verb (alternation) bias, which emerges from "the syntactic preference of a specific verb" given the frequency with which it appears in a particular structure (Bernolet & Hartsuiker, 2010, p. 455). However, it remains unclear how these two lexical factors interact with one another to influence syntactic priming between speakers. This section introduces these two lexical factors and discusses how each of the two mechanistic accounts of syntactic priming predict or fail to predict these in the context of interactive dialogue.

3.1 LEXICAL BOOST

The lexical boost (or lexical enhancement) effect refers to the phenomenon where

[2] Closed-class lexemes or function words such as determiners, prepositions, and conjunctions are not included in abstract structural representations and do not show evidence of syntactic priming (Chang et al., 2006; Pickering & Branigan, 1998).

overlapping content words between prime and target strengthen syntactic priming effects. Lexical boost effects of syntactic priming have been reported in psycholinguistic experiments (i.e., Branigan & Pickering, 1998; Branigan et al., 2000; Hartsuiker et al. 2008; Scheepers et al., 2017), corpus analyses of naturalistic conversation (i.e., Gries, 2005; Healey et al., 2014), and neuroimaging studies (Segaert, Kempen, Petersson, & Hagoort, 2013). In a study using written sentence-completion of the dative alternation, Pickering and Branigan (1998) found larger syntactic priming effects when the same verb was repeated between the prime and target structures than when the verbs differed. Branigan et al. (2000) also found a lexical boost effect for verb overlap in syntactic priming of the dative alternation.

Lexical boost effects on syntactic priming are not limited to the main verb in a structure: the repetition of nouns between prime and target structures has also been found to boost syntactic priming effects (Cleland & Pickering, 2003; Scheepers et al., 2017). Scheepers et al. found evidence of a "cumulative lexical boost effect," where the number of lexical items shared between prime and target structures increases the priming effects that lexical boost for syntactic priming, irrespective of lexical status or syntactic headedness (2017, p. 30). In a recent metanalysis of over seventy syntactic priming studies, Mahowald et al. (2016) report a significant syntactic priming effect, such that "a construction X which occurs 50% of the time in the absence of priming would occur 63% if primed without lexical repetition and 77% of the time if primed with lexical repetition" (p. 1). Altogether these studies suggest that lexical repetition, particularly verb overlap, significantly boosts syntactic priming during sentence production.

The modality of language, whether production or comprehension, complicates the influence of lexical boost effects in syntactic priming. Although syntactic priming reliably occurs during production regardless of lexical overlap (Branigan et al., 2000; Hartsuiker et al., 2008), several behavioral studies of sentence comprehension found syntactic priming only when some lexical overlap between the prime and target structures occurred (e.g., Arai et al., 2007; Branigan, Pickering, & McLean, 2005). This would suggest that lexical factors, including lexical boost from repetition, might play different roles in syntactic production versus comprehension. Consequently, lexical boost might differ depending upon the context of an interactive dialogue where a speaker can both self-prime (production-to-production) and be primed by another interlocutor (comprehension-to-production). However, the lexical boost effect could reflect differences in depth of processing required by comprehension and production tasks. In an fMRI study comparing the activation patterns of lexical boost during syntactic priming, Segaert and colleagues (2013) found syntactic priming in both comprehension and production tasks regardless of lexical overlap. Instead, lexical repetition appeared to be necessary to produce syntactic priming in highly frequent syntactic structures, such as the active voice; meanwhile, lexical repetition is not necessary for priming less frequent structures, such as the passive voice.

The error-based implicit learning account assumes syntactic priming is "insensitive to both verb and morphological overlap" (Chang et al., 2006, p.252). Therefore, the lexical boost effect is not a consequence of the same mechanism which is responsible for syntactic priming in a recent comparison of the mechanistic accounts for the lexical boost effect in syntactic priming, Tooley (2020) tested the timescale of lexical

boost effects using eye-tracking during self-paced readings of reduced relative clauses and found evidence that the lexical boost disappeared after a lag between prime and target linguistic material. This finding supports Chang et al.'s claim that "the repeated content word serves as a cue to the [explicit] memory of the prime" and as such operates at a distinct level outside of abstract structural priming mechanism (2006, p. 256). Additional evidence comes from studies on persons with aphasia, who reliably demonstrate effects of abstract syntactic priming but not for lexical boost from verb overlap (Man, Meehan, Martin, Branigan & Lee, 2019). To date, tentative consensus rests that a different mechanism driving the lexical boost effect, and this operates separately from the mechanism driving abstract syntactic priming.

3.2 VERB BIAS

Verb alternation bias can be regarded as the "syntactic preference of a specific verb," given the frequency with which it appears in a particular structure (Bernolet & Hartsuiker, 2010, p. 455). Unlike lexical boost from repetition, verb bias appears to selectively interact with syntactic structure. For example, freely alternating verbs such as *hand* might have a weak verb bias for either the DO (2a) or PO (2a) constructions:

(2a) The officer handed [the dancer]$_{\text{NP-RECIPIENT}}$ [the ticket] $_{\text{NP-THEME}}$.

(2b) The officer handed [the ticket]$_{\text{NP-THEME}}$ [to the dancer] $_{\text{PP-RECIPIENT}}$.

On the surface, it would seem that the two structures covey the same meaning and differ only in word order and the additional *to* in the PO structure (Arai et al., 2007). However, there has been significant debate as to the semantic equivalence between these two closely related constructions. The DO construction (2a) conveys a transfer of possession, while the PO construction (2b) implies caused motion toward some animate or inanimate

goal (Bresnan et al., 2007; Allen et al., 2012). However, not all ditransitive verbs participate freely in the dative alternation and some scholars even disagree on the classification of non-alternating verbs. In her book on English verb classes, Beth Levin records verbs of Latinate origins, such as *donate,* as "non-alternating *to* only," occurring only in the PO construction (1993, p. 46). However, as English – like any natural language – continuously evolves, verbs which were previously considered to be restricted to one construction may begin to alternate between the syntactic structures. In cases such as the verb *donate*, the verb may begin to alternate in certain situations, but its structural bias remains strongly PO. Melinger and Dobel (2005) found that single dative verb primes were sufficient to bias sentence production choices in Dutch and German speakers. Gries further reports that "some verbs are much more resistant or responsive to priming than others" (2005, p. 365). Therefore, verb bias should be considered on a continuum from weak to strong bias for the structures in which they might alternate, rather than a categorical distinction between structures.

The verb bias effect in syntactic priming is reported to be strongest when the priming syntactic structure clashes with the verb's bias, leading to verb-specific "inverse preference effects" (Jaeger & Snider, 2007; Bernolet & Hartsuiker, 2010). This phenomenon is likely due to surprisal: a verb which has a strong bias towards the PO structure, such as *kick,* might become more salient to the listener when used in a DO structure. Of course, as with syntactic preferences, verb biases differ cross-linguistically, for particular verb forms and entire verb classes: in Dutch, for example, the PO structure is generally the more preferred dative construction (Bernolet & Hartsuiker, 2010). In one syntactic priming study examining verb bias in the Dutch dative alternation, Bernolet and

Hartsuiker (2010) found the strongest priming effects for the less-preferred DO-dative structure when the biases of the prime verb and the target verb were strongly PO biased. They also reported that "the proportion of PO-datives for the 16 verbs…selected is much lower in the Colleman data (35.1%) than in…pretest (78.8%)", but that these ratios were comparable to previous experimental reports done on the Dutch dative alternation (2010, p. 457). Speakers of American English generally show a preference for the DO-dative structure, and consequently, the PO-dative structure shows stronger syntactic priming due to inverse preference effects[3] (Bernolet & Hartsuiker, 2010; Kaan & Chun, 2018). However, several corpus studies of naturalistic dialogue report a relatively balanced distribution between the PO and DO structures in the English dative alternation (Gries, 2005; Gries & Stefanowitsch, 2004). Bresnan and colleagues (2007) further report that controlling for certain semantic and syntactic properties, such as pronouns in the noun phrase, reduces the discrepancy of frequencies of the DO and PO constructions between different corpora of written and spoken English.

Another point of debate concerns the cognitive effort required in processing the alternate structures in the dative alternation. It could be argued that the structural differences between the PO and DO structures might impose different processing strategies between sentence production or comprehension. In an fMRI analysis, Allen and colleagues (2012) measured the neural response differences in comprehension of the dative alternation using multi-voxel pattern analysis (MVPA). They found that the

[3] Structural preferences in the dative alternation structures have also been found to differ across dialects of English. Scheepers et al. found that the British English speakers in their priming study "were about twice as likely to produce PO rather than DO target structures" (2017, p. 21).

alternating PO/DO syntactic constructions did not significantly differ in terms of processing complexity; rather, the analysis revealed “a qualitative difference between the two constructions” and similar neural activity patterns during comprehension (Allen et al., 2012, p. 178). Overall, the dative alternation is well-attested in the syntactic priming literature and serves as an ideal structure to test the effects of verb bias in an interactive discourse setting.

3.3 INTERACTION OF LEXICAL BOOST AND VERB BIAS

Some scholars argue that lexical boost effects should be regarded separately from abstract syntactic priming on the premise that these two phenomena appear to result from different mechanisms in memory (Hartsuiker et al., 2008; Pickering & Branigan, 1998; Pickering & Garrod, 2004; Scheepers et al., 2017; Tooley, 2020). The lexical boost is relatively short-lived and sensitive to intervening linguistic material, whereas syntactic priming has been shown to persist over the duration of a discourse (Hartsuiker et al., 2008; Bernolet & Hartsuiker, 2010; Reitter & Moore, 2006; Tooley, 2020), suggesting that syntactic priming depends upon more than just lexical overlap. This persistence across intervening linguistic material supports an error-based implicit learning account, which assumes “changes to connection weights that map a certain message to a certain structure are relatively permanent” and updated according to probability given previous input (Hartsuiker et al. 2008, p. 216; cf. Chang et al., 2006; Scheepers et al., 2017). The previous literature has shown that lexical boost enhances syntactic priming effects (Branigan et al., 2000; Healey et al., 2014; Pickering & Branigan, 1998; Segaert, 2013) and that verb bias modulates priming strength, leading to verb-specific inverse preference effects for less-preferred structures (Jaeger & Snider, 2007; Bernolet & Hartsuiker,

2010). However, it is unclear how these two factors might interact in modulating syntactic priming effects between speakers in an interactive discourse setting.

To summarize, lexical overlap strongly boosts syntactic priming effects, while verb alternation bias selectively modulates the priming of less-preferred syntactic structures (such as the PO dative structure in American English). The main research question addressed in this study is: How do verb biases and lexical boost effects from verb repetition interactively modulate the strength of syntactic priming of sentence production during in an interactive dialogue? In an English replication of Bernolet and Hartsuiker's (2010) study of verb bias effects on syntactic priming in the dative alternation, this thesis investigates the combined effects of verb repetition and verb bias on syntactic priming between speakers, considers the results within two prevalent accounts of syntactic priming, and discusses the implications for psycholinguistic models of linguistic alignment during interactive dialogue.

3.4 THE CURRENT STUDY

The current study includes one preliminary verb bias survey and two priming experiments, all conducted virtually through online platforms. The main study's overall design is a 2x2x2 factorial design. The first priming experiment uses a 2x2 factorial design, with two within-subjects factors: prime verb bias type (PO, DO) and syntactic structure (PO, DO). The second experiment includes the same factors as the first but adds another within-subjects factor of verb repetition (repeated, not repeated). Both experiments employ a picture-description and verification task using a scripted confederate paradigm to elicit syntactic priming effects (Branigan et al., 2000; Bernolet & Hartsuiker, 2010).

3.4.1 Predictions

The two main hypotheses tested in the present study concern the relative effects of lexical repetition and verb bias upon syntactic priming between speakers engaged in a task-oriented dialogue. First, verb bias should produce greater syntactic priming effects for the less-preferred, PO-dative structure between speakers. According to the residual activation account, verbs (and other lexical items) contain syntactic information stored in the lemma stratum as well as abstract structural associations accessed via combinatorial nodes (Pickering & Branigan, 1998). Since these associations are fixed and not dependent upon frequency of input, the residual activation account does not provide a mechanism to predict specific verb biases based upon frequency in input. On the other hand, an error-based implicit learning account uses probabilistic information to predict lexical item occurrences in particular argument structures based upon prior experience or frequency in input. Under this account, less expected structures will result in stronger priming effects (i.e., inverse preference effects), allowing this model to predict different syntactic priming effects depending upon the strength of verb bias.

The second prediction is that lexical repetition of the main verb should produce greater syntactic priming effects (due to lexical boost) for both PO- and DO-dative structures between speakers. The residual activation account predicts a lexical boost effect when the repetition of an open-class lexeme – such as a verb or noun – produces both activation at the verb node, the combinatorial node and the shared connections between them for the most recently activated syntactic structure (Pickering & Branigan, 1998). Therefore, syntactic priming will be stronger when the verbs overlap between prime and target structures than in the different verb priming conditions. Under Chang et

al.'s (2006) "explicit learning" extension of the error-based learning account, a repeated verb may serve as an explicit memory cue to retrieve the most recently processed abstract structure from working memory. Therefore, this account also predicts that verb repetition between prime and target verbs will temporarily enhance syntactic priming effects for the most recently processed structure.

The remainder of this paper focuses on the methodology and results of one preliminary verb bias survey and two syntactic priming experiments used to test these hypotheses and compare verb bias effects on syntactic priming with and without lexical overlap.

CHAPTER 4

PRELIMINARY VERB BIAS SURVEY

The verb alternation bias scores for 20 dative verbs were obtained in a word order preference survey using the online platform Qualtrics (https://www.qualtrics.com) in order to create the experimental stimuli used in the syntactic priming experiments. This method was selected for several reasons. First, as discussed earlier in the introduction, corpus analyses have shown that the PO and DO dative structures show a relatively balanced distribution in American English (Gries, 2005; Gries and Stefanowitsch, 2004). Second, although the relative proportion of DO vs. PO verb biases gathered in the survey will necessarily differ from a corpus collexemic analysis due to factors such as context and speaker differences, the task was aimed to tap into a speakers' intuitive preference for a verb's naturalness in either the DO or PO dative structure. Finally, and most critically, at the time of conducting this study, online data collection was mandatory, and this method proved most expedient while also minimizing the likelihood of unusable data.

4.1 Participants

A total of 69 undergraduate students recruited through the Psychology Participant Pool internal to the University of South Carolina participated. Data from 7 participants were excluded, either due to reporting a first language other than English spoken at home growing up or submitting an incomplete survey response, resulting in a total of 62 participants (52 female; age $M = 20.71$, $SD = 2.8$). Participants included in the analysis

were all native speakers of American English with normal or corrected-to-normal vision and no reported language impairments. Participants were imbursed one experimental credit upon completion of the verb bias survey.

4.2 Procedure

Participants were asked to rate two sentence versions describing a picture using a 7-point continuous Likert scale (see Appendix A). The survey instructions prompted participants to indicate their preference for the sentences they thought best described the action in the picture and rate based on their first impression. Four versions of the survey were created to balance for the nuisance variables of visual direction of theme transfer in the picture (left to right, right to left) and sentence type as displayed on the scale (DO-1 to PO-7, PO-1 to DO-7). The 16 verbs with the strongest dative alternation biases will be used in the subsequent priming experiments (4 target verbs; 12 prime verbs). Additional demographic questions at the beginning of the survey collected information about the participants' age, gender, first and additional language(s). The verb bias survey took around ten minutes to complete.

4.4 Results

The Likert scales were all converted to the same ranges, such that a score of 1 indicated stronger bias for the PO dative and a 7 indicated a strong bias for DO dative. The 12 verbs with the strongest average dative alternation biases were selected as the prime verbs for the subsequent priming experiments: *award, bring, deliver, donate, pass, pay, present, sell, serve, show, throw,* and *write.* Four verbs with neutral bias scores (situated near 4 on the scale) were selected as the target verbs: *give, hand, lend,* and *offer*. Twelve verbs were strongly PO-biased, including: *deliver, donate, kick, loan, pass,*

present, read, sell, send, serve, throw, and *write.* Several verbs were freely alternating or near-neutral: *award, bring, give, hand, lend,* and *offer*. Only two verbs, *pay* and *show,* appeared to be strongly DO-biased. (See Appendix B for all verb biases.) Verb biases were normalized in R version 4.0.2 (RStudio Team, 2020) whereby -1 corresponded to strongly PO-biased and 1 to strongly DO-biased.

CHAPTER 5

EXPERIMENT 1

The first experiment was a replication of Bernolet and Hartsuiker's (2010) study on the effects of lexical bias on syntactic priming using a picture-description task using the confederate scripting paradigm (Branigan et al., 2000). This study's experiment differs from the original in two ways: first, by examining the effects of verb bias in English, rather than Dutch, and second, introduces several different target verbs due to translational differences[4], including *bring, kick, lend, loan, send, serve,* and *throw.*

5.3.1 Participants

A total of 38 native speakers of American English (23 female; age *M* = 24.93, *SD* = *3.69*) were recruited through Prolific Academic Ltd (www.prolific.co). All participants reported having normal or corrected-to-normal vision and no language impairments. All participants gave consent to participate in the study and for the session to be audio recorded during the experiment. No participants who completed the preliminary verb bias survey participated. Participants were compensated for their time upon completion of the experimental session.

5.3.2 Materials

The stimuli for the first experiment consisted of a set of target pictures for the

[4] For example, the Dutch verb "schenken" can either be translated as "give" or "donate" in English, but these two verbs have distinctly different syntactic argument structures in English. The Dutch verb "geven" translates more directly to "give".

participant to describe and a list of priming sentences for the confederate speaker to read aloud. A total of 48 target pictures (12 pictures per target verb) and 96 fillers (including 60 transitive pictures and 36 intransitive pictures) were created. Two participant description sets were created to counter-balance the theme transfer direction shown in the picture (left to right, right to left). To ensure strong effects of syntactic priming, dative verbs with strong DO or PO biases from the norming survey were used as the prime verbs, and the weaker biased verbs were used as the target verbs (see Bernolet & Hartsuiker, 2010).

The visual stimuli for the picture description task included black and white line-drawings used in earlier studies on syntactic priming (Bernolet & Hartsuiker, 2010; Hartsuiker et al., 2008) available on the Open Science Framework (https://osf.io/jsrc6/). The participant's description consisted of 144 pictures, including 48 critical items and 96 fillers, labeled with the English target verb to be used in constructing the picture description. For each target picture, three prime sentences (DO, PO, Baseline) were created and balanced across the confederate's description lists. None of the verbs overlapped between the prime sentence and target stimulus. The confederate's description set included a script of the prime sentences by prime type: DO-primes, PO-primes, and transitive baseline primes (see Appendix C for an example stimulus picture and primes). The prime lists were always presented in the same pseudo-random order and were rotated between participants, with filler trials between critical prime trials. An equal number of filler pictures (n = 144) were used in the masking verification task; half of the pictures matched between the scripts and half mismatched.

5.3.3 Procedure

The primary researcher (SW) reviewed an electronic invitation-to-participate letter outlining the study goals and experimental procedure with each participant, reminded participants of their right to withdraw consent at any time during the experiment without negative consequence, and allowed time for questions. Participants were informed that the session would be audio recorded for transcription purposes and provided consent to having the session recorded through Zoom. Either a female or male undergraduate student served as the confederate speaker, acting as a second participant in the dialogue game with the participant. The participant and confederate then received separate links to the experiment, which ran on Qualtrics (https://www.qualtrics.com).

The primary task was a picture-description task using a scripted confederate paradigm modeled after Bernolet and Hartsuiker (2010; cf. Branigan et al., 2000; Cleland & Pickering, 2003). The experimenter informed the subjects that they were taking part in a study to see how well people communicate during a dialogue in online settings. The session was recorded through the Zoom record option and saved locally on the experimenter's hard drive. The true purpose of the experiment was masked using a picture verification task, where both the subject and the confederate indicate if the current picture matches their partner's description between picture description trials (cf. Hartsuiker et al. 2008; Bernolet & Hartsuiker, 2010). During the picture verification trials, the participant and the confederate responded to their partner's picture description by selecting either "Yes" or "No" on their respective screens. Half of the pictures between the participant's set and the confederate's set matched and the other half did not.

The experimental session lasted approximately 40 minutes, including time for the instructions and questions.

5.3.4 Coding and Analysis

Responses were transcribed and coded as follows: "DO" if the direct object followed the indirect object, coded as 1; "PO" if the indirect object followed the direct object and the preposition "to", coded as 0; and "Other", coded as 2 if responses lacked either a direct object (Theme) or indirect object (Recipient) (i.e., "The inmate hands") ungrammatical constructions, or null responses due to a technological issue of recording software or poor internet connection. From the initial 1824 responses, 25 "Other" responses were excluded, roughly accounting for 1.37% from the final analysis. An additional 56 responses where subjects substituted a target verb other than the one shown (i.e., *give* instead of *hand*) were excluded, leaving 1743 data points in the final analysis.

5.3.5 Results

High accuracy for the masking picture verification task (above 98%) suggests that participants were indeed paying attention to the task and listening to their partner's picture descriptions. The response data (N = 1743) were analyzed for syntactic priming effects between participants, with syntactic choice for the dative alternation measured against the baseline transitive primes. Participants produced 6.36% more PO responses (n = 927) than DO responses (n = 816) across conditions, as shown in Figure 5.1 below.

Table 5.1 reports the raw count of responses by priming condition. Participants produced slightly more PO-responses (n = 301, 52.35%) than DO-responses (n = 274, 47.65%) in the Baseline condition. As expected, participants produced more DO-responses (n = 302, 51.62%) in the DO-prime condition than PO-responses (n = 238,

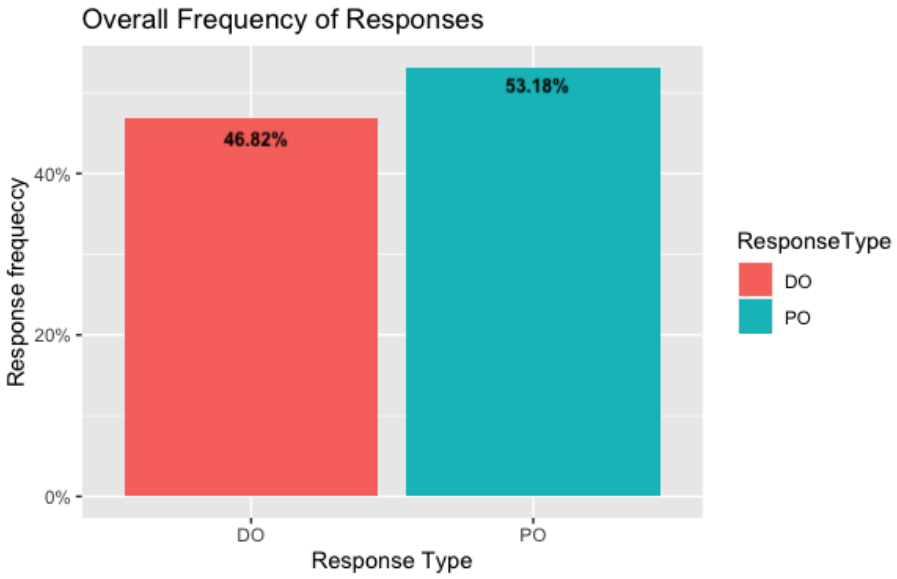

Figure 5.1: Overall response percentages for experiment 1

Table 5.1 Raw counts of responses by priming condition for experiment 1

	DO-responses	**PO-responses**	**%PO**
Baseline	274	301	52.35%
DO-prime	302	283	48.38%
PO-prime	240	343	58.83%

48.38%), and produced more PO-responses (*n* = 343, 58.83%) than DO-primes (*n* = 240, 41.17%) in the PO-prime condition (see Figure 5.2).

Effects of syntactic priming were fit to a series of mixed logit regression models (Jaeger, 2008; cf. Bernolet & Hartsuiker, 2010) using the *lme4* package version 1.1-23 (Bates et al., 2015) in R version 4.0.2 (RStudio Team, 2020). The full model included a maximum 3-way interaction between the factors Prime Structure Type (PO, DO, Baseline), Prime Verb Bias (verb biases of the 12 prime verbs), and Target Verb Bias

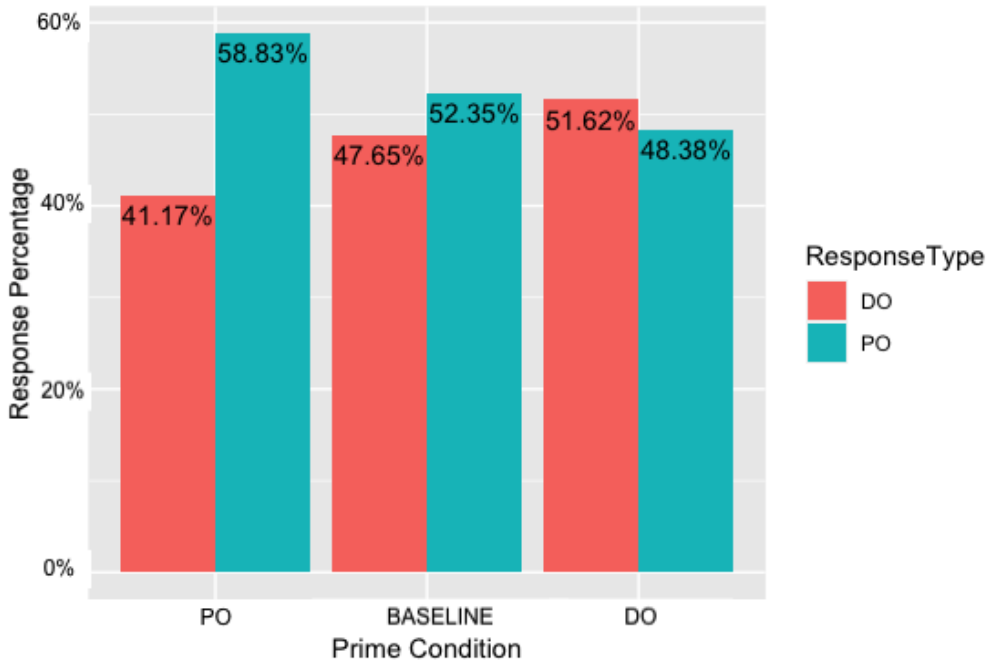

Figure 5.2 Response type frequencies by priming condition for experiment 1

(verb biases of the 4 target verbs). Random intercepts were also included for subjects and items (Target Verb)[5]. The full mixed logit model yielded significant main effects for the PO-prime Structure Type ($\beta\hat{}$ = -0.459, *SE* = 0.094, *z* = -4.879, *p* < .0001) and Target Verb Bias ($\beta\hat{}$ = 0.222, *SE* = 0.106, *z* = 2.087, *p* < .0.037), but no interactions or other main effects reached significance (see Appendix D for the full model results). A series of backward step-wise comparisons with simpler mixed effects models were also fitted and the models' goodness of fit was tested using a Chi-squared analysis within the ANOVA function. Both factors of Prime Structure Type and Target Verb Bias remained statistically significant (all *p*'s < .05) after removing the factor Prime Verb Bias and all interactions, and the model was not significantly different from the full model in fitting

[5] Since object transfer direction (left-to-right vs. right-to-left) was counterbalanced in the experimental design between participants, this factor is not included in the analysis.

the data, $X^2(8) = 3.82$, $p = 0.87$. Further removing the Target Verb Bias variable did not greatly impact the model's fit, $X^2(9) = 6.47$, $p = 0.69$. However, when the factor Prime Structure Type was removed altogether, the model was significantly worse at predicting the data, $X^2(10) = 30.01$, $p < .0008$. As such, the model which best predicted DO or PO responses without overfitting the data included only the fixed effect of Prime Structure Type plus random intercepts for subject and item (see Table 5.2 below).

Although the covariate of Prime Verb Bias failed to interact significantly with either of the syntactic priming conditions in the mixed logit model, the effects of prime verb bias were further evaluated[6] . The average response types (DO, PO) for each of the 12 prime verbs were calculated by priming condition (PO, DO)[7] using the *dplyr* package (Wickham et al., 2022) and plotted in R version 4.0.2 (RStudio Team, 2020). As shown in Figure 5.3 below, the negative slopes indicate a strong main effect of syntactic priming for the PO-structure. Participants were more likely to produce a PO response following a PO-biased prime verb, such as *deliver*, used in the PO structure. Conversely, participants were more likely to produce a response using the DO structure only after hearing a PO-biased prime verb, such as *show*, used in the DO structure. These verb effects by condition supports the results reported in the mixed logit model, where the syntactic priming effect dominated the verb bias effects. Regardless of whether the prime verb was PO- or DO- biased, participants were primed more strongly when the PO structure was used.

[6] The effects of target verb biases were not evaluated, given that targets verbs in this experiment were all neutrally biased by design.
[7] Since the dative prime verbs were never presented in the baseline condition, this condition is not included in experiment 1.

Table 5.2 Mixed logit model results for experiment 1

	Coefficient	**SE**	**Z-value**	***p*-value**
Intercept (Baseline)	-0.24194	0.40023	-0.604	0.546
PO-Prime	-0.45769	0.09366	-4.887	**.000001**
DO-Prime	0.10538	0.09236	1.141	0.254

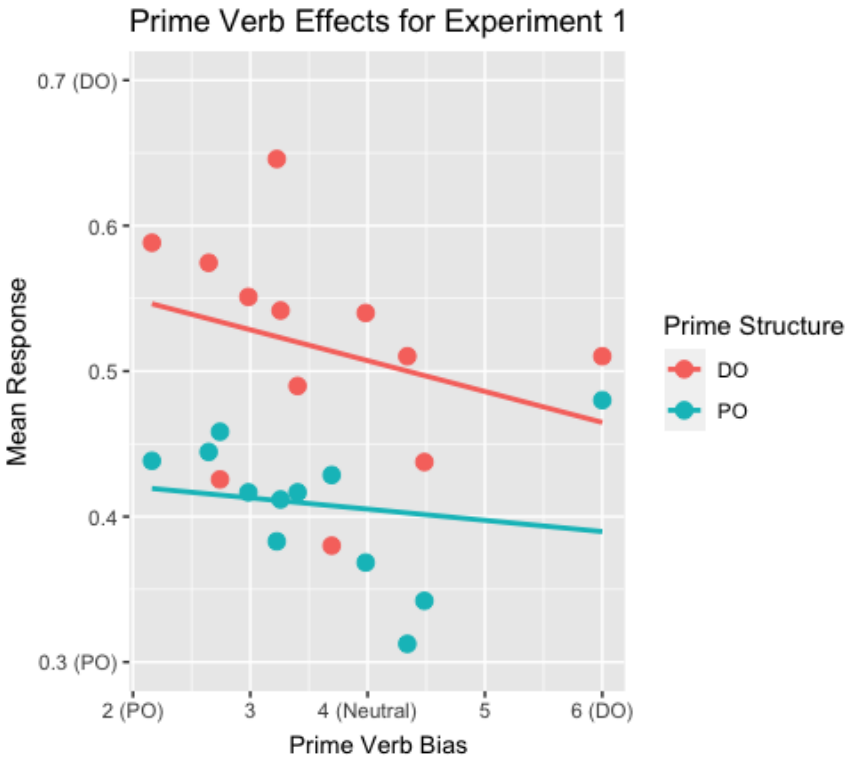

Figure 5.3 Priming effects for prime verbs in experiment 1

Although all of the verbs used in this study were selected carefully with verb frequency in mind, and are therefore all relatively frequent, we also tested the effects of verb frequency on these results. Verb frequencies were obtained from a word frequency data list of lemma forms based on the Corpus of Contemporary American English

(COCA; Davies, 2011) to assess the possible influence of verb frequency on the syntactic priming and verb bias effects. In order to compare verb bias and frequency on a similar magnitude, the verb frequency data for the prime and target verbs were then normalized in RStudio. When we included the verb biases and verb frequencies for both Prime and Target verbs as covariates in the model, neither Prime Verb Frequency nor Target Verb Frequency reached significance (all *p's>.1*). The main effect of PO priming remained significant ($\beta\hat{}$= -0.463, *SE* = 0.094, *z* = -4.928, *p* < .0001), but this was at the expense of eliminating any effect of Target Verb Bias ($\beta\hat{}$ = 0.167, *SE* = 0.114, *z* = 1.461, *p* > 0.1). It is important to note that verb bias and verb frequency were highly correlated: a Pearson's product-moment correlation showed that Prime Verb Bias and Prime Verb Frequency were significantly correlated, *r*(1741) = 0.66; *CI* [0.63, 0.69]; *p* < .001, and Target Verb Bias and verb frequency were also highly correlated, *r*(1741) = 0.53; *CI* [0.5, 0.56]; *p* < .0001. This suggests that verbs which have a stronger DO-bias were less frequent than verbs with a low bias (PO-bias).

5.3.6 Discussion

As predicted in the first hypothesis, there was a significant effect of syntactic priming for the PO-dative structure, though there was less of an effect for verb bias than expected. This finding partially supports the "inverse frequency effect," where less-expected or preferred syntactic structures prime more strongly than frequent structures (Jaeger & Snider, 2007). The lack of a significant effect for the DO-dative structure is somewhat surprising, but priming effects for the DO dative are reportedly much weaker compared to PO-primes for speakers of American English (Bernolet & Hartsuiker, 2010; Kaan & Chun, 2018) and this experiment might lack the power necessary to detect a

weaker priming effect. However, it is notable that participants did not display a significant preference for either DO or PO structures in the Baseline condition (p = .546). This supports several previous corpus analyses suggesting that the English dative alternation may be relatively balanced in frequency depending upon the speaker population and discourse context (Bresnan et al., 2007; Gries, 2005; Gries & Stefanowitsch, 2004).

One concern is the experiment's failure to replicate the significant interaction effects for verb bias and syntactic priming reported in Bernolet and Hartsuiker (2010). The significant main effect of target verb bias suggests that verb bias did weakly influence syntactic choice during the experiment, but since this effect did not withstand the model comparisons it appears that verb bias was outweighed by the stronger syntactic priming effects, specifically for the PO-structure. It is also worth noting that the verbs selected to be target verbs were freely alternating (aka neutrally-biased) verbs, so it was expected that the prime verbs would show stronger bias effects – this was not the case. Another possible factor influencing this effect is that the influence of verb bias on syntactic choice might accumulate with exposure, rather than surfacing at an immediate, turn-by-turn level. The second experiment therefore attempts to boost the verb bias effect on syntactic priming by introducing lexical overlap as a within-subjects factor. It is expected that verbs with a strong DO-bias or a strong PO-bias will produce a boost in syntactic priming effects most significantly when repeated between prime and target trials.

CHAPTER 6

EXPERIMENT 2

The design of the second experiment is identical to the first, but with the addition of another within-subjects factor of verb repetition (repeated, not repeated) while holding all other factors constant. Whereas the verbs were never repeated in the first experiment, half of the target verbs matched the dative verb in the priming sentence (repeated condition), while the other half of targets remained different, with the same target verbs as used in experiment 1 (unrepeated condition). No participants who completed either the preliminary verb bias survey or the first experiment participated in experiment 2.

6.1 Participants

A total of 38 native speakers of American English (28 female; age $M = 23.79$, $SD = 3.57$) participated in the second experiment. Thirty-six participants were recruited through Prolific Academic Ltd. (www.prolific.co). Two additional participants were recruited through word-of-mouth at the end of the study in order to match the sample size of the first experiment. All participants reported having normal or corrected-to-normal vision, no language impairments, and gave consent to participate in the study and for the video session to be recorded during the experiment. No participants who completed the preliminary verb bias survey or the first experiment participated. Participants were compensated for their time upon completion of the experiment session. A female or male undergraduate student served as the confederate speaker as in the dialogue game experiment.

6.2 Materials

The same materials were used as in experiment 1, except the participant lists were altered to include overlap between prime and target verbs (see Appendix D). Two target lists were created to counterbalance for direction of theme transfer (left-to-right vs. right-to-left). The same three prime lists as used in experiment 1 were rotated between participants (see Appendix E for example stimulus and prime structures).

6.3 Procedure

The procedure used for the second experiment was identical to experiment 1.

6.4 Coding and Analysis

Responses (n = 1824) for the critical trials were coded in the same manner as for the first experiment. The final analyses excluded 101 "Other" responses[8], accounting for approximately 5.54% of the response data. An additional 44 responses where subjects substituted a target verb other than the one shown were excluded, leaving 1679 total data points in the final analysis.

6.5 Results

Accuracy scores for the verification task were all greater than 91.67%, indicating that participants paid attention to the task and their partner's descriptions. The response data were analyzed for general effects of syntactic priming between participants, with syntactic choice for the dative alternation measured against the baseline transitive primes. Overall, participants showed a general tendency to use the PO structure across all priming conditions, producing 32.6% more PO responses (n = 1113) than DO responses (n = 566) across conditions (see Figure 6.1). There were nearly twice as many PO responses

[8] Several data points were excluded from analysis due to internet interruptions.

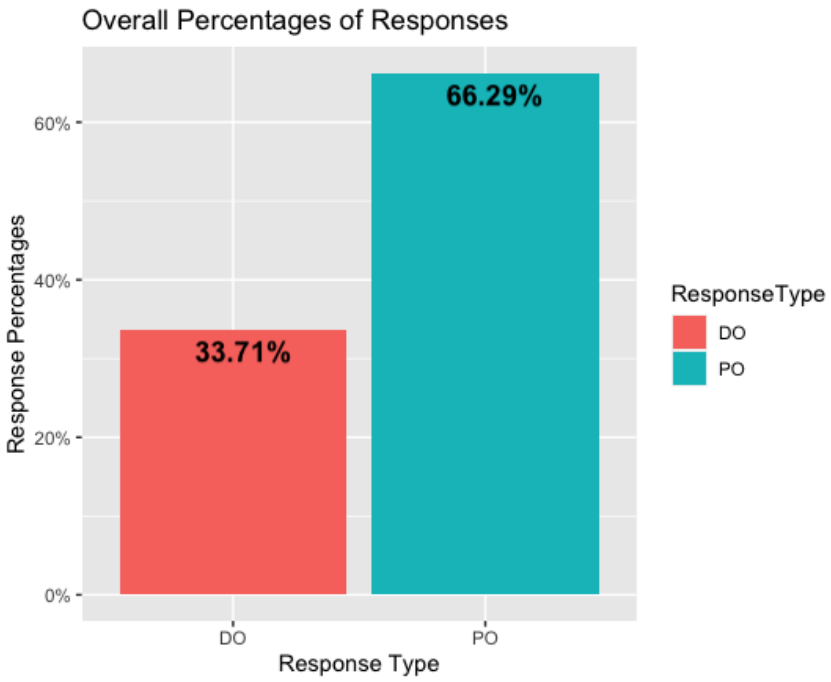

Figure 6.1 Overall response percentages for experiment 2

(*n* = 357) as DO-responses (*n* = 184) in the Baseline condition. In the DO-prime condition, there were slightly fewer DO-responses (*n* = 263) than PO-responses (*n* = 306) (see Table 6.1). Judging from the raw count alone, the weak DO-priming effect reported in the first experiment seems to have disappeared in experiment 2, while the PO priming effect has strengthened. As expected, participants produced more PO responses (*n* = 450) than DO-responses (*n* = 119) in the PO-priming condition, that is a 25.3% increase in PO-responses compared to the Baseline condition (see Figure 6.2). However, participants produced 11.1% more DO responses in the DO priming condition than in the other two conditions, suggesting that the DO-priming condition still weakly influenced syntactic choice to some extent, even if it was not significant.

As with experiment 1, the data was fit to a series of mixed logit regression models (Jaeger, 2008; cf. Bernolet & Hartsuiker, 2010) using the *lme4* package version 1.1-23

Table 6.1 Raw counts of responses by priming condition for experiment 2

	DO-responses	**PO-responses**	**%PO**
Baseline	184	357	66%
DO-prime	263	306	53.8%
PO-prime	119	450	79.1%

(Bates et al., 2015) in R version 4.0.2 (RStudio Team, 2020). We started from a full model with the maximum 4-way interaction between the factors Prime Structure Type (PO, DO, Baseline), Prime Verb Bias, Target Verb Bias, and Verb Overlap (same verb, different verb). Random intercepts were also included for subjects and items (Target Verb). The full mixed logit model failed to converge, so the fixed-factor of Prime Verb Bias was removed (see Appendix F for full model results). The selected model (shown in Table 6.2) revealed a significant 3-way interaction between the Prime Structure Type, Target Verb Bias, and Verb Repetition ($\beta\hat{} = -0.396$, SE= 0.009, z= -2.626, p=0.009). When we attempted to reduce the model complexity to all 2-way interactions between Prime Structure Type and Target Verb Bias, Prime Structure Type and Verb Overlap, and Target Verb Bias and Verb Overlap, this significantly worsened the model fit $X^2(2) = 10.275$, $p < .01$.

In order to compare these results more directly with the results from experiment 1, we analyzed a subset of the data from experiment 2 consisting only of the trials where the verb differed between the prime and target structures (N=945). The trend for a strong preference to use the PO dative structure across all prime conditions remained, but this

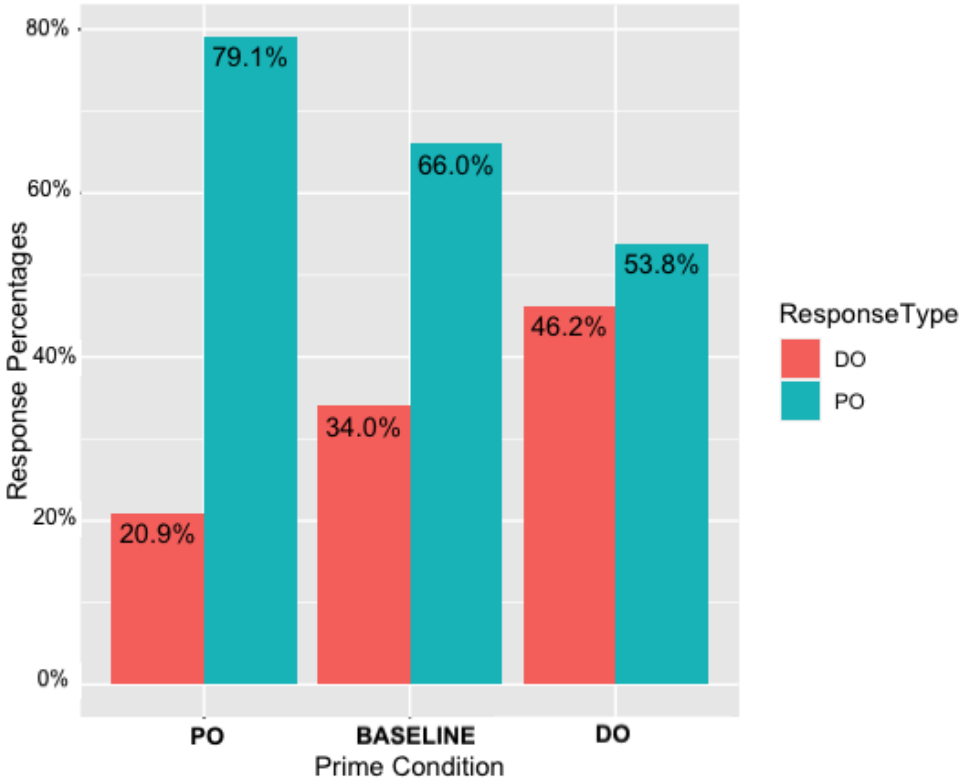

Figure 6.2 Response type by priming condition for experiment 2 (with repetition)

Table 6.2 Mixed logit model results for experiment 2

	Coefficient	**SE**	**Z-value**	***p*-value**
Intercept (Baseline)	-1.08421	0.29313	-3.699	**0.000217**
PO-Prime	-1.03296	0.12923	-9.333	**.000001**
DO-Prime	0.16339	0.10798	1.513	0.130220
Target verb bias	0.69272	0.17089	4.054	**.000001**
Verb overlap	0.29580	0.18878	1.567	0.117143
DO prime * Target Verb Bias	-0.07468	0.15092	-0.495	0.620719
PO prime * Target Verb Bias	0.03790	0.12115	0.313	0.754420
PO prime * Verb Overlap	0.85728	0.12830	6.682	**.000001**
DO prime * Verb Overlap	-0.11054	0.10792	-1.024	0.305690
Target Verb Bias * Verb Overlap	-0.24211	0.17057	-1.419	0.155779
PO prime * Target Verb Bias * Verb Overlap	-0.39601	0.15082	-2.626	**0.008648**
DO prime * Target Verb Bias * Verb Overlap	0.04359	0.12040	0.362	0.717300

preference was not quite as strong as when verbs were repeated between trials. The responses for the DO prime condition remained roughly the same as compared to the trials with repetition (PO = 174, DO = 142) (see Figure 6.3). Participants produced 11.4% fewer PO responses (PO = 216, DO = 103) in the PO prime condition and 6.3% fewer PO responses in the Baseline condition (PO = 185, DO = 125). We analyzed this subset of data without verb repetition following the same modeling procedures as before, starting with a full model which included a 3-way interaction between the fixed-factors Prime Structure Type, Target Verb Bias, and Verb Overlap as well as subject and items random, but this failed to converge. Including the factor Prime Verb Bias as a covariate did not improve the model's fit $X^2(3) = 1.02$, $p > .1$, so it was excluded from the final analysis. Model fit weakened when Target Verb Bias was removed, $X^2(3) = 26.76$, $p < .0001$, suggesting that the target verb's bias was a significant predictor of syntactic choice. The final best-fitting model, which included Prime Structure Type and Target Verb Bias as interaction terms, revealed a significant interaction between the PO-prime structure and Target Verb Bias, ($\hat{\beta} = -0.51$, $SE = 0.136$, $z = -3.73$, $p < 0.01$).

The results for experiment 2 largely reflect the results from the mixed-logit regression results in the first experiment, where the PO-prime structure showed a larger priming effect than the DO priming effect, and also that the target verb bias was significant. The interaction of these two factors is much more robust in experiment 2, however, despite fewer data points ($N = 945$) compared to the first experiment ($N = 1743$). This suggests that verb overlap is a strong predictor of the priming effects shown in the data and potentially creates a spillover effect, even on non-repetition trials where

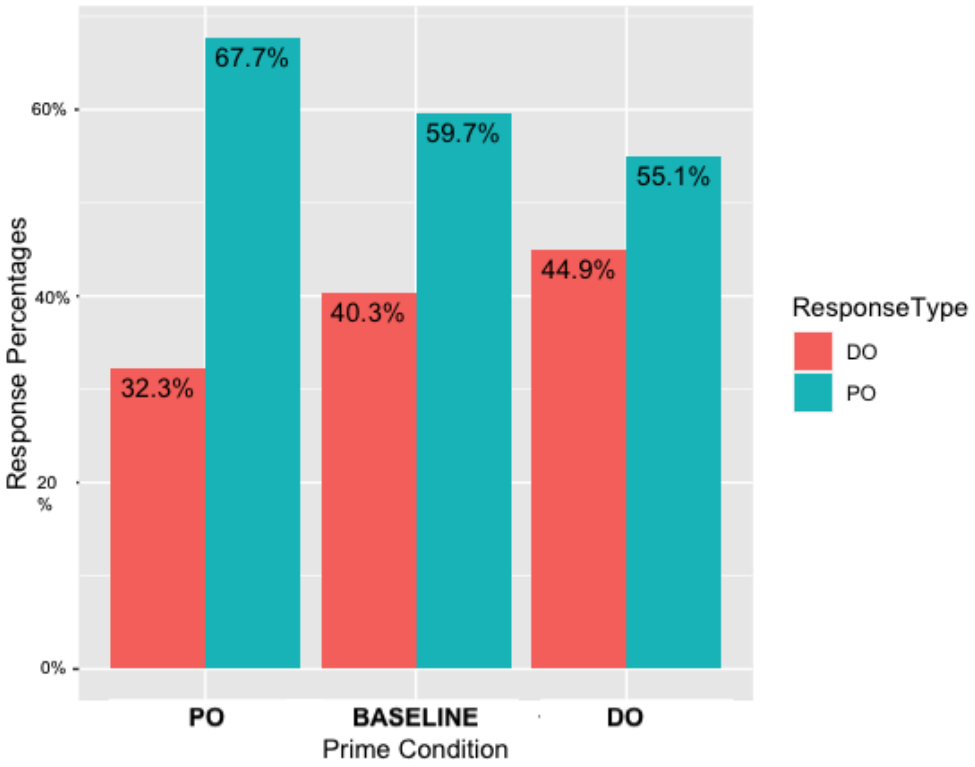

Figure 6.3: Response type by priming condition for experiment 2 (without repetition)

the verbs differed between prime and target structures. The implications of this effect are compared to the results from experiment 1 in greater depth in the discussion section.

Following the same procedure as reported in experiment 1, the average responses per prime verb by Prime Structure Type and Prime Verb Bias were again calculated for the prime verbs. However, contrary to the first experiment, the average response showed a positive trend with the Prime Structure Type and the verb bias when the verbs were repeated between the prime and target trials (Figure 6.4). As might be expected, participants were more likely to produce PO responses upon hearing a PO-biased prime verb used in a PO Prime Structure; they produced more DO responses following a DO-biased prime verb used in a DO-Prime Structure. This suggests that although the syntactic priming effect of the PO structure was still strong overall, even on the Baseline trials, the

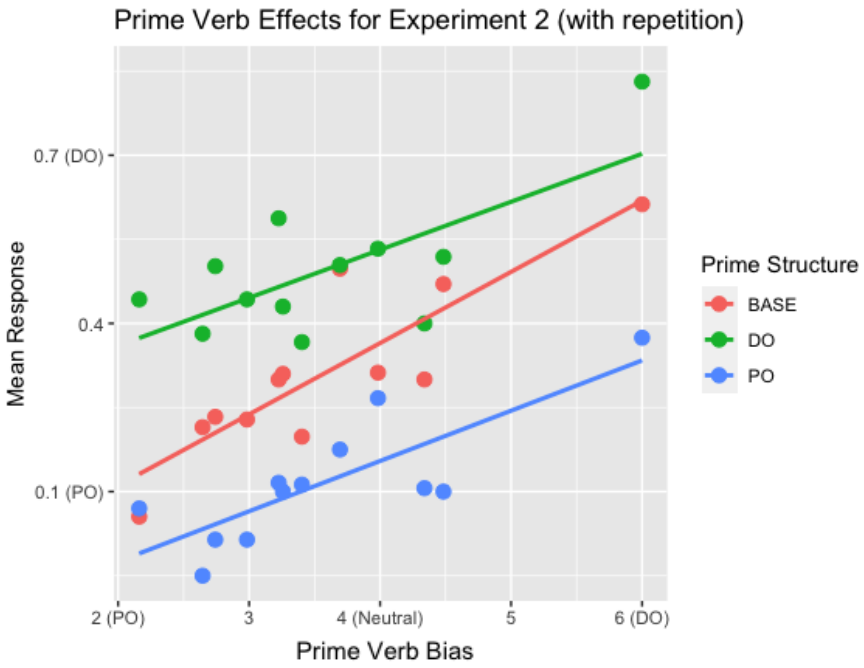

Figure 6.4 Priming effects for prime verbs in experiment 2 (with repetition)

additional factor of Verb Overlap between prime and target verbs strengthened verb bias effects, for both DO-biased and PO-biased verbs.

To better compare these results more directly with the results from experiment 1, we evaluated the influence of prime verb bias when there was no verb overlap. The average responses per prime verb by Prime Structure Type and Prime Verb Bias were calculated using the subset of data where the verb differed between the prime and target structures (N = 945). As shown in Figure 6.5 below, when verb overlap is removed, the slopes for the response structures fall drastically, particularly for the DO Prime Structure condition, nearly reversing the verb bias effects. Participants were more likely to produce a DO response following a PO-biased verb used in a DO prime structure, suggestive of an inverse preference effect, and this preference diminished for more neutrally or PO-biased prime verbs used in the DO structure. Participants were more likely to use a PO response following a PO-Prime structure, regardless of the prime verb's bias, suggesting that the

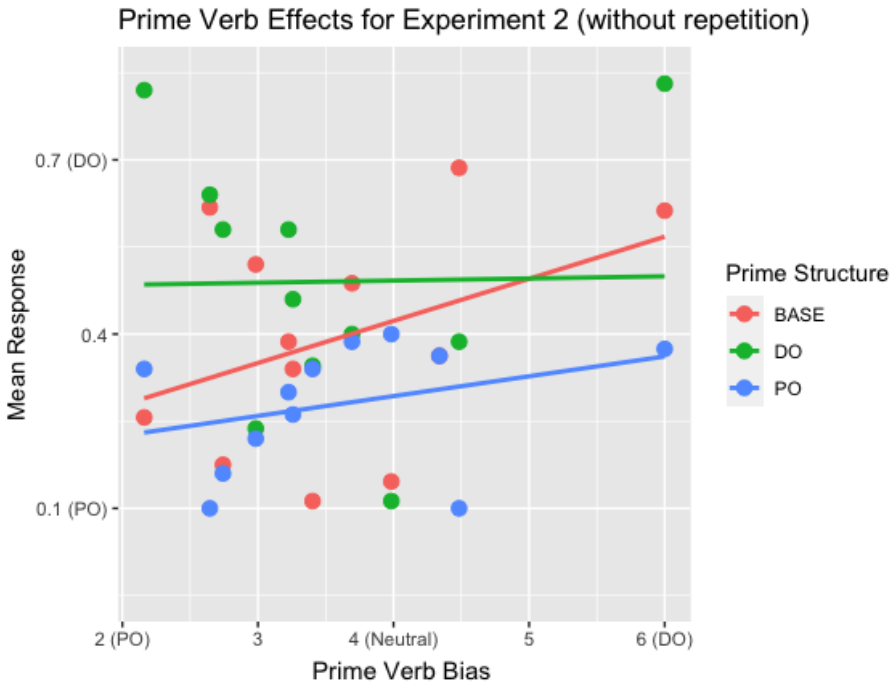

Figure 6.5 Priming effects for prime verbs in experiment 2 (without repetition)

PO-Structure remained significant. These results suggest that the lexical boost did impact the verb bias effects on syntactic priming.

6.6 Discussion

The second experiment revealed that repetition of strongly biased verbs does impact the rates of syntactic priming, but in very distinct ways for the two alternative dative structures. The PO structure was primed more strongly in participants' sentence productions, even in the Baseline condition. However, the previously weak evidence of a DO priming effect disappeared, though participants did produce more DO responses in the DO-prime condition than Baseline or PO-prime condition. The absence of a significant DO-priming effect in the second experiment is unsurprising for several reasons. As shown in the first experiment, DO-priming appears to be much weaker than PO-priming effects for this population of speakers, most likely because it is more highly preferred than the PO structure in the American English dative alternation (cf. Bernolet &

Hartsuiker, 2010; Kaan & Chun, 2018). Also, most of the dative verbs used in this study displayed moderate to strong bias for the PO structure; in fact, only the verbs *pay* and *show* appeared biased towards the DO structure. However, the fact that participants still produced more DO responses in the DO-priming condition as compared to the Baseline suggests that the influence of syntactic priming on participant syntactic choice is still present. As such, it appears that the abstract priming effect for the DO-dative structure is weakened when lexical preference is biased towards the alternative structure, which would, in this case, be the PO structure.

Another critical finding from the second experiment is that the repetition of strongly biased verbs between prime and target structures does influence syntactic priming, but only in favor of the PO-prime structure. It appears that the addition of verb overlap created a spillover effect on the strength of target verb bias on syntactic priming, but only for the PO-prime structure. This suggests that when a participant hears a strongly PO-biased verb used in the PO structure, it is highly likely they will use the PO structure for verbs with a similar PO bias, even if that verb is not the same verb. In short, the second experiment partially supports the second hypothesis that verb overlap would strengthen the effects of verb bias on the dispreferred PO syntactic structure only.

CHAPTER 7

GENERAL DISCUSSION

This thesis investigated the effects of verb repetition and verb alternation bias on syntactic priming during an interactive dialogue task. The first syntactic priming experiment partially supported Bernolet and Hartsuiker's (2010) findings that verb bias modulates the rate of syntactic priming. Less support was found, however, for "inverse preference effects" wherein priming appears strongest when the syntactic structure clashes with the verb's alternation bias (Jaeger & Snider, 2007; Bernolet & Hartsuiker, 2010). The first experiment did not reveal such as interaction, which might have been due to a lack of power or from a relatively weak verb bias effect on levels of priming. The primary aim of second experiment was to strengthen verb bias effects by introducing lexical (verb) repetition between half of the prime and target trials. A stronger effect of priming appeared only for the PO-prime condition, while the priming effect for DO-structures disappeared entirely. This result could be interpreted in several ways, but we conclude that the combination of disproportionately more PO-biased verbs and probable spillover effects from the PO-priming condition lead to an increase in PO responses for most verbs, whether or not they overlapped between the prime and target structures.

Both experiments found support for the first hypothesis that verb bias would generate greater syntactic priming effects for the less-preferred, PO-dative structure. In the first experiment, the syntactic priming effect for the PO-dative structure and target

verb biases interacted weakly and there were no other significant interactions or main effects. This result suggests that, as predicted, the less-preferred PO-dative structure was more susceptible to verb bias effects. However, the finding that DO-biased verbs and PO-biased verbs showed a positive trend of interaction for the same PO-syntactic priming condition does not support the "inverse preference effect" reported in previous syntactic priming studies (Jaeger & Snider, 2007; Bernolet & Hartsuiker, 2010). There are several possible explanations for this result. One possibility is that there were too few strongly DO-biased verbs to impact the structural priming effects. Only two verbs (*pay* and *show*) were strongly DO-biased, whereas most verbs were strongly PO-biased, and the remaining verbs were freely alternating (aka neutral). Another possibility is a lack of power or not enough exposures to a verb with a strong bias.

The second experiment was designed to "boost" the syntactic priming effect by purposely including verb repetition while holding all other factors constant. We found partial support for the second hypothesis that lexical repetition of the verb between prime and target trials would significantly facilitate priming effects. Although lexical repetition did boost the priming effect for the PO-dative structure, it did so across all conditions, including the Baseline condition, which was not initially predicted. Furthermore, the predicted inverse preference effects for verb bias on speakers' syntactic choices only emerged in experiment 2, when participants produced more DO responses following a PO-biased verb in the DO-Prime Structure condition, on trials without verb overlap. It therefore appears that the lexical boost effect evidenced in this data was strongest for the PO-dative due to the high frequency of the strongly PO-biased verbs in the input which created a highly constrained environment for PO-dative responses to emerge.

7.1 Considerations for Mechanistic Accounts Priming and Alignment

The syntactic priming results of the current study appear to lend mixed to support to each of the two mechanistic accounts of syntactic priming, but only the error-based learning account (Chang et al., 2006) can sufficiently predict the differential effects of verb bias and lexical boost. According to the error-based implicit learning account, the use of a less expected structure produces stronger priming effects due to greater surprisal. That grammatical structure will then receive a stronger weight in the memory, and will therefore become more likely for subsequent production, immediate or delayed. This theory of implicit learning can be further extended to lexical items. Since associations are flexible and constantly updated, the error-based learning account uses probabilistic information from prior experience and frequency to predict a lexical item's occurrence in a particular argument structure. Under this account, we can predict that verb bias will produce greater syntactic priming effects for the less-preferred, PO-dative structure between speakers. This prediction cannot be justified by the residual activation account (Pickering & Branigan, 1998), wherein the syntactic properties of lexical items are fixed and stored in the lemma stratum and associated with abstract structural associations.

The second prediction is that lexical repetition of the main verb should produce greater syntactic priming effects (due to lexical boost) for both PO- and DO-dative structures between speakers. The residual activation account predicts a lexical boost effect when the repetition of an open-class lexeme – such as a verb or noun – produces both activation at the verb node, the combinatorial node and the shared connections between them for the most recently activated syntactic structure (Pickering & Branigan, 1998). Therefore, syntactic priming will be stronger when the verbs overlap between

prime and target structures than in the different verb priming conditions. According to Chang et al.'s (2006) explicit learning extension of the error-based learning account, a repeated verb may serve as an explicit memory cue to retrieve the most recently processed abstract structure from working memory. Therefore, this account also predicts that verb repetition between prime and target verbs will temporarily enhance syntactic priming effects for the most recently processed structure.

To conclude, the results presented in this study largely support the error-based implicit learning account (Chang et al., 2006), where the probability for a syntactic structure is weighted according to prediction and frequency in input, rather than the residual activation account where lexical and syntactic connections are relatively permanent, and priming is transient (Pickering & Branigan, 1998). More critically, however, the results presented here support the IAM's assumption that priming percolates across linguistic levels, though perhaps lexical and syntactic priming are produced by two distinct priming mechanisms. As Pickering and Garrod aptly note, "transient activation explains some aspects of alignment, and memory-based mechanisms explain other aspects of alignment" (2004, p. 213).

7.2 Limitations

There are several limitations which should be addressed so that future work can improve upon and extend this research. First, dative verb alternation biases were estimated from a grammaticality judgment task, rather than from spontaneous production or corpus analysis. This testing method was chosen for multiple reasons, including the prioritization of remote data collection at the time of testing. This particular measure appears robust for the purposes of the current study: the sample size was relatively large

(N=69), the verb bias ratings appeared homogenous across the sample, and the verb bias effects were moderately to strongly significant in the priming experiments. Another minor limitation is that a different subject population than those who completed the priming experiments were recruited for the preliminary verb bias survey. However, we took caution to target a similar population and heavily restrict the inclusionary criteria for the priming experiments to match the surveyed population as closely as possible. As such, it is very unlikely that this difference in subject pool would affect the quality of the data. Finally, it is possible that participants in the priming experiments might have had some inclination as to the purpose of the study and exaggerated their responses, but most participants seemed unaware of the true priming condition or that their dialogue partner was a confederate assistant to the study.

7.3 Implications and Future directions

Research which investigates lexical and syntactic priming during interactive discourse is interesting and informative for several reasons. First, the unconscious and automatic nature of syntactic priming allows for tests of implicit knowledge and learning of language structure (cf. Chang et al., 2006; Pickering & Branigan, 1998; Pickering & Garrod, 2004). Second, the finding that the verb repetition in addition to PO verb bias created a large spill-over effect of PO priming, even across without verb repetition trials, suggests that lexical factors such as verb biases and repetition do indeed interact to facilitate or restrict abstract syntactic priming effects. From a theoretical perspective, if syntactic priming were truly abstract, it should not be the case that repetition of PO-biased verbs would overpower any DO-priming effects. This suggests that verb bias effects might be underlyingly driving syntactic priming (cf. Bernolet & Hartsuiker),

which is not entirely surprising if one considers probability of a verb appearing with a specific argument structure (cf. Chang et al., 2006).

Finally, the context of interactive discourse allows for investigation into between-speaker priming, which has been shown to produce different linguistic behaviors than solitary language comprehension or production tasks. Further research in this vein might select for different discourse dynamics, such as syntactic priming between second language speakers (of English or another language) or speakers of distinct dialects within the same language. We also aim in future research to test whether these priming mechanisms extend across non-literal (figurative) language, such as in the use of metaphor and idiomatic expressions. Finally, future investigation should measure multiple levels of linguistic representation as well as multiple aspects within a single linguistic level to better tease apart the cascading effects of priming that lead to greater linguistic alignment between speakers.

7.3 Conclusion

Syntactic priming during interactive dialogue is a robust phenomenon that is nevertheless still sensitive to other linguistic factors such as verb bias and lexical repetition. The first experiment replicated results from previous priming studies such that speakers in an interactive discourse task are more likely to use the same syntactic structure as produced by the other speaker but found only a weak effect of verb bias influencing these effects and no evidence of verb-specific "inverse preference effects" (i.e., Bernolet & Hartsuiker, 2010). The second experiment found that syntactic priming was significantly stronger for the PO-dative when the verbs were repeated between prime and target trials. More critically, the lexical boost from verb repetition created a spill-over

effect for strongly biased PO-dative verbs, essentially outweighing the DO-priming effect. We conclude that these results support an implicit error-based learning account of syntactic priming (Chang et al., 2006), whereby frequency and surprisal for less-preferred or unexpected syntactic structures produces greater priming effects between speakers.

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APPENDIX A

PRELIMINARY SURVEY MATERIALS

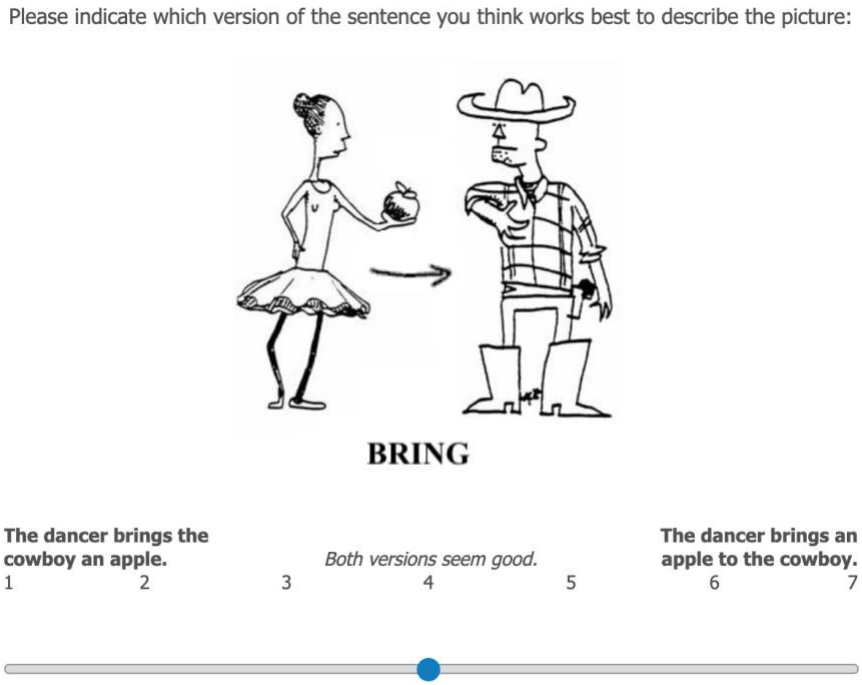

Figure A.1: Preliminary survey question example

APPENDIX B

VERB BIASES AND FREQUENCIES

Verb biases are displayed on a scale of 1=PO biased to 7=DO biased. Verb frequencies obtained from the Corpus of Contemporary American English (COCA; Davies, 2011).

Table A.1 Verb biases and frequencies

Verb	**Bias**	**Frequency**
kick	2.14516129	59307
donate	2.16129032	19564
deliver	2.64516129	77338
present	2.74193548	111731
throw	2.98387097	152388
send	3.01612903	256309
write	3.22580645	439865
sell	3.25806452	198982
pass	3.40322581	203033
loan	3.5	2498
read	3.53225807	386352
serve	3.69354839	213511
offer	3.72580645	234189
lend	3.93548387	17776
award	3.98387097	54712
hand	4.03225807	40469
give	4.24193548	10448189
bring	4.33870968	439445
show	4.48387097	536889
pay	6	365255

APPENDIX C

EXPERIMENT 1 STIMULI EXAMPLE

An example of a target stimulus picture with corresponding priming sentences from the three priming conditions (DO, PO, and Baseline).

Figure C.1 Syntactic priming stimulus example for experiment 1

(a) The chef passes the clown a cake.	*DO-dative*
(b) The chef passes a cake to the clown.	*PO-dative*
(c) The chef kicks the clown.	*Transitive baseline*

APPENDIX D

STATISTICAL RESULTS FROM EXPERIMENT 1

Table D.1 Results from maximal mixed logit model for experiment 1

	Coefficient	SE	z-value	*p*-value
Intercept (Baseline)	-0.23865	0.38142	-0.626	0.5315
PO-Prime	-0.45866	0.09402	-4.879	**.0000001**
DO-Prime	0.10574	0.09277	1.140	0.2544
Prime verb bias	-0.08505	0.06570	-1.294	0.1955
Target verb bias	0.22191	0.10635	2.087	**0.0369**
PO Structure * Prime verb bias	0.08510	0.09279	0.917	0.3591
DO Structure * Prime verb bias	-0.03279	0.09440	-0.347	0.7283
PO Structure * Target verb bias	-0.03880	0.09255	-0.419	0.6750
DO Structure * Target verb bias	0.01239	0.09276	0.134	0.8937
Prime Verb Bias * Target Verb Bias	0.03705	0.06568	0.564	0.5727
PO Structure * Prime verb bias * Target Verb Bias	0.06354	0.09417	0.675	0.4998
DO Structure * Prime verb bias * Target Verb Bias	-0.07308	0.09611	-0.760	0.4470

APPENDIX E

EXPERIMENT 2 STIMULI EXAMPLE

An example of a target stimulus picture with corresponding priming sentences from the three priming conditions (DO, PO, and Baseline) for a trial with verb repetition.

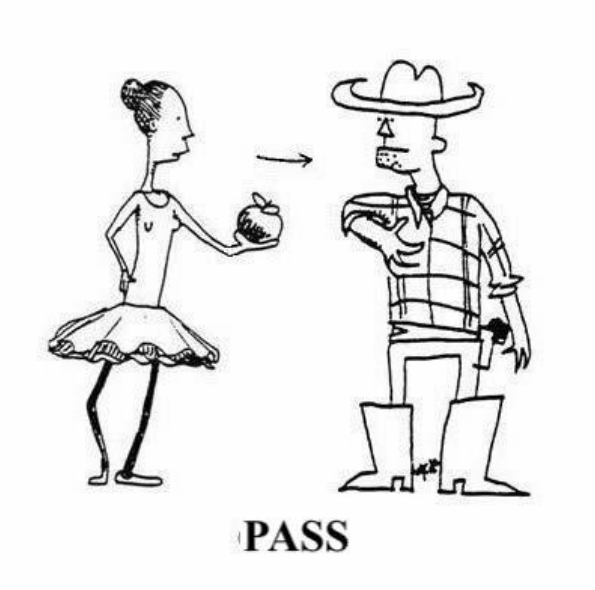

Figure E.1 Syntactic priming stimulus example for experiment 2

(a) The chef passes the clown a cake. *DO-dative*

(b) The chef passes a cake to the clown. *PO-dative*

(c) The chef kicks the clown. *Transitive baseline*

APPENDIX F

STATISTICAL RESULTS FROM EXPERIMENT 2

Table F.1 Results from maximal mixed logit model for experiment 2

	Coefficient	SE	z-value	*p*-value
Intercept (Baseline)	-1.08421	0.29313	-3.699	0.000217***
PO-Prime	-1.03296	0.12923	-7.993	**0.000001*** **
DO-Prime	0.16339	0.10798	1.513	0.130220
Target verb bias	0.69272	0.17089	4.054	**0.000001*** **
Verb Overlap	0.29580	0.18878	1.567	0.117143
PO Structure * Target verb bias	-0.07468	0.15092	-0.495	0.117143
DO Structure * Target verb bias	0.03790	0.12115	0.313	0.620719
PO Structure * Verb Overlap	0.85728	0.12830	6.682	**0.000001*** **
DO Structure * Verb Overlap	-0.11054	0.10792	-1.024	0.305690
Prime Verb Bias * Target Verb Bias	-0.24211	0.17057	-1.419	0.155779
PO Structure * Target Verb Bias * Verb Overlap	-0.39601	0.15082	-2.626	0.008648**
DO Structure * Target Verb Bias * Verb Overlap	0.04359	0.12040	0.362	0.717300