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Declaration of interest

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Data and Code Availability

All data and code are publicly available through the Open Science Framework. Available at https://osf.io/uxwej/

Abstract

We studied the role of discourse coherence relations on structure formulation in sentence production by examining whether a connective, an essential signal of coherence relations, modulates the tendency for speakers to reuse sentence structures (i.e., structural priming). We further examined three possible modulating factors: the type of connectives (additive vs. adversative connective), event similarity (similar event vs. different event), and topic cohesion (with or without available anaphoric antecedent). In four structural priming experiments, native Dutch participants were asked to read either a Dutch double object (DO) sentence or a prepositional object (PO) sentence and describe pictures that depicted ditransitive events. Critically, the prime and the target either were linked by a connective (*en* 'and' or *maar* 'but') or were not linked. The verb overlap between the prime and the target was also manipulated. In Experiment 1, the presence of *en* facilitated structural priming, but only when the verbs were different. In Experiment 2, *maar* reduced structural priming when the verbs were repeated. Experiment 3 replicated the findings of Experiment 1 and 2 in a within-subjects design. In Experiment 4, there was no referential link between the sentences. Now there was no connective effect on structural priming. Taken together, we demonstrated that the insertion of a connective influences syntactic persistence. The connective effects vary across semantic properties of the connectives, event similarity, and referential continuity, suggesting that the production of sentence structure is modulated by speakers' prediction about listeners' inference of coherence relations between consecutive utterances.

Keywords: structural priming; lexical boost; discourse coherence; grammatical encoding

Introduction

In daily communication, speakers make decisions about how to construct the sentences they want to say. Among others, they need to choose syntactic frames for the sentences they intend to produce. For example, one could say *The princess awarded the janitor a medal* or *The princess awarded a medal to the janitor*. Both answers convey a similar message, but they differ in the syntactic structure: The first sentence has a double object (DO) structure while the second has a prepositional object (PO) structure. As speakers can only choose one syntactic structure in the end, the formulation of a sentence entails a decision among one or more syntactic alternatives. Many scholars argue that the message the speakers want to communicate influences how they are going to frame their utterance. That is, the choice of syntactic structure can be guided by the conceptual configuration of the message (e.g., Vigliocco & Hartsuiker, 2002). For example, if one intends to make the one who received a medal the topic (and what was awarded as the comment), they tend to put the recipient of the event (in this case *the janitor*) earlier in the sentence and produce a DO sentence accordingly (*The princess awarded the janitor a medal*) (see Arnold, Losongco, Wasow, & Ginstrom, 2000 for a related discussion).

Many psycholinguistic studies have demonstrated that conceptual relations at the message level modulate the structural formulation of a sentence (e.g., Bernolet, Hartsuiker, & Pickering, 2009; Ziegler, Snedeker, & Wittenberg, 2018). Nevertheless, most of these studies focussed on the production of isolated sentences. Less is known about how the conceptual relations between sentences (i.e., coherence relations[1]) influence the coordination of syntactic structures in consecutive utterances. In this study, we asked whether the inference of coherence

[1] In the current study, we will follow the terminology used by Kehler (2002), in which some of the main types of coherence relations include the Parallel relation (a propositional relation where the events described by two clauses are in common), Contrast relation (the events described by two clauses are contrasting), Result relation (the second clause can be inferred to as the result of the first clause), and so on.

relations across sentences, similarly to message encoding of an individual sentence, guides structure formulation in language production.

Inference of coherence relations plays a crucial role for listeners to understand the conversation. For example, if someone said to you *A janitor saved the princess from a burning palace yesterday. This morning the princess awarded the janitor a medal.* You will probably infer that the reason why the janitor got a medal is that he saved the princess. This shows that the listeners tend to make inferences about the coherence relations based on the context. If they fail to do so, they might construe the utterances as independent events and their interpretation of the communicative intention across the utterances would break down. Thus, inference of coherence relations is crucially important in understanding and tracing the ongoing discourse beyond individual sentences (Hobbs, 1979; Kehler, 2002).

Importantly, how listeners make inferences about the conversation also has implications for speakers. Arguably, a speaker formulates utterances in a way that accommodates the listeners' interpretation of the conversation. This so-called audience design process suggests that speakers would tailor the linguistic representations of their speech in accordance with the listeners' knowledge of the ongoing discourse (Ahn & Brown-Schmidt, 2020; Ferreira, 2019; Horton & Gerrig, 2002). Building on this idea, speakers should make their formulation of syntactic structures consistent with the coherence relation inferences the listeners are likely to make (see Arnold & Zerkle, 2019 for a discussion). This is the case even when no listeners are present, since monologue and dialogue exploit very similar mechanism of audience design (Pickering & Garrod, 2013). In short, the assumption of audience design predicts that the generation of syntactic structures should be modulated by the coherence relations in the discourse.

In the current study, we tested this prediction by investigating whether speakers' tendency to perseverate syntactic structure (i.e., structural priming, Pickering & Ferreira, 2008) is modulated by coherence relations between sentences. We first review the theoretical models and the empirical findings about how messages can be mapped onto syntactic structures, then

motivate our research question by discussing the effect of coherence relations on the encoding of syntactic functions, and finally introduce the four experiments we conducted to test the detailed predictions regarding the effect of coherence relation on the formulation of syntactic structures.

The Role of Message Encoding in Sentence Structure Formulation

Models of sentence production envisage a speech generation process that starts from the formulation of a non-linguistic message (message encoding). This is followed by the selection of a lemma (a representation that entails the lexical and syntactic features of a word), the formulation of morphological and phonological forms, and ends with physical articulation (Bock & Levelt, 1994; Levelt, Roelofs, & Meyer, 1999; Vigliocco & Hartsuiker, 2002). During message encoding, the coherence relation between the context and the upcoming utterance is decided. The conceptual perspectives of the messages (e.g., givenness, animacy, thematic role) are also encoded at this stage. The final product of message encoding then enters grammatical encoding where lemmas are selected and the syntactic functions (e.g., subject, object) and the linear position of the lemmas are assigned. Because the establishment of coherence relations occurs during message formulation, the modulation effect of coherence relations on syntactic formulation should reflect how messages map onto syntactic encoding. So, in order to study the information flow from coherence relations to syntactic structures, we first have to consider the relationship between conceptual information and grammatical encoding in sentence production.

It has been well established that the conceptual properties that are bound to lemmas influence syntactic configuration in sentence production (Bock & Warren, 1985; Ferreira, 1994; Kelly, Bock, & Keil, 1986; McDonald, Bock, & Kelly, 1993; Onishi, Murphy, & Bock, 2008; Prat-Sala & Branigan, 2000; Tanaka, Branigan, McLean, & Pickering, 2011; Tannenbaum & Williams, 1968). Concretely, the inherent features of lexical concepts the speaker intends to express (e.g., animacy, concreteness, and prototypicality) and their derived features (e.g., topicality, focus, and thematic role) are informative of the type of syntactic functions that are

assigned to these lexical concepts. One classic example comes from Bock and Warren (1985)'s study about the role of concreteness on the syntactic formulation in a sentence recall task. The participants memorized and then recalled DO and PO sentences in which the arguments vary in concreteness (e.g., *The old hermit left the property to the university* vs. *The old hermit left the university the property*, in which *the university* is more concrete in meaning than *the property*). The participants sometimes misrecalled the sentence in the alternate form (e.g., a DO instead of a PO or vice versa). Such misrecall was more likely if it resulted in a sentence with the more concrete noun in an earlier position. This tendency was not shown when they tested the recall of sentences with conjoined NPs (*The lost hiker fought time and winter* vs. *The lost hiker fought winter and time*, in which *winter* is more concrete than *time*). DO and PO vary both in syntactic function assignment and linear order whereas sentences with conjoined NPs only vary in linear order, so the more likely locus of the concreteness effect is the function assignment stage of grammatical encoding. This shows that lexical-specific concepts can be mapped onto syntactic functions, such that the conceptually more acceptable entity (i.e., the entity that is the agent/topic/emphasis of the message or is animate/concrete/typical) tends to appear as the subject of the sentence.

The mechanisms described above are not the only route in the mapping from message to syntax. The conceptual accessibility effect generally points to the role of conceptual information in the word-driven formulation of syntactic information, since both lexical concepts and syntactic functions are bound to a lemma. Arguably, in addition to such word-driven formulation, speakers can also follow a structure-driven route wherein they first build a syntactic framework from the conceptual structures and then insert the lexical items into the slots (Bock & Ferreira, 2014; Konopka & Meyer, 2014). It is important to note that the structure-driven route of message-to-syntax mapping is more critical to our research question than the word-driven route. Coherence relations are clearly not piecemeal messages but conceptual structures across sentences, so it is reasonable for such conceptual structures to be primarily mapped onto subsequent relational

frameworks such as syntactic structures. Because the syntactic relations of the arguments are decided before lexical selection, the structure-driven syntactic formulation assumes that certain syntactic operations in sentence production are lexically independent. As the studies mentioned above mainly test lexical dependent effects in sentence production, they cannot be taken as evidence for structure-driven syntactic formulation.

Evidence for the structure-driven route comes from studies using a structural priming paradigm. Structural priming in production refers to the tendency to spontaneously reuse the syntactic structure of a previously experienced sentence (Bock, 1986). It has been shown that a structural priming effect can emerge when no lexical content overlaps between the utterances (e.g., Bock, 1986; Bock & Griffin, 2000; Ferreira, Bock, Wilson, & Cohen, 2008). For example, Bock (1986) found that speakers were more likely to choose a DO structure (e.g., *A rock star sold an undercover agent some cocaine*) over a PO structure (e.g., *A rock star sold some cocaine to an undercover agent*) when spontaneously describing a picture after they heard a DO sentence. Critically, the picture they described (e.g., a man is reading a book to a boy) shared no meaningful event with the sentence they just heard, so that the speakers could not reuse any of the lexical content. The findings of the abstract structural priming effects suggest that the message can directly map onto syntactic structure without channeling specific lexical items, supporting the structure-driven route of sentence formulation.

In addition, it has been assumed that the priming of the relationship between two structures shows a direct mapping between them (e.g., Cai, Pickering, & Branigan, 2012; Chang, Bock, & Goldberg, 2003; Pappert & Pechmann, 2014). Structural priming paradigms have thus been widely employed in the studies on the mappings between syntactic structures and other relational structures such as information structure, thematic structure, and event structure (see Branigan & Pickering, 2017; Pickering & Ferreira, 2008 for a review). To better understand how coherence relations influence the structure-driven route of syntactic formulation, we first review the structural priming studies on the mapping from conceptual structures to syntactic structures.

First of all, some structural priming studies showed that overlap in the hierarchical structures of events contributes to the structural priming effects (e.g., Bunger, Papafragou, & Trueswell, 2013; Griffin & Weinstein-Tull, 2003; Ziegler et al., 2018). For example, Bunger and colleagues (2013) asked the participants to describe video clips of motion events (e.g., an alien drives a car into a cave) after reading a prime sentence. They found that the participants were more likely to describe a motion event with a sentence that incorporates event roles of both manner (e.g., the alien in a car…) and path (e.g., …entered a cave) when the prime sentence also contains both event roles and shared the event type with the target description (e.g., The zebra on the motorcycle entered the garage). In addition, the participants did so in such a way that mirrored the primed mapping between event role and syntactic function (i.e., manner information in subjects, path information in verbs), such that they preferred *The alien in a car entered the cave* over other types of expressions such as *The alien drove into the cave*. This study showed a persistent mapping between motion event structure and syntactic structure. Similarly, other studies found priming effects of the mapping between event structures and syntactic structures (e.g., Cai et al., 2012; Pappert & Pechmann, 2014), which further supported the idea that the encoding of relational structures at the message level has implications for grammatical encoding.

Additionally, some studies showed the persistence of information structure such as the relational structure of emphasis (e.g., Bernolet et al., 2009; Fleischer, Pickering, & McLean, 2012; Maier, Pickering, & Hartsuiker, 2017; Vernice, Pickering, & Hartsuiker, 2012). Bernolet and colleagues (2009) demonstrated that cross-linguistic priming effects of transitives can not only be attributed to the persistence of constituent structure but also the persistence of binding between discourse emphasis and thematic roles. Specifically, they found that, after a Dutch agent-first passive prime (e.g., *Door de bliksem wordt de kerk getroffen*, literally “by the lightning is the church struck”), the Dutch-English bilingual participants were less likely to produce an English patient-first passive (e.g., *the boxer is chased by a pirate*) in comparison with that after a Dutch patient-first passive prime (e.g., *De kerk wordt door de bliksem getroffen*, literally “the church is

by the lightning struck"). The authors reasoned that although Dutch agent-first passive primes share the functional assignment with English passives (patient-subject, agent-oblique object), its patient is de-emphasized so that the emphasis patterns are inconsistent. The inconsistency in emphasis structures reduced the syntactic priming effect. Such findings suggest that speakers incorporate the information of discourse status (e.g., which element was emphasized/given in the context) in message planning, which further modulates the formulation of syntactic structures in sentence production.

A suggestion of Bernolet et al. (2009) that is important for our study is that the mapping between messages and syntactic configurations in structure-driven production is probably not confined to isolated sentences. Speakers might plan consecutive utterances in a supra-sentential way, whereby they treat them as a mini-discourse and coordinate the syntactic structures based on the conceptual links between them. This implies that paradigms of structural priming can be a useful tool to study the effect of coherence relations on the formulation of syntactic structures. In the current study, we employed a structural priming paradigm to examine whether the coherence relation modulates the persistence of syntactic structures in sentence production. To the best of our knowledge, no mechanistic framework of structural priming makes specific assumptions about the role of coherence relations. In the next section, we will detail our theoretical motivation derived from related findings from other strands of research with the focus of referential production.

Coherence Relation and Syntactic Encoding

Some concrete evidence for the role of coherence relations in syntactic encoding comes from studies on reference production (e.g., Arnold, 2001; Fukumura & Van Gompel, 2010; Rohde & Kehler, 2014; Stevenson, Crawley, & Kleinman, 1994). Reference production involves the process in which speakers decide which element from the preceding discourse to refer to and in what way they refer to this element (e.g., by using a full noun or a pronoun). In most cases of

reference production, the concept of an anaphoric antecedent should be mapped onto a syntactic function of the current sentence (Grosz, Joshi, & Weinstein, 1995; Levelt, 1989). Many authors have argued that such a process is essentially constrained by the syntactic function of the referent (Fukumura & Van Gompel, 2010; Grosz et al., 1995; Kehler, Kertz, Rohde, & Elman, 2008; Rohde & Kehler, 2014 see Arnold, 2010 for a review). For example, Arnold and colleagues (2009) reported that speakers were more likely to use a pronoun when the syntactic function of the referent matched with that of the antecedent. Take the story of the janitor for example, following *A janitor saved the princess,* speakers would use a pronoun over a full noun to refer to the antecedent JANITOR if it is placed at the subject position again (i.e., *And he* [rather than *the janitor*] *rescued a kitty*). Such a tendency decreased when the syntactic functions did not match (i.e., speakers were less likely to say *And the butler protected him* [rather than *the janitor*]). The effect of matching syntactic function echoes a similar effect in sentence comprehension (Smyth, 1994 see Elman et al., 2006 for a discussion), suggesting that syntactic operations are at play when anaphoric expressions are selected.

More importantly, a number of studies further reveal that the effect of matching syntactic functions on anaphoric choice is preconditioned by the coherence relation (Elman et al., 2006; Kehler et al., 2008). It was reported that pronouns tended to be resolved to antecedents with the matching syntactic function only when a Parallel relation is construed between sentences (Elman et al., 2006; Kehler et al., 2008). For example, Elman et al. (2006) reported that the pronoun *him* was more likely to be interpreted as the syntactically matching antecedent *Justin* in sentences with a Parallel relation: *Samuel threatened Justin with a knife, and Erin blindfolded him*, while such a tendency reversed to *Samuel* in sentences with a Result relation: *Samuel threatened Justin with a knife, and Erin stopped him*. A similar interplay between Parallel relation and matching syntactic functions was also found when the speed of pronoun interpretation was assessed (Wolf, Gibson, & Desmet, 2004). The above evidence implies that the syntactic encoding of referents hinges on the inference of coherence relations. Specifically, the establishment of a Parallel

relation entails the inference that some elements between utterances share common properties. As a referent (in this case a pronoun) clearly shares lexical concepts with an element in the preceding sentence, it can be expected that the referent also shares other linguistic properties with that element, such as the syntactic function. This way, the argument that shares the syntactic function with the pronoun is more easily identified as the antecedent. In comparison, the establishment of a Result relation leads to the expectation that some entities in the first clause serve as a possible cause of the event in the second clause (Kehler, 2002; Kehler et al., 2008; Rohde & Kehler, 2014). Thus, the referential processing under a Result relation has little to do with the matching of syntactic functions between the antecedent and the referent. In short, some coherence relations can lead to the expectation of links of linguistic properties between utterances, which facilitate the mapping between syntactic functions and references.

Note that such an expectation-based mechanism should not only underpin listeners' comprehension of coherence relations, it should also be subsumed into speakers' computation of linguistic representations. As we have mentioned, speakers adapt to listeners' understanding of the ongoing discourse via audience design, utilizing a model of listener comprehension based on the communicative context (Ferreira, 2019). In such a model, coherence relations should be established in the same way as they are established in the listeners' mind. Following this logic, we can assume that speakers generate expectations of the links between the elements across utterances based on the perceived coherence relations in the context. Some studies employing sentence completion tasks showed evidence that supports this context-dependent hypothesis in reference production: Speakers were more likely to complete a sentence that referred to the object of the first clause when the clauses were connected by *so* (which elicits a Result relation, such as *Samuel threatened Justin with a knife, so Justin ran away*) in comparison with when the clauses were connected by *because* (which elicit a reversal of Result relation) (Fukumura & Van Gompel, 2010; Stevenson et al., 1994). But just like the conceptual accessibility effects, the effects of coherence relations in reference production only tell a part of the story. Given that the concept

and the syntactic function that are constructed during reference production are specific to a referent, previous studies on reference production only showed how information of coherence relation maps onto syntactic function via a word-driven route. It is still not clear whether coherence relations play a similar role in a structure-driven route. Specifically, does the establishment of coherence relations have implications for the choice of syntactic structures?

In the current study, we designed four structural priming experiments to assess the role of coherence relations in structure-driven formulation of syntactic structures. Concretely, we manipulated the syntactic structure of the prime sentence as well as the presence of a connective between a prime and a target. Connectives are explicit signals of coherence relations (Halliday & Hasan, 1976). It has been argued that the presence of a connective helps listeners to disambiguate the coherence relation between sentences (Crible & Pickering, 2020). Conceivably, a connective that links a prime and a target can reinforce the perceived coherence relation between them. We further varied the type of connectives, such that the connective employed in the experiment signaled either a Parallel relation (using an additive connective like 'and') or a Contrast relation (using an adversative connective like 'but'). If coherence relations indeed modulate sentence structure formulation as they do in reference production, the Parallel relation would be computed in the model of listener comprehension, which helps speakers further establish an expectation of shared linguistic representations between the prime and target. This way, the speakers are more likely to re-use the primed syntactic structure to facilitate the target sentence production. Such an effect would contribute to the overall structural priming effect. In the remainder of the paper, we elaborate on the detailed predictions and present four experiments that tested these predictions.

Experiment 1 The Effect of an Additive Connective and Event Similarity on Structural Priming

In the present experiment we investigated the effect of coherence relations on sentence structure formulation, using a structural priming paradigm. To this end, we manipulated the

presence of an additive connective between the prime and the target. We asked whether the presence of an additive connective (like 'and') between two clauses leads the speaker to predict that the listener will expect parallel structures. And if so, does such a prediction pressurize the speakers to more frequently produce syntactic structure that is in parallel with the preceding one, yielding a stronger structural priming effect? To the best of our knowledge, no sentence production study has addressed these questions. However, several studies on the parallelism effect in sentence comprehension are closely related to this issue (Frazier, Munn, & Clifton, 2000; Frazier, Taft, Roeper, Clifton, & Ehrlich, 1984; Knoeferle, 2014; Sturt, Keller, & Dubey, 2010). The basic assumption of the parallelism effect, similar to the effect of parallel syntactic functions in reference resolution (Wolf et al., 2004), is that if the first constituent is syntactically parallel with the second constituent, the processing of the second constituent becomes easier. For example, Frazier and colleagues (1984) found that the reading time for the second conjunct of the coordinated sentences that were syntactically parallel (active and active) such as *The tall gangster hit John and the short thug hit Sam* (the critical region is underlined) was shorter than for coordinated sentences that were non-parallel (passive and active) such as *The tall gangster was hit by John and the short thug hit Sam*. Such a processing advantage is arguably driven by structural priming in sentence comprehension (Knoeferle, 2014; Sturt et al., 2010): When processing coordination, the activation of the syntactic representation of the first conjunct persists to the second conjunct, yielding a priming effect that facilitates sentence parsing.

Importantly, some authors suggested that this parallelism effect is conditional on the type of connectives: the processing advantage occurs when the constituents are embedded in an 'and'-coordinated structure (Frazier et al., 2000; Knoeferle, 2014). Frazier and colleagues found that when readers processed a non-coordinated sentence (e.g., a transitive sentence), there was no processing advantage of the second noun phrase for a structurally parallel sentence (e.g., *A strange man noticed a tall woman yesterday at Judi's*) relative to a structurally non-parallel sentence (*A man noticed a tall woman yesterday at Judi's*). This contrasts with their previous

finding of a significant parallelism effect in coordinate structures (Frazier et al., 1984), which indicates that the coordination imposed by an additive connective (*and* in this case) might be a prerequisite for parallelism effects (cf. Sturt et al., 2010). One interpretation of this connective-specific constraint on parallelism, very much similar to the context-dependent hypothesis for the coherence relation effects on reference production, is that the access to an additive connective triggers a Parallel relation between the two conjuncts, which subsequently leads to the expectation of overlapping linguistic properties. This way, the presence of a connective 'boosts' the effect of structural priming (see Knoeferle, 2014 for a discussion).

In Experiment 1, we manipulated the presence of an additive connective in Dutch (*en* 'and') between the prime and the target. Note that an additive connective such as *en* may also signal other coherence relations, such as the Result relation, which might give rise to certain difficulties in disambiguating the coherence relations (see Crible & Pickering, 2020 for a discussion). Nevertheless, the prototypical coherence relation elicited by *en* is the Parallel relation (Evers-Vermeul, 2005). In addition, it has been argued that one of the semantic features inherent to *en* 'and' is the overlap in the situation models: It carries the connotation that the first and the second clauses occur in the same situation (Posner, 1980). It is thus reasonable that accessing *en* would primarily predispose the speakers to establish a Parallel relation between a prime-target pair. Following the previously mentioned rationale, we predicted that the Parallel relation induced by *en* would increase the magnitude of the structural priming effect.

We further asked whether the connective effect on structural priming can be modulated by event similarity between the prime and the target. Verb overlap substantially enhances the structural priming effect (e.g., Pickering & Branigan, 1998). Pickering and Branigan (1998) demonstrated that the priming effect was much larger when the verb of the target sentence completion (e.g., *show* in *The patient showed…*) matched with the verb in the prime sentence completion (e.g., *show* in *The racing driver showed the helpful mechanic…*) relative to when the verbs were unmatched (*e.g., give-show*). Importantly, verb overlap can also be taken as an

extreme case of event similarity (Pickering & Ferreira, 2008). For example, *The princess awarded a medal to the janitor* is closer in meaning to *The captain awarded a gold coin to the pirate* than *The captain threw a gold coin to the pirate* because only the sentences with *award* carry the connotation that the agent intends to honor the recipient. As a Parallel relation requires shared events between clauses, it could be assumed that event overlap can function along with an additive connective in helping listeners establish a Parallel relation between the clauses. If this is the case, verb overlap not only facilitates structural priming by itself but also possibly reinforces the effect of coherence relation induced by an additive connective. This would suggest a stronger connective effect on structural priming when the verbs are repeated.

In short, in Experiment 1 we investigated whether coherence relations affect structural priming by manipulating the presence of an additive connective that links a prime and a target. If structural priming is influenced by coherence relations, the presence of an additive connective could modulate the effects of structural priming. We further examined the factor of event similarity (i.e., verb overlap) that possibly enhances the connective effect.

Specifically, we asked the participants to first read a prime sentence and then spontaneously describe a picture that elicits the production of a target structure. We employed Dutch DO (e.g., *De piraat geeft de monnik een bal*. 'The pirate gives the monk a ball.']) and PO structures (e.g., *De piraat geeft een bal aan de monnik.* 'The pirate gives a ball to the monk.') as the critical syntactic alternation. The reason we chose the Dutch dative alternation is that it is one of the most well-tested structure alternations in the literature on structural priming (Mahowald, James, Futrell, & Gibson, 2016). Verb overlap between the prime and the target was also manipulated. Crucially, we manipulated the presence of a connective that preceded the target production. In a part of the trials, the preamble in the target picture started with a Dutch additive connective *en* 'and', whereas in the rest of the trials, the preamble directly started with the agent noun phrase. We predicted that the insertion of *en* would effectively promote the overall structural priming effect, and it might be further amplified when there is verb overlap.

Method

Participants.

One hundred and five students from Ghent University, all native Dutch speakers, participated in Experiment 1 in exchange for course credit (85 females and 20 males, average age 18.95 years, SD 1.95 years). All participants reported to be non-color-blind and had a normal or corrected-to-normal vision. Nine of the participants were excluded. Seven of them failed to produce any connective in the critical trials and two of them encountered technical issues.

Figure 1

Example of a target picture. The preamble is shown below the picture (*En de piraat geeft* [And the pirate gives] _____).

Materials.

We created a verification set of 192 pictures and a description set of 144 pictures. All pictures showed line drawings of cartoon images. The participant's description set contained 48 critical description pictures and 96 filler description pictures. The critical description pictures depicted dative events (e.g., a pirate giving a jug to a dancer; see Figure 1). A preamble that contained at least the agent and the verb of the target sentence was placed beneath the picture (e.g., *En de piraat geeft* [And the pirate gives] _____). For each target picture, two versions of the preambles were created. In one version, all preambles started with the connective *en* (En condition, 1a). In the other version, all preambles started with the noun phrase that denoted the

agent of the sentence (No Connective condition, 1b). We selected six target verbs (*geven* [to give], *overhandigen* [to hand], *presenteren* [to present], *schenken* [to gift], *tonen* [to show], *verkopen* [to sell]). Each target verb corresponded to eight target pictures. The filler description pictures depicted transitive expressions (e.g., a waitress tickling a monk). Beneath the filler pictures we also showed preambles (with or without *en*) that induced transitive expressions (e.g., *De serveerster kietelt* [The waitress tickles _____]).

1a) En de piraat geeft [And the pirate gives] _____. *En*

1b) De piraat geeft [The pirate gives] _____. *No connective*

The verification set contained 96 critical pictures that depicted dative events and 96 filler pictures that depicted transitive events. Corresponding to each critical target picture, two critical verification pictures were created. The two pictures featured the same agent and recipient. The action depicted in one verification picture was similar to the target picture and that in the other verification picture was different from the target. The verification pictures contained no preamble. One filler verification picture was created corresponding to each of the filler target pictures. In half of the filler verification tasks, the events were the same as their corresponding target pictures, and in the other half, the events were different from the targets.

2a) De piraat geeft de monnik een bal. *DO, Same Verb*

[The pirate gives the monk a ball.]

2b) De piraat geeft een bal aan de monnik. *PO, Same Verb*

[The pirate gives a ball to the monk.]

2c) De piraat verkoopt de monnik een bal. *DO, Different Verb*

[The pirate sells the monk a ball.]

2d) De piraat verkoopt een bal aan de monnik. *PO, Different Verb*

[The pirate sells a ball to the monk.]

A set of 288 prime sentences was created (see Appendix A). For each of the 96 critical verification pictures, two structurally counterbalanced critical prime sentences were constructed. Specifically, there were a DO sentence (e.g., 2a and 2c) and a PO sentence (e.g., 2b and 2d). These sentences also varied in verb overlap. In half of the sentences (e.g., 2a and 2b), the prime verb matched with the target verb (*geven - geven*), and in the other half (e.g., 2c and 2d), they were different (*verkopen - geven*)[2]. All of the prime sentences matched with the critical verification pictures. For each of the 96 filler verification pictures, an active prime sentence was constructed (e.g., *De serveerster kietelt de dokter* [The waitress tickles the doctor]. The verb in the filler prime sentence was always different from that in the filler target preamble. Among the filler prime sentences, 24 were the same as their corresponding verification picture and 72 differed from the pictures in one component of the event (agent or recipient). This way, in each experiment list there were 72 matched pictures and 72 unmatched pictures. In all the trials, the agent of the target preamble was always the same as that of the prime sentence.

A critical trial was defined as a pairing of the critical prime sentence and the critical description picture. Thus, 48 critical trials and 96 filler trials were created for each participant. We had a 2 (prime condition) x 2 (verb overlap) x 2 (connective condition) design; all factors were manipulated within-items and -participants. We constructed sixteen pseudo-random lists that counterbalanced the experimental conditions and the item order. There were four fillers at the beginning of each list; critical trials were separated by 1 to 3 filler trials. Each participant was presented with one of the sixteen lists.

[2] To minimize the semantic similarity in Different Verb conditions, we controlled the pairing of prime and target verbs. Specifically, in the Different Verb condition, the target verbs that roughly corresponded to "give" (*geven, overhandigen*, and *schenken*) were only paired with prime verbs that corresponded to "show" (*tonen* and *presenteren*), or to "sell" (*verkopen*), and vice versa.

Procedure.

The participants sat in front of a 27-inch screen (screen resolution: 1024 × 768 pixels, approximate viewing distance: 60cm). They were told that they would complete a series of picture verification tasks and picture description tasks. At the beginning of the experiment, the participants read the instruction concerning the series of tasks they would perform and the possible pictures they would see during the experiment. They then familiarized themselves with the procedure in a practice session. The practice session included four filler trials.

At the beginning of each trial, the participants started by reading a sentence displayed on the screen and then pressed "3" on the numeric pad. A verification picture was displayed on the screen. The participant pressed "1" if the description matched with the verification picture on the screen and "2" otherwise. After the keypress, the verification picture immediately disappeared from the screen and a description picture appeared after an interval of 500 ms. The participant then described the picture and pressed "3" to continue. Finally, feedback on the picture verification task was illustrated on the screen. The duration of the experiment was about 45 minutes. A Sony ICD-PX440 recorder was used to record the utterances made by the participant and the confederate.

Scoring.

All the participants' descriptions of target pictures were coded as DO, PO, or Other responses. A description was a DO if the utterance was grammatical and the sentence preamble was completed in such a way that the target verb was immediately followed by the recipient and then the theme (e.g., *En de piraat geeft de danseres een kan* [And the pirate gives the dancer a jug]). It was taken as a PO if the utterance was grammatical and the sentence preamble was completed in such a way that the verb was immediately followed by the theme, the preposition *aan* (meaning "to"), and then the recipient (e.g., *En de piraat geeft een kan aan de danseres* [And the pirate gives a jug to the dancer]). All other utterances were categorized as Other responses,

including ungrammatical utterances, utterances that used the wrong verb, utterances that failed to follow the preamble (e.g., utterances that failed to include *En* as mandated by the preamble; utterances that did include *En* despite its absence in the preamble).

Table 1

Proportions of DO Responses out of All the DO and PO Responses for Each Prime Condition X Verb Overlap X Connective Condition in Each Experiment

			Prime condition		
Experiment	Verb overlap	Connective condition	DO	PO	Structural priming
1	Same Verb	En	.652	.030	.622
		No connective	.677	.028	.650
	Different Verb	En	.384	.089	.296
		No connective	.353	.124	.229
2	Same Verb	Maar	.571	.047	.524
		No connective	.623	.028	.595
	Different Verb	Maar	.350	.140	.209
		No connective	.320	.130	.190
3	Same Verb	En	.537	.017	.520
		Maar	.491	.024	.467
		No connective	.535	.022	.513
	Different Verb	En	.369	.091	.278
		Maar	.304	.073	.231
		No connective	.304	.100	.204
4	Same Verb	En	.514	.046	.468
		Maar	.519	.042	.477
		No connective	.512	.032	.480
	Different Verb	En	.252	.085	.167
		Maar	.276	.098	.178
		No connective	.269	.091	.178

Note. "DO" and "PO" in the header row indicate the prime condition. The "Structural priming" in the header row indicate the priming effect (the proportion of DO responses in DO prime condition minus that in the PO prime condition).

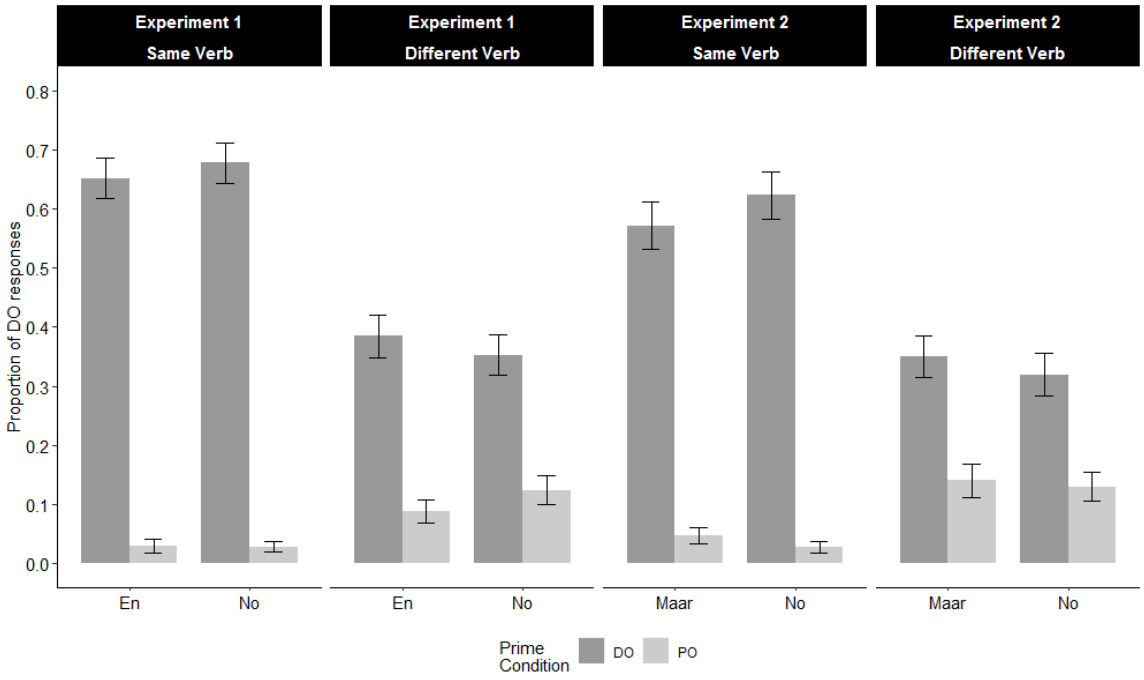
Results

Data and analysis scripts for all experiments reported in this paper are available online (on the Open Science Framework at https://osf.io/uxwej/). Critical trials in which participants produced no response or an Other response were excluded from the analyses (1.7 % of the data).

The final data set contained 4396 target responses, among which were 3116 PO transitive responses (70.9%) and 1280 DO responses (29.1%).

Figure 2

The proportion of DO responses as a function of prime condition, verb overlap, and connective condition in Experiments 1 and 2. The error bars indicate the standard error aggregated over subjects. En = En condition, Maar = Maar condition, No = No Connective condition.



The descriptive data of the DO production for each prime condition x verb overlap x connective condition are illustrated in Table 1 and Figure 2. The proportion of DO responses was 51.5% after DO primes and 6.5% after PO primes, resulting in a 44.9% overall structural priming effect. The structural priming effect was 63.4% in the Same Verb condition and 26.2% in the Different Verb condition, resulting in a 37.1% lexical boost. The priming effect was 45.9% in the En condition and 44.0% in the No Connective condition, resulting in a 1.9% connective effect on structural priming. In the Different Verb condition, the connective effect amounted to 6.7%, but in the Same Verb condition, there was a reverse connective effect (-2.8%). Thus, the descriptive data of the connective effect on verb-dependent structural priming did not match our prediction.

The participants' responses were fit by a Generalized Linear Mixed model (GLM model), using the *lme4* package (version 1.1.23) in R (version 3.4.0). The model predicted the logit-transformed likelihood of a DO response. Prime condition, verb overlap, and connective condition were included in the model as fixed factors. All predictors were entered into the model in the mean-centered form (deviation coded). For the analysis (and all the analyses thereafter), we employed the maximal random effects structure justified by the design (Barr, Levy, Scheepers, & Tily, 2013). Specifically, we included in the model the by-subject and by-item random intercepts as well as random slopes for all main effects and interactions in the fixed model. If the maximal model could not converge or if it showed singularity, we first dropped the random correlation terms in one go. If the model without random correlations did not converge either, we began to drop one random factor at a time, starting from the most complex terms in the random model. When there were multiple terms with the same complexity, we compared the variances of the random effects in the last model and dropped the term that accounted for the least amount of variance. We repeated this step until the model converged and no warning of singular fit was reported.

The final model included a random intercept, a random slope of prime condition, and a random slope of verb overlap for subjects as well as a random intercept and a random slope of prime condition for items. The random correlations were dropped. The summary of the fixed effects of the model is listed in Table 2. Here we report the significance of the effects based on the fixed effect estimate of the LME models. This is because by using contrast coding, the fixed effects of the model are informative about the main effects and the interactions (Schad, Vasishth, Hohenstein, & Kliegl, 2020). We found a significant intercept, indicating that speakers prefer to produce a PO response rather than a DO response. We found a significant main effect of prime condition ($p_z < .001$), indicating a very strong overall structural priming effect. There was a significant interaction between prime condition and verb overlap ($p_z < .001$), showing a lexical boost effect with a considerable magnitude. However, the interaction between prime condition

and connective condition was not significant (p_z = .365). We did find a significant three-way interaction among prime condition, verb overlap, and connective condition (p_z = .045). This corroborates the descriptive data that the connective effect on structural priming was stronger in the Different Verb condition (6.7%) relative to the Same Verb condition (-2.8%). No further effects were significant (p_z > .1).

Table 2

Fixed Effect Estimates (in Log-Odds Units), Experiment 1

	Estimate	**SE**	**z**	**p-value**
Full dataset				
(Intercept)	-1.919	0.177	-1.845	< .001
Prime	4.048	0.226	17.943	< .001
Verb	0.091	0.141	0.648	.517
Connective	-0.105	0.121	-0.872	.383
Prime: Verb	3.424	0.259	13.204	< .001
Prime: Connective	0.219	0.242	0.905	.365
Verb: Connective	0.091	0.241	0.376	.707
Prime: Verb: Connective	-0.965	0.481	-2.005	.045
Subset Same Verb				
(Intercept)	-1.901	0.190	-9.985	< .001
Prime	5.792	0.388	14.939	< .001
Connective	-0.058	0.197	-0.297	.766
Prime: Connective	-0.240	0.387	-0.621	.535
Subset Different Verb				
(Intercept)	-1.955	0.192	-10.160	< .001
Prime	2.332	0.200	11.668	< .001
Connective	-0.146	0.142	-1.026	.305
Prime: Connective	0.677	0.273	2.478	.013

Note. Prime = Prime condition (PO as the baseline level), Verb = verb overlap (Different Verb condition as the baseline level), Connective = connective condition (No Connective condition as the baseline level) were in the mean-centered form.

To further explore the three-way interaction among prime condition, verb overlap, and connective condition, we divided the dataset by verb overlap and fitted one GLM model for each subset. The GLM model predicted the likelihood of DO production. Prime condition and

connective condition (all in the mean-centered form) were taken as predictors. The final model for the Same Verb subset included a random intercept and a random slope of prime condition for subjects as well as a random intercept, a random slope of prime condition, and a random slope of connective condition for items. The random correlations were dropped. The summary of the fixed effects of the model is listed in Table 2. The intercept and the main effect of prime condition were significant (p_zs < .001). There was no significant two-way interaction between prime condition and connective condition (p_z = .535). No further effects were significant (p_z > .1). The final model for the Different Verb subset included a random intercept and a random slope of prime condition for subjects as well as a random intercept for items. The random correlation was dropped. The summary of the fixed effects of the model is listed in Table 2. The intercept and the main effect of prime condition were significant (p_zs < .001). Importantly, there was a significant two-way interaction between prime condition and connective condition (p_z = .013), indicating the effect of structural priming was stronger when the prime and target were linked with the connective *en.* No further effects were significant (p_z > .1).

Discussion Experiment 1

In Experiment 1, we replicated the well-documented structural priming effect on DO production (e.g., Bock, 1986) as well as the lexical boost effect on structural priming (Hartsuiker, Bernolet, Schoonbaert, Speybroeck, & Vanderelst, 2008; Pickering & Branigan, 1998). More importantly, we found that when there was no verb overlap, the structural priming effect was stronger when the connective *en* 'and' was placed between the prime and target, confirming our prediction with regard to the facilitation effect of *en* on structural priming. To the best of our knowledge, we are the first to observe such a connective effect on structural priming in sentence production. However, the connectives did not significantly modulate the structural priming effect when the verbs were repeated. The null effect of connectives on verb-dependent structural priming was unexpected. One possible explanation of the null effect is that, as we have argued,

the repetition of event structures induced by verb overlap could also help listeners establish an expectation of a Parallel relation between the prime and the target. It is possible that the speakers, consistent with the listeners' expectation, primarily engaged the cue of verb overlap to build up the parallel structures between sentences. This way, the effect of the connective, which pointed to the same expectation as verb overlap, was overshadowed (see Myachykov, Garrod, & Scheepers, 2012 for a similar account of cue competition in structural priming). In Experiment 2, we tested the role of an adversative connective (*maar* 'but') in structural priming.

Experiment 2 The Effect of Adversative Connective and Event Similarity on Structural Priming

Connectives have distinct semantic features that are compatible with one or more types of coherence relations (Halliday & Hasan, 1976; Sanders, Spooren, & Noordman, 1992; Wolf & Gibson, 2005). It follows that the activation of the connective should only spread to the coherence relations that are linked to the connective. This way, any effect of coherence relations on structural priming may be connective-specific. We have already predicted that the additive connective *en* 'and' can elicit a Parallel relation between the conjuncts. One intriguing question is how the semantic opposite of *and*, namely *but* (here we considered *but* an adversative connective, based on the classification of Halliday & Hasan, 1976) functions in structural priming. Conceivably, an adversative connective induces a Contrast relation. Such a coherence relation might further raise the expectation of contrasting (or at least non-parallel) representations between clauses, which could attenuate the processing advantage of a parallel structure in the second clause. Indeed, Knoeferle (2014) demonstrated that while the German additive connective *und* 'and' elicited a parallelism effect in reading coordinated transitive sentences, the adversative connective *aber* 'but' failed to show a similar effect. Knoeferle's study lent evidence for a view that the effects of coherence relation hinge on the semantics of the connective. Following such a view, we predicted that an adversative connective in Experiment 2 might similarly lower

listeners' expectation of parallel structures between utterances. We further predicted that the effect of an adversative connective on structural priming should be different from that of an additive connective. Via audience design, an adversative connective might fail to boost structural priming or even reduce the magnitude of the structural priming effect. In the current study, we tested this prediction by manipulating the insertion of an adversative connective *maar* 'but'.

In addition, the prediction regarding the interplay between the presence of a connective and event similarly should also be reconsidered. In particular, in the condition where both connective *maar* and verb overlap are present, the two cues point to the opposite directions for the listeners: verb overlap triggers expectation of a Parallel relation while *maar* signals a non-parallel relation (or even a Contrast relation) between sentences. Such a competition between the two can also be detected by speakers via the model of listener comprehension. Given that speakers accommodate their syntactic formulation to listeners' interpretation, the way they encode the coherence relation might depend on listeners' prediction about the cue strengths. If the distribution of cue strengths is similar to that in Experiment 1, it is possible that the stronger cue of verb overlap once again overshadows the weaker cue of connective (in this case *maar*). Another possibility is that the competition between the two cues reduces both the connective effect and the verb overlap effect on structural priming. In both scenarios, we predicted that when the verb repeats between the prime and the target, the effect of connective *maar* on structural priming might be weaker in comparison with that when there is no verb overlap.

Method

Participants.

Nighty-eight students from Ghent University, all native Dutch speakers, participated in exchange for course credit (80 females and 18 males, average age 18.68 years, SD 1.53 years). All participants reported to be non-color-blind and had a normal or corrected-to-normal vision. Two participants were excluded because they did not produce any dative sentences.

Materials, procedure, and scoring.

The materials of Experiment 2 were the same as Experiment 1 except that instead of using the additive connective *en* in the preamble, in half of the preambles (e.g., 3a) we used the adversative connective *maar* 'but'.

3a) Maar de piraat geeft [But the pirate gives] _____.	*Maar*
3b) De piraat geeft [The pirate gives] _____.	*No connective*

The procedure and the scoring were the same as in Experiment 1.

Results

Critical trials in which participants produced no response or an Other response were excluded from the analyses (1.0 % of the data). The final data set contained 4497 target responses, among which were 3248 PO transitive responses (72.2%) and 1249 DO responses (27.8%). The descriptive data of the DO production for each prime condition x verb overlap x connective condition are illustrated in Table 1 and Figure 2. The proportion of DO responses was 46.8% after DO primes and 8.5% after PO primes, resulting in a 38.3% overall structural priming effect. The structural priming effect was 55.9% in the Same Verb condition and 20.1% in the Different Verb condition, resulting in a 35.9% lexical boost effect. The priming effect was 37.0% in the Maar condition and 39.5% in the No Connective condition, resulting in a -2.5% connective effect on overall structural priming. In the Same Verb condition, there was a reverse connective effect of -7.0% and in the Different Verb condition, the connective effect amounted to 1.9%.

The participants' responses were fit by a GLM model. The final model included a random intercept, a random slope of prime condition, a random slope of verb overlap, and a random slope of connective condition for subjects as well as a random intercept, a random slope of prime condition, and a random slope of connective condition for items. The fixed effects of the

model are listed in Table 3. We found a significant intercept and a significant main effect of prime condition ($p_z < .001$). There was a significant interaction between prime condition and verb overlap ($p_z < .001$), showing once again a lexical boost effect. The two-way interaction between prime condition and connective condition was significant ($p_z = .025$); the negative estimate suggested the presence of *maar* reduced structural priming. We found a significant three-way interaction among prime condition, verb overlap, and connective condition ($p_z = .006$). This suggests that the reduction effect of *maar* should be primarily attributed to the connective effect in the Same Verb condition. No further effect was significant (p_zs > .1).

To further explore the three-way interaction among prime condition, verb overlap, and connective condition, we divided the dataset by verb overlap and fitted one GLM model for each subset. The final model for the Same Verb subset included a random intercept and a random slope of prime condition for subjects as well as a random intercept for items. The random correlations were dropped. The summary of the fixed effects of the model is listed in Table 3. The intercept and the main effect of prime condition were significant (p_zs < .001). There was a significant two-way interaction between prime condition and connective condition ($p_z = .004$), suggesting the presence of *maar* reduced the effect of verb-dependent structural priming. No further effect was significant ($p_z > .1$). The final model for the Different Verb subset included a random intercept, a random slope of prime condition, and a random slope of connective condition for subjects as well as a random intercept and a random slope of prime condition for items. The random correlations were dropped. The summary of the fixed effects of the model is listed in Table 3. The intercept and the main effect of the prime condition were significant (p_zs < .001). There was no significant two-way interaction between prime condition and connective condition ($p_z = .689$). No further effects were significant (p_zs > .1).

Table 3

Fixed Effect Estimates (in Log-Odds Units), Experiment 2

	Estimate	SE	z	p-value
Full dataset				
(Intercept)	-2.266	0.234	-9.698	< .001
Prime	3.940	0.236	16.714	< .001
Verb	-0.043	0.151	-0.285	.776
Connective	0.183	0.135	1.359	.174
Prime: Verb	3.925	0.275	14.266	< .001
Prime: Connective	-0.555	0.248	-2.241	.025
Verb: Connective	-0.018	0.238	-0.074	.941
Prime: Verb: Connective	-1.318	0.482	-2.737	.006
Subset Same Verb				
(Intercept)	-2.261	0.263	-8.615	< .001
Prime	5.959	0.403	14.777	< .001
Connective	0.155	0.190	0.815	.415
Prime: Connective	-1.100	0.381	-2.883	.004
Subset Different Verb				
(Intercept)	-2.239	0.238	-9.403	< .001
Prime	1.970	0.230	8.585	< .001
Connective	0.191	0.154	1.243	.214
Prime: Connective	0.107	0.268	0.400	.689

Note. Prime = Prime condition (PO as the baseline level), Verb = verb overlap (Different Verb condition as the baseline level), Connective = connective condition (No Connective condition as the baseline level) were in the mean-centered form.

Discussion Experiment 2

In Experiment 2 we did not find a facilitation effect of an adversative connective between prime and target. When the verbs were not repeated, the presence of *maar* did not influence the structural priming effect. The null effect contrasts with a significant effect of *en* on verb-independent structural priming in Experiment 1. This null effect is not very surprising. As *maar* is an adversative connective, it does not signal a Parallel relation. Therefore, no difference in priming is to be expected relative to the No Connective condition, since in neither of the cases the speakers could exploit a connective to establish parallel structures. Indeed, the pattern of findings is consistent with those of Knoeferle (2014) who also failed to find any effect of an adversative

connective influencing the processing of parallel structures. The null effect of *maar* is in line with a weak version of the context-dependent hypothesis: Contrast relation elicited by an adversative connective should at least show a null effect rather than a facilitation effect on structural priming.

Meanwhile, we observed that the presence of *maar* reduced verb-dependent structural priming. Such an effect was not observed with *en* in Experiment 1. This underlines that the effects of coherence relation are modulated by the semantic properties of the connectives. In Experiment 1, there were two cues (connective and event similarity) that differed in cue strengths, but both pointed to parallelism. It is possible that the weak cue (connective) did not add much to the strong cue (event similarity), so that there was a null effect of connective when there was verb overlap. But in Experiment 2, the two cues were in opposition: the event similarity denotes parallelism while the connective *maar* signals a Contrast relation. In this case, it is more likely that the connective counteracted the event similarity, so that the effect elicited by event similarity was reduced when the two cues co-occur. We will further discuss this reduction effect in the General Discussion.

In Experiment 3, we tried to test the effect of *en* and *maar* on structural priming in a within-subjects design.

Experiment 3 A Combined Experiment

Method

Participants.

Ninety-eight students from Ghent University, all native Dutch speakers, participated in exchange for course credit (79 females and 19 males, average age 18.92 years, SD 1.79 years). All participants reported to be non-color-blind and had a normal or corrected-to-normal vision.

Six of the participants were excluded. Four of them failed to produce any additive connective in the critical trials and two of them encountered technical issues[3].

Materials, procedure, and scoring.

In Experiment 3, we created 24 critical description pictures and 48 filler description pictures in addition to the materials of Experiment 1. Now we had in total 72 critical description pictures and 144 filler description pictures. Corresponding to each description picture, three versions of preambles were created. One version started with a connective *en* (1a, the example sentences are repeated below for convenience's sake), one version with a connective *maar* (3a), and the other version with no connective (1b).

1a) En de piraat geeft [And the pirate gives] _____. *En*

3a) Maar de piraat geeft [But the pirate gives] _____. *Maar*

1b) De piraat geeft [The pirate gives] _____. *No connective*

Forty-eight additional critical verification pictures and 48 additional filler verification pictures were created. Corresponding to these pictures, 96 critical prime sentences and 48 filler prime sentences were constructed (see Appendix B for the additional materials used in the critical trials).

An additional change was made to the filler sentences. Note that in Experiment 1 and 2, the verbs in the filler trials were not repeated. In Experiment 3 and 4, we further balanced verb repetition in the filler trials. Concretely, half of the filler prime sentences shared the verb with the filler target task, and the other half was composed of prime-target pairs that were different in

[3] We performed power estimation based on the data of Experiment 1 and Experiment 2. The result of power estimation suggested we need at least 92 participants to reach 80% statistical power to detect a connective effect on structural priming. Thus, the sample size in Experiment 3 (92 participants) and Experiment 4 (96 participants) should be sufficient in detecting the effects under investigation.

verbs. We made this change to ensure that the distribution of verb overlap would be homogeneous across items.

This manipulation posited a problem for Experiment 3. Conceivably, two sentences with the same agent doing the same action to a different patient should not be compatible with a Contrast relation, such that they cannot be connected by an adversative connective. For example, sentences such as *The sailor kicks the teacher. But the sailor kicks the clown* sound rather odd. This is because the events in the sentences are too similar to allow the inference that they are contrastive (Kehler, 2002).

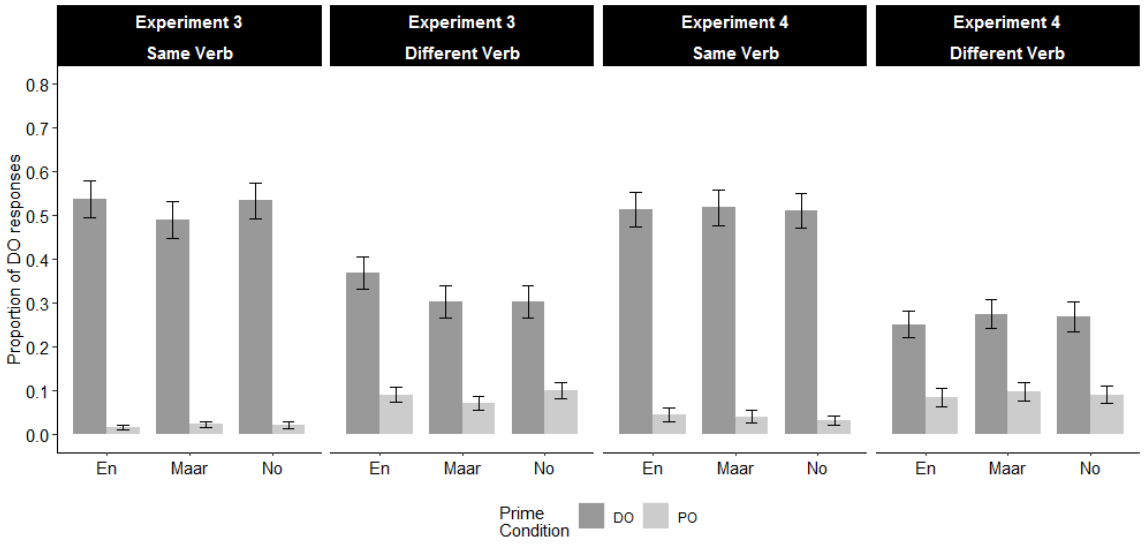
To solve this problem, we made a further change in the filler target tasks of Experiment 3: In the filler preambles that started with *maar*, we added a negative adverb *nooit* (meaning "never") after the verb to guide the participants to express the negation of the event shown on the screen. We also added a cross on the corresponding target pictures to emphasize such negation. The filler preambles that started with *maar* were then composed of four components: *Maar* + Agent + Verb + *nooit.* This allowed the filler prime-target pairs to refer to an event and a negation of a very similar event (e.g., *De matroos schopt de leraar. Maar de matroos schopt nooit de clown* [The sailor kicks the teacher. But the sailor never kicks the clown]), which could be plausibly connected by an adversative connective such as *maar*. This change was only made in Experiment 3 and only in the Maar condition (i.e., the filler target preambles that start with *en* or no connective maintained the normal preamble form of *En* /No connective + Agent + Verb).

In sum, 72 critical trials and 144 filler trials were created for each participant. We had a 2 (prime condition) x 2 (overlap condition) x 3 (connective condition) within-subjects design. We constructed 24 pseudo-random lists that counterbalanced the experimental conditions and the item order.

The procedure and the scoring were the same as Experiment 1.

Figure 3

The proportion of DO responses as a function of prime condition, verb overlap, and connective condition in Experiments 3 and 4. The error bars indicate the standard error aggregated over subjects. En = En condition, Maar = Maar condition, No = No Connective condition.



Results

Critical trials in which participants produced no response or an Other response were excluded from the analyses (3.2 % of the data). The final data set contained 6415 target responses, among which were 4883 PO transitive responses (76.1%) and 1532 DO responses (23.9%). The descriptive data of the DO production for each prime condition x verb overlap x connective condition are illustrated in Table 1 and Figure 3. The proportion of DO responses was 42.4% after DO primes and 5.4% after PO primes, resulting in a 37.0% overall structural priming effect. The structural priming effect was 49.9% in the Same Verb condition and 23.8% in the Different Verb condition, resulting in a 26.1% lexical boost effect. The priming effect was 39.9% in the En condition, 35.2% in the Maar condition, and 35.8% in the No Connective condition, resulting in a 4.2% connective effect of *en* and a -0.6% connective effect of *maar* on overall structural priming. In the Same Verb condition, this connective effect of *en* and *maar* amounted

to 0.1% and -4.5%, respectively, whereas in the Different Verb condition, the connective effect of *en* and *maar* amounted to 7.4% and 2.7%, respectively.

Table 4

Fixed Effect Estimates (in Log-Odds Units), Experiment 3

	Estimate	**SE**	**z**	**p-value**
Full dataset				
(Intercept)	-2.805	0.256	-10.961	< .001
Prime	4.065	0.227	17.935	< .001
Verb	-0.109	0.125	-0.869	.385
Connective (En vs. No)	-0.010	0.145	-0.068	.946
Connective (Maar vs. No)	-0.235	0.152	-1.550	.121
Prime: Verb	3.330	0.235	14.166	< .001
Prime: Connective (En vs. No)	0.554	0.280	1.976	.048
Prime: Connective (Maar vs. No)	0.079	0.275	0.289	.773
Verb: Connective (En vs. No)	-0.327	0.279	-1.169	.242
Verb: Connective (Maar vs. No)	0.070	0.268	0.260	.795
Prime: Verb: Connective (En vs. No)	-0.297	0.558	-0.534	.594
Prime: Verb: Connective (Maar vs. No)	-0.811	0.535	-1.515	.130
Subset Same Verb				
(Intercept)	-2.890	0.275	-10.504	< .001
Prime	5.797	0.400	14.506	< .001
Connective (En vs. No)	-0.133	0.227	-0.587	.557
Connective (Maar vs. No)	-0.153	0.211	-0.725	.468
Prime: Connective (En vs. No)	0.336	0.454	0.740	.460
Prime: Connective (Maar vs. No)	-0.430	0.422	-1.019	.308
Subset Different Verb				
(Intercept)	-2.640	0.249	-10.586	< .001
Prime	2.398	0.211	11.348	< .001
Connective (En vs. No)	0.156	0.144	1.088	.277
Connective (Maar vs. No)	-0.261	0.149	-1.757	.079
Prime: Connective (En vs. No)	0.690	0.287	2.402	.016
Prime: Connective (Maar vs. No)	0.449	0.296	1.515	.130

Note. Prime = Prime condition (PO as the baseline level), Verb = verb overlap (Different Verb condition as the baseline level), Connective = connective condition (No Connective condition as the baseline level) were in the mean-centered form. "No" in the first column denotes the No Connective condition.

The participants' responses were fit by a GLM model. Prime condition, verb overlap, and connective condition were included in the model as fixed factors. Prime condition and verb overlap were entered into the model in mean-centered form (deviation coded). The predictor of connective condition was entered into the model via simple effect coding in which we treated the No Connective condition as the reference level and the two levels of the predictor represented contrasts between that baseline level and each of the two remaining levels. The final model included a random intercept, a random slope of prime condition, a random slope of verb overlap, and a random slope of connective condition for subjects as well as for items. The random correlations were dropped. The fixed effects of the model are listed in Table 4. We found an intercept that was significant and a significant main effect of prime condition (p_zs < .001). There was a significant interaction between prime condition and verb overlap (p_z < .001), showing once again a lexical boost effect. There was a significant two-way interaction between prime condition and connective condition En vs. No (p_z = .048), but the interaction between prime condition and connective condition Maar vs. No was not significant (p_z = .773). There was neither a three-way interaction among prime condition, verb overlap, and connective condition En vs. No (p_z = .594) nor a significant three-way interaction among prime condition, verb overlap, and connective condition Maar vs. No (p_z = .130). No other effect was significant (p_zs > .1).

Although we did not find a significant three-way interaction between prime condition, verb overlap, and connective condition En vs. No, the magnitudes of the connective effects were numerically different between the Same Verb condition (0.1%) and Different Verb condition (7.4%). This made us wonder whether the significant two-way interaction between prime condition and connective condition was mainly driven by the connective effect in the Different verb condition. To test this hypothesis, we divided the dataset by verb overlap and fitted one GLM model for each subset. Prime condition structure (mean-centered) and connective condition (simple effect coded, No Connective as the reference level) were taken as predictors. The final model for the Same Verb subset included a random intercept and a random slope of prime

condition for subjects as well as for items. The random correlations were dropped. The summary of the fixed effects of the model is listed in Table 4. The intercept and the main effect of the prime condition were significant (p_zs < .001). The two-way interaction between prime condition and connective condition En vs. No was not significant (p_z = .460) and neither was the two-way interaction between prime condition and connective condition Maar vs. No (p_z = .308). No other effect was significant (p_zs > .1). The final model for the Different Verb subset included a random intercept and a random slope of prime condition for subjects as well for items. The random correlations were dropped. The summary of the fixed effects of the model is listed in Table 4. The intercept and the main effect of the prime condition were significant (p_zs < .001). There was a significant two-way interaction between prime condition and connective condition En vs. No (p_z = .016). The two-way interaction between prime condition and connective condition Maar vs. No was not significant (p_z = .130). Unexpectedly, there was also a marginal main effect of connective condition Maar vs. No (p_z = .079). We refrain from our interpretation of this main effect since the effect was only marginal and the same effect was not found in the rest of the experiments. No further effects were significant (p_zs > .1).

Discussion Experiment 3

In Experiment 3, we found a connective effect of *en* on overall structural priming. As no connective effect of *en* can be observed in the Same Verb subset (0.1% connective effect on verb-dependent structural priming), we refrain from interpreting the results as showing that *en* promoted both the verb-dependent structural priming and the verb-independent structural priming. Further analysis by verb overlap subsets showed that the connective effect of *en* was only significant in the Different Verb subset (7.4% connective effect on verb-independent structural priming), suggesting that the connective effect in Experiment 3 was mainly driven by the effect in the Different Verb condition. This is in line with the finding in Experiment 1 that connective *en* induced a stronger structural priming effect when the verb was not repeated. Thus,

there is consistent evidence in support of a significant role of the additive connective in verb-independent structural priming.

However, although there was a numerical trend (-4.5% connective effect on verb-dependent structural priming), we failed to replicate the inhibitory effect of connective *maar* on verb-dependent structural priming. This is different from the significant reduction of priming by *maar* found in Experiment 2. We did not expect a weaker connective effect of *maar* in Experiment 3. One possible explanation is that the effect of *maar* was weakened by a methodological artifact in the filler trials. Recall that in Experiment 3 we manipulated the verb overlap in the filler trials. To guarantee the plausibility of the sentences with same agent, same verb that were connected by *maar*, we added a negative adverb (*nooit* meaning "never") in the preamble in such condition. As much as the addition of *nooit* avoided the implausibility of filler sentences in the Maar condition, in retrospect we are concerned that it might have exerted a spillover effect that reduced the connective effect in the critical trials. Throughout Experiment 3, the participants experienced a number of exemplars in the filler trials where *maar* appeared together with verb overlap and non-parallel events. They might have gradually learned that the events could be non-parallel when the utterances were cued by verb overlap. They might have further generalized this idea to the critical trials so that the conflict between *maar* and verb overlap in the critical trials was attenuated. If this was the case, it is reasonable that the effect of *maar* on verb-dependent structural priming gradually decreased over the course of the experiment.

To examine this proposal, we fitted a model based on the omnibus model to test the cumulative effects in Experiment 3. We included trial number (numerical predictor, divided by 100, so that all predictors were on a similar scale) as an additional variable. Critically, there was a three-way interaction between prime condition, connective condition Maar vs. No, and trial number (β = -3.430, SE = 1.263, p_z = .007). The negative estimate indicates that the reduction

effect of *maar* on structural priming was mitigated as the experiment progressed. The three-way interaction between prime condition, connective condition En vs. No, and trial number was not significant ($\beta = 1.194$, SE = 1.022, $p_z = .243$). Taken together, the analysis of cumulative effects suggests that speakers learned the binding between verb overlap and event non-parallelism over the course of the experiment so that the effect of *maar* on verb-dependent structural priming was weakened.

Experiment 4 The Effects of Connectives on Structural Priming without Anaphoric Antecedent

In the last experiment, we introduced a variable of topic cohesion in the study as an additional test of whether the connective effects we examined in the current study are intrinsically driven by discourse coherence inference. Here, we asked what would happen to the connective effects when no antecedent from the context is available for speakers to recycle. Conceivably, inference of coherence relation might break down if there is no referential link between the utterances. For example, hardly any meaningful relations can be constructed from clauses such as *The janitor saved the princess from a burning palace yesterday and the captain threw a gold coin to the pirate.* This is because no elements from the second clause correspond to the antecedents in the first clause, so they cannot be taken as cues to connect back to the context (Givón, 1992; Grosz et al., 1995). In cases as such, the principle of relation in a cooperative speech has been violated (Grice, 1975). Speakers are likely to encode the clauses as two separate events that are not inferentially connected (see Kaiser, 2012 for a discussion), which takes away an essential precondition for the effects of coherence relations. Following this logic, we would predict that the connective effects found in the previous experiments would disappear or at least get attenuated when no anaphoric elements are available. To test this prediction, we replicated the design of

Experiment 3 with one crucial change: The agents were no longer shared between the prime and the target so that speakers cannot refer back to any of the antecedents in the prime.

Method

Participants.

One hundred and two students from Ghent University, all native Dutch speakers, participated in exchange for course credit (91 females and 11 males, average age 18.92 years, SD 1.87 years). All participants reported to be non-color-blind and had a normal or corrected-to-normal vision. Six participants were excluded because they failed to produce any additive connective in the critical trials.

Materials, procedure, and scoring.

The materials in Experiment 4 were the same as in Experiment 3 except that we replaced the agent in each verification picture and prime sentence with a character that was different from that in the corresponding target sentence. For example, corresponding to the picture that a pirate is giving a jug to the dancer (see Figure 1), prime sentences 4a-d were constructed. This way, the agents were no longer repeated between the prime sentence and the target sentence.

4a) De inbreker geeft de monnik een bal. *DO, Same verb*
[The burglar gives the monk a ball.]

4b) De inbreker geeft een bal aan de monnik. *PO, Same verb*
[The burglar gives a ball to the monk.]

4c) De inbreker verkoopt de monnik een bal. *DO, Different verb*
[The burglar sells the monk a ball.]

4d) De inbreker verkoopt een bal aan de monnik. *PO, Different verb*
[The burglar sells a ball to the monk.]

The procedure and the scoring were the same as in Experiment 1.

Results

Critical trials in which participants produced no response or an Other response were excluded from the analyses (2.0% of the data). The final data set contained 6682 target responses, among which were 5151 PO transitive responses (77.1%) and 1531 DO responses (22.9%). The descriptive data of the DO production for each prime condition x verb overlap x connective condition are illustrated in Table 1 and Figure 3. The proportion of DO responses was 39.1% after DO primes and 6.6% after PO primes, resulting in a 32.6% overall structural priming effect. The structural priming effect was 47.5% in the Same Verb condition and 17.5% in the Different Verb condition, resulting in a 30.1% lexical boost effect. The priming effect was 31.6% in the En condition, 33.0% in the Maar condition, and 33.1% in the No Connective condition, resulting in a -1.5% connective effect of *en* and a -0.2% connective effect of *maar* on overall structural priming. In the Same Verb condition, this connective effect of *en* and *maar* was -1.1% and -0.2%, respectively, whereas in the Different Verb condition the connective effect of *en* and *maar* amounted to -1.1% and -0.1%, respectively.

The participants' responses were fit by a GLM model. The final model included a random intercept, a random slope of prime condition, and a random slope of verb overlap for subjects as well as a random intercept for items. The random correlations were dropped. The fixed effects of the model are listed in Table 5. The intercept was significant and there was a significant main effect of prime condition (p_zs < .001). There was also a significant interaction between prime condition and verb overlap (p_z < .001), showing a lexical boost effect. There was no two-way interaction between prime condition and connective condition En vs. No (p_z = .321) or between prime condition and connective condition Maar vs. No (p_z = .444). Neither was there a three-way interaction among prime condition, verb overlap, and connective condition En vs. No

(p_z = .499) or among prime condition, verb overlap, and connective condition Maar vs. No (p_z = .723). There was a significant main effect of verb overlap (p_z = .015). Although this effect was not predicted, we argue that this might be a by-product of the lexical boost effect. It is possible that the facilitation effect of the verb overlap on the persistence of sentence structure further led to an increase of the overall production of the least frequent structure (DO), resulting in a higher likelihood of overall DO production when there was a verb overlap. The other effects were not significant (p_zs > .1).

Table 5

Fixed Effect Estimates (in Log-Odds Units), Experiment 4

	Estimate	**SE**	**z**	**p-value**
Full dataset				
(Intercept)	-2.712	0.243	-11.138	< .001
Prime	3.557	0.181	19.611	< .001
Verb	0.301	0.124	2.432	.015
Connective (En vs. No)	0.028	0.125	0.221	.825
Connective (Maar vs. No)	0.135	0.124	1.088	.277
Prime: Verb	3.110	0.222	14.012	< .001
Prime: Connective (En vs. No)	-0.248	0.250	-0.992	.321
Prime: Connective (Maar vs. No)	-0.190	0.248	-0.766	.444
Verb: Connective (En vs. No)	0.331	0.250	1.326	.185
Verb: Connective (Maar vs. No)	0.091	0.248	0.367	.713
Prime: Verb: Connective (En vs. No)	-0.337	0.499	-0.676	.499
Prime: Verb: Connective (Maar vs. No)	-0.176	0.496	-0.354	.723

Note. Prime = Prime condition (PO as the baseline level), Verb = verb overlap (Different Verb condition as the baseline level), Connective = connective condition (No Connective condition as the baseline level) were in the mean-centered form. "No" in the first column denotes the No Connective condition.

Note that only in Experiment 4, both of the theoretically interesting effects, namely the two-way interaction between prime condition and connective condition, as well as the three-way interaction among prime condition, verb overlap, and connective condition, were found to be non-significant. The non-significant effects cannot be directly interpreted as evidence supporting the null hypothesis (Szucs & Ioannidis, 2017). The evidence for null hypothesis was thus further examined by estimating the Bayes factor (BF_{01}), using Bayesian Information Criteria (BIC; Jarosz

& Wiley, 2014) to assess the extent to which the evidence supports the null effects. This analysis compares the fit of the data under the alternative hypothesis (i.e., a model with a specific interaction term) to the null hypothesis (i.e., a model without such interaction term). Based on the standard interpretation of the Bayes factors as evidence for the null hypotheses (Raftery, 1995), BF_{01} ranging from 1 to 3 can be taken as weak evidence for the null hypothesis. The higher a BF_{01}, the more evidence in support of the null hypothesis (3-20: positive evidence; 20-150: strong evidence; >150: very strong evidence).

In the Bayesian analysis, we found an estimated BF_{01} for the two-way interaction between prime condition and connective condition that suggested the data were 4006 times more likely to occur under a model without the two-way interaction than under a model including it. There was thus very strong evidence for the null hypothesis, namely that there was no difference in the priming effects among the connective conditions. An estimated BF_{01} for the three-way interaction among prime condition, connective condition, and verb overlap indicated that the data were 5376 times more likely to occur under a model without the three-way interaction than under a model including it. This suggested strong evidence for the null hypothesis that there was no difference in the magnitude of the lexical boost effects among the connective conditions.

Discussion Experiment 4

As expected, we did not find any connective effects on structural priming in Experiment 4. As the only difference between Experiment 3 and 4 was whether speakers were able to refer back to the prime sentence, the null effects of connectives in Experiment 4 indicate that a coherent discourse is one of the important preconditions for connectives to be functional in structural priming. This provides further evidence for the hypothesis that the connective effects in Experiment 1-3 are essentially a result of a process that is driven by coherence relation inference.

General Discussion

The main purpose of this study was to investigate the effect of coherence relations on the formulation of syntactic structure in sentence production. We hypothesized that the presence of a connective helps listeners to disambiguate the coherence relation between utterances. As speakers accommodate their speech to listeners' understanding of the discourse, they would adjust their formulation of linguistic forms to the coherence relations in the context. This would result in effects of coherence relations on sentence production, wherein speakers choose to produce overlapping structures (and hence show more structural priming) similar to listeners' expectation of parallel structures after a specific coherence relation is elicited by connectives. Such an effect might vary across the type of connectives, event similarity, and the availability of an anaphoric antecedent. These hypotheses were tested in four experiments. In Experiment 1, we presented the Dutch additive connective *en* 'and' between prime and target. The presence of *en* facilitated structural priming, but only when there was no verb overlap. In Experiment 2, we employed an adversative connective, *maar* 'but'. There was a significant reduction of priming in the condition with repeated verbs. In Experiment 3, we presented both *en* and *maar* in a within-subjects design. We replicated the facilitation effect of *en* on the verb-independent structural priming. There was also a numerical trend of the reduction effect on verb-dependent structural priming that was induced by *maar*. In Experiment 4, we replicated the design of Experiment 3 but, different from the first three experiments, we did not repeat any nouns between the prime and the target. This time, we did not find any connective effect. Taken together, we found evidence that the inference of coherence relations modulates the effect of structural priming. The effect of coherence relation is connective-specific and can be mediated by event similarity.

Connective Effects on Structural Priming

To the best of our knowledge, our study is the first to find evidence of coherence relation effects on the persistence of sentence structure in language production. We found that the pattern

of the coherence relation effects is not straightforwardly facilitatory or inhibitory. Rather, the strength and direction of coherence relation effects were constrained by multiple factors concerning coherence relation inference in the discourse.

The facilitation effect of a Parallel relation elicited by additive connective *en* 'and' fits nicely with the studies on the parallelism effect in sentence comprehension (Frazier et al., 2000; Knoeferle, 2014). In line with these studies, the finding supports the view that an additive connective signals a Parallel relation, which helps listeners construct expectations of a parallel structure in the second conjunct that is linked to the connective. As speakers construct linguistic forms based on the discourse relations they inferred from the context, the presence of an additive connective results in an expectation of parallel structures in sentence production. This contributes to the overall effect of structural priming. However, we found that the effect was not across-the-board: The additive connective only boosted priming when there was no verb repetition. This is unexpected, as we predicted that overlap in verb events could reinforce the connective effect on structural priming. We cannot compare this finding to any of the studies in sentence comprehension, since none of these studies was concerned with the effect of verb overlap. Nevertheless, the null effect of an additive connective on verb-dependent structural priming is compatible with a competition view of sentence production (Myachykov et al., 2012; Stallings, MacDonald, & O'Seaghdha, 1998). Based on this view, a cue would function in selecting representations in sentence production only when at least two representations are sufficiently activated to be competitive in determining the outcome. Following this logic, we can assume that the combined cues of overlapping events and a Parallel relation elicited by *en* point to the same outcome of parallel structures (over non-parallel structures) in sentence production. It is possible that the competition between parallel and non-parallel structures had been essentially resolved by the highly overlapping events, which suggested a Parallel relation between the prime and the target. In this case, the additive connective was no longer needed in electing a Parallel relation. This way, the processing of verb semantics overrode the information carried forward from

message encoding, so that no effect of an additive connective could be found in verb-dependent structural priming. In this case, the additive connection as a cue for parallel structures becomes redundant.

Another way to interpret the lack of additive connective boost of priming in the repeated-verb conditions concerns the expectation of gapping when narrating a sequence of similar events (Kehler, 2002; Tanenhaus & Carlson, 1990; Thomas, 1979). An omitted verb can arguably be taken as a signal to the listeners of the re-enactment of the event from the previous sentence. Speakers might therefore establish an expectation to produce gapping in the ensuing utterances when they intend to describe an event that has already been mentioned. This expectation can be reinforced when the coherence relation is made explicit by coordinating connectives (Kehler, 2002). Specific to the current study, we can assume that the perception of repeated events between the prime and the target gave rise to the expectation of gapping in the target production (e.g., *De piraat geeft de monnik een bal, en de danseres een kan,* literally "the pirate gives the monk a ball, and the dancer a jug"). However, as the participants were asked to complete the preamble, they had to produce the full form of verb phrases in the target tasks. The conflict between the expectation of gapping and the preparation of full forms might induce processing difficulty in the target production, which might subsequently influence the production of parallel structures. Since the expectation of gapping is stronger when there is a connective, the prediction error is larger. This way, the connective effect on verb-dependent priming might be counteracted by the expectation violation of gapping that was evoked by verb overlap. Note that neither of the interpretations takes away our main conclusion about the facilitation effect of the additive connective in the verb-independent persistence of sentence structure.

By contrast, when an adversative connective *maar* 'but' was inserted between the prime and the target, the effect of verb-dependent structural priming was reduced. The reduction induced by *maar* can be explained by the competition between the expectation of Contrast relation induced by *maar* and the inference of a Parallel relation based on event similarity. Let's

again take the perspective of the listeners. On the one hand, the overlap in events would help the listeners establish a reading of Parallel relation between utterances. On the other hand, the connective they perceive would be *maar* 'but', a connective that prototypically signals a Contrast relation. As the listeners can only proceed with one type of interpretation of coherence relations, there might be a competition between event similarity and *maar.* The competition in coherence relation inference should also be modelled into speakers' formulation of the linguistic representations. One possible outcome of such a competition in production was that the speakers showed optionality in utilizing the cues to construct coherence relations. Speakers might engage *maar* to construct a Contrast relation in some trials and might channel event similarity to build a Parallel relation in the other. When *maar* was functional, the effect of event similarity might be blocked, such that the speakers were unlikely to construct the coherence relation based on event similarity. In this case, the information of event similarity could not effectively stream down to the processes that encode other linguistic forms. This way, the effect of event similarity on syntactic encoding, which arguably constitutes the lexical boost effect (Pickering & Ferreira, 2008), might be attenuated. Such a reduction effect should occur only when the two cues are in conflict, thus the reduction of the effect of event similarity was only found in the Maar condition, but not in the En condition.

Taken together, our findings are in favor of the view that a component of supra-sentential message planning underpins the persistence of syntactic structure (Bernolet et al., 2009). In Experiment 1-3, manipulations in the strength and the type of coherence relations resulted in changes in the magnitude of structural priming effects. The modulation of priming by coherence relation indicates that there are top-down effects of message encoding that possibly dictate the listeners' expectation of a parallel structure, which, via audience design, has implications for the choices of the subsequent syntactic structures in sentence production. This is in line with the previous studies demonstrating that the activation of a primed conceptual structure contributes to the overall effect of structural priming (e.g., Bernolet et al., 2009; Bunger et al., 2013; Cai et al.,

2012; Chang et al., 2003; Griffin & Weinstein-Tull, 2003; Ziegler et al., 2018). The current study broadens the scope of such effects of conceptual structure to the discourse level: Not only the conceptual configurations of a single sentence (e.g., event structure, thematic structure) but also the conceptual links across multiple sentences constrain the structure-driven route of syntactic encoding in sentence production.

Note that we do not claim that structural priming is solely driven by discourse-dependent factors. In the current experiments, the presence of a connective can only account for a modest proportion of the variation in the structural priming effects. This implies that there should be components other than discourse coherence relations influencing syntactic choices. Indeed, in all four experiments, we found substantial and consistent effects of verb overlap on structural priming, which were much stronger than the connective effects. These lexical boost effects add to the growing body of evidence that structural priming is essentially constrained by lexical-specific factors (e.g., Bernolet, Hartsuiker, & Pickering, 2013; Branigan, Pickering, & Cleland, 2000; Cleland & Pickering, 2003; Hartsuiker et al., 2008; Pickering & Branigan, 1998; Zhang, Bernolet, & Hartsuiker, 2020).

One reason that the effects of coherence relations are fairly small is that the role of the connective in coherence relation inference might not be very crucial. As listeners primarily establish the coherence relation based on the propositional relation of the events between clauses, the presence of a connective should not be a prerequisite for establishing coherence relations (Kehler et al., 2008; Sturt et al., 2010). As a result, it is probable that listeners were able to generate inferences regarding the conceptual connection between the prime and the target even though no connective was provided. In such cases, accessing a connective might only weakly promote the processing of discourse coherence. As the connective did not yield much effect on message encoding, it could not pass its impact to the syntactic level.

Additionally, it should be noted that the effects of coherence relations can only apply to the cases where the participants were able to complete referential processing. When they could

not build up referential connections between the prime and the target because no anaphoric antecedent was available (i.e., in Experiment 4), they failed to exploit coherence relation inference in structural priming with or without the help of a connective.

Discourse Relation in the Production of Syntax

Our findings demonstrate that discourse-related processes influence the extent to which speakers exploit recent syntactic experience. This essentially underlines an interaction between discourse-related processes and syntactic encoding in sentence production. Such an interactive view is conceptually compatible with previous findings that coherence relations drive the form-meaning mapping of the referential elements (Elman et al., 2006; Kehler et al., 2008; Wolf et al., 2004).

As we have mentioned, few studies have directly looked into the discourse factors in the syntactic encoding beyond a single sentence. Granted, a number of studies have reported structural priming effects situated in natural speech (Branigan et al., 2000; Chia et al., 2019; Chia et al., 2020; Gries, 2005; Levelt & Kelter, 1982; Tantucci & Wang, 2021), which suggests syntactic persistence across utterances is an indispensable mechanism that underlies our daily communication (see Pickering & Garrod, 2004 for a discussion). These studies, however, did not test whether speakers flexibly adapt their syntactic encoding to the discourse constraints. The current study provides an alternative avenue to assess the factors inherent to discourse processing in sentence structure formulation across multiple utterances. In our experiments, we showed that the insertion of a discourse marker (i.e., a connective) affected the persistence of sentence structure across utterances. The presence of a connective did not necessarily change the syntactic form or the event structure of the prime or the target, nor did it change the relative accessibility of the arguments. The locus of the connective effect should thus be situated at a stage other than event planning or syntactic encoding, which is most likely to be the supra-sentential inference of

the discourse relations. The current study indicates that speakers can engage in discourse-related processes when they make syntactic decisions for a cluster of sentences.

Do such discourse-dependent processes of syntactic encoding come about every time we make a cluster of sentences? The current study suggests otherwise. In Experiment 4, we showed that the presence of a connective failed to yield any effect on syntactic processing when the prime-target pair did not constitute a cohesive discourse (i.e., there was no referential continuity). Although the null results should be taken with much caution, the fact that connective effects were absent in all conditions implies that the functionality of coherence inference might hinge on whether the utterances can be coherent in the first place. If no meaningful link can be constructed between sentences, sentence formulation might proceed without channeling the meaning of the previous utterances. One methodological implication rendered from such an assumption is that in tasks where participants generate a number of isolated sentences with no topic relatedness (e.g., a picture description task, Gleitman, January, Nappa, & Trueswell, 2007; Griffin & Bock, 2000), speakers might not engage discourse inference processes during sentence encoding. But in studies that encompass an experimental design that involves repeating agents, the possible contribution of discourse coherence should be taken into consideration.

It should also be noted that such an assumption does not take away the prediction that structural priming effects (be it the priming of syntactic structure or event structure) occur in cases where no meaningful referential components are shared between the prime and the target. Arguably, some components that underpin the structural priming effect are highly automatic (Chang, Dell, & Bock, 2006; Hartsuiker et al., 2008), so it is not necessary for speakers to constantly consult the information in the discourse model when they exploit previous syntactic experience. Taken together, we suggest that the occurrence of discourse coherence processes in sentence production is conditional on the likelihood that the utterances are topically cohesive. If there are elements that are available to construct referential links between the sentences, speakers are likely to exploit coherence relation inference to facilitate sentence production.

Our proposal should be applied to any cluster of (minimally two) sentences. That is to say, whether or not a series of utterances can finally constitute a meaningful discourse, as long as two consecutive utterances among them are referentially connected (i.e., an element from the second sentence can be referred back to the first one), speakers would embark on processes of coherence relation inference. Of course, our proposal needs to be further tested. It would be interesting for future studies to manipulate the possibility for participants to build up a referential connection between the utterances within experiments. Such an experimental design would allow us to test the specific conditions that instigate discourse coherence inference in sentence production.

Additionally, as we demonstrated in the experiments, how discourse coherence is realized syntactically is constrained by multiple factors including event similarity and connective semantics. Future studies need to have a more extensive investigation on the moderators of the discourse coherence effects on the production of syntax. In particular, it is suggestive for future research to further explore the role of event similarity by employing more explicit manipulation of the similarity in verb semantics or contrasting structures with greater variability in verb events.

In conclusion, in four structural priming experiments, we demonstrated the effects of connectives on structural priming. The effects were dependent on the type of the connectives and interacted with event similarity and topic cohesion. The evidence jointly delineates a process in structural priming that is underpinned by coherence relation inference, which further suggests that there are discourse-driven components of grammatical encoding in sentence production.

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Appendix A Prime Sentences and Names of Target Pictures in Experiments 1-4 with English Translations in Square Brackets

For every item set, sentence (a) is the DO prime, (b) is the PO prime, and (c) is an English description of the target picture in the double object form; In sentence (a-b), the noun in the first parentheses is the agent used in Experiment 4, the verb in the second parentheses is the verb used in the Different Verb condition in Experiment 1-4. The English translations of the prime sentences are betweensquare brackets beneath the prime sentence.

1a) De (soldaat) agent geeft (presenteert) de matroos een taart.

[The (soldier) policeman gives (presents) the sailor a cake.]

1b) De (soldaat) agent geeft (presenteert) een taart aan de matroos.

[The (soldier) policeman gives (presents) a cake to the sailor.]

1c) The policeman gives the doctor a jug.

2a) De (piraat) cowboy geeft (verkoopt) de zwemmer een bal.

[The (pirate) cowboy gives (sells) the swimmer a ball.]

2b) De (piraat) cowboy geeft (verkoopt) een bal aan de zwemmer.

[The (pirate) cowboy gives (sells) a ball to the swimmer.]

2c) The cowboy gives the burglar a banana.

3a) De (serveerster) danseres geeft (presenteert) de bokser een banaan.

[The (waitress) dancer gives (presents) the boxer a banana.]

3b) De (serveerster) danseres geeft (presenteert) een banaan aan de bokser.

[The (waitress) dancer gives (presents) a banana to the boxer.]

3c) The dancer gives the monk a cake.

4a) De (schilder) inbreker geeft (verkoopt) de monnik een appel.

[The (painter) burglar gives (sells) the monk an apple.]

4b) De (schilder) inbreker geeft (verkoopt) een appel aan de monnik.

[The (painter) burglar gives (sells) an apple to the monk.]

4c) The burglar gives the sailor a book.

5a) De (leraar) kok geeft (verkoopt) de danseres een sleutel.

[The (teacher) cook gives (sells) the dancer a key.]

5b) De (leraar) kok geeft (verkoopt) een sleutel aan de danseres.

[The (teacher) cook gives (sells) a key to the dancer.]

5c) The cook gives the boxer a gun.

6a) De (kok) leraar geeft (toont) de matroos een hoed.

[The (cook) teacher gives (shows) the sailor a hat.]

6b) De (kok) leraar geeft (toont) een hoed aan de matroos.

[The (cook) teacher gives (shows) a hat to the sailor.]

6c) The teacher gives the doctor an apple.

7a) De (danseres) non geeft (toont) de zwemmer een geweer.

[The (dancer) nun gives (shows) the swimmer a gun.]

7b) De (danseres) non geeft (toont) een geweer aan de zwemmer.

[The (dancer) nun gives (shows) a gun to the swimmer.]

7c) The nun gives the boxer a book.

8a) De (cowboy) schilder geeft (presenteert) de bokser een taart.

[The (cowboy) painter gives (presents) the boxer a cake.]

8b) De (cowboy) schilder geeft (presenteert) een taart aan de bokser.

[The (cowboy) painter gives (presents) a cake to the boxer.]

8c) The painter gives the soldier a ball.

9a) De (non) serveerster geeft (verkoopt) de piraat een kopje.

[The (nun) waitress gives (sells) the pirate a cup.]

9b) De (non) serveerster geeft (verkoopt) een kopje aan de piraat.

[The (nun) waitress gives (sells) a cup to the pirate.]

9c) The waitress gives the dancer a cake.

10a) De (monnik) soldaat geeft (toont) de dokter een hoed.

[The (monk) soldier gives (shows) the doctor a hat.]

10b) De (monnik) soldaat geeft (toont) een hoed aan de dokter.

[The (monk) soldier gives (shows) a hat to the doctor.]

10c) The soldier gives the pirate an apple.

11a) De (kok) agent overhandigt (verkoopt) de monnik een appel.

[The (cook) policeman hands (sells) the monk an apple.]

11b) De (kok) agent overhandigt (verkoopt) een appel aan de monnik.

[The (cook) policeman hands (sells) an apple to the monk.]

11c) The policeman hands the sailor a banana.

12a) De (monnik) cowboy overhandigt (verkoopt) de bokser een hoed.

[The (monk) cowboy hands (sells) the boxer a hat.]

12b) De (monnik) cowboy overhandigt (verkoopt) een hoed aan de bokser.

[The (monk) cowboy hands (sells) a hat to the boxer.]

12c) The cowboy hands the burglar an apple.

13a) De (non) danseres overhandigt (verkoopt) de clown een sleutel.

[The (nun) dancer hands (sells) the clown a key.]

13b) De (non) danseres overhandigt (verkoopt) een sleutel aan de clown.

[The (nun) dancer hands (sells) a key to the clown.]

13c) The dancer hands the burglar a cup.

14a) De (cowboy) inbreker overhandigt (toont) de soldaat een taart.

[The (cowboy) burglar hands (shows) the soldier a cake.]

14b) De (cowboy) inbreker overhandigt (toont) een taart aan de soldaat.

[The (cowboy) burglar hands (shows) a cake to the soldier.]

14c) The burglar hands the doctor a key.

15a) De (inbreker) kok overhandigt (presenteert) de piraat een paraplu.

[The (burglar) cook hands (presents) the pirate an umbrella.]

15b) De (inbreker) kok overhandigt (presenteert) een paraplu aan de piraat.

[The (burglar) cook hands (presents) an umbrella to the pirate.]

15c) The cook hands the swimmer a cake.

16a) De (soldaat) leraar overhandigt (toont) de dokter een geweer.

[The (soldier) teacher hands (shows) the doctor a gun.]

16b) De (soldaat) leraar overhandigt (toont) een geweer aan de dokter.

[The (soldier) teacher hands (shows) a gun to the doctor.]

16c) The teacher hands the boxer a cup.

17a) De (serveerster) non overhandigt (toont) de dokter een banaan.

[The (waitress) nun hands (shows) the doctor a banana.]

17b) De (serveerster) non overhandigt (toont) een banaan aan de dokter.

[The (waitress) nun hands (shows) a banana to the doctor.]

17c) The nun hands the soldier a hat.

18a) De (schilder) piraat overhandigt (presenteert) de inbreker een paraplu.

[The (painter) pirate hands (presents) the burglar an umbrella.]

18b) De (schilder) piraat overhandigt (presenteert) een paraplu aan de inbreker.

[The (painter) pirate hands (presents) an umbrella to the burglar.]

18c) The pirate hands the clown a book.

19a) De (agent) schilder overhandigt (presenteert) de piraat een boek.

[The (policeman) painter hands (presents) the pirate a book.]

19b) De (agent) schilder overhandigt (presenteert) een boek aan de piraat.

[The (policeman) painter hands (presents) a book to the pirate.]

19c) The painter hands the monk a gun.

20a) De (danseres) serveerster overhandigt (toont) de kok een banaan.

[The (dancer) waitress hands (shows) the cook a banana.]

20b) De (danseres) serveerster overhandigt (toont) een banaan aan de kok.

[The (dancer) waitress hands (shows) a banana to the cook.]

20c) The waitress hands the swimmer a key.

21a) De (schilder) agent presenteert (schenkt) de monnik een boek.

[The (painter) policeman presents (gives) the monk a book.]

21b) De (schilder) agent presenteert (schenkt) een boek aan de monnik.

[The (painter) policeman presents (gives) a book to the monk.]

21c) The policeman presents the clown an apple.

22a) De (soldaat) cowboy presenteert (geeft) de non een taart.

[The (soldier) cowboy presents (gives) the nun a cake.]

22b) De (soldaat) cowboy presenteert (geeft) een taart aan de non.

[The (soldier) cowboy presents (gives) a cake to the nun.]

22c) The cowboy presents the swimmer a hat.

23a) De (monnik) inbreker presenteert (schenkt) de bokser een taart.

[The (monk) burglar presents (gives) the boxer a cake.]

23b) De (monnik) inbreker presenteert (schenkt) een taart aan de bokser.

[The (monk) burglar presents (gives) a cake to the boxer.]

23c) The burglar presents the pirate a book.

24a) De (piraat) kok presenteert (schenkt) de clown een geweer.

[The (pirate) cook presents (gives) the clown a gun.]

24b) De (piraat) kok presenteert (schenkt) een geweer aan de clown.

[The (pirate) cook presents (gives) a gun to the clown.]

24c) The cook presents the sailor a book.

25a) De (kok) leraar presenteert (overhandigt) de soldaat een paraplu.

[The (cook) teacher presents (hands) the soldier an umbrella.]

25b) De (kok) leraar presenteert (overhandigt) een paraplu aan de soldaat.

[The (cook) teacher presents (hands) an umbrella to the soldier.]

25c) The teacher presents the boxer a banana.

26a) De (inbreker) monnik presenteert (overhandigt) de matroos een bal.

[The (burglar) monk presents (hands) the sailor a ball.]

26b) De (inbreker) monnik presenteert (overhandigt) een bal aan de matroos.

[The (burglar) monk presents (hands) a ball to the sailor.]

26c) The monk presents the doctor an umbrella.

27a) De (leraar) piraat presenteert (schenkt) de monnik een sleutel.

[The (teacher) pirate presents (gives) the monk a key.]

27b) De (leraar) piraat presenteert (schenkt) een sleutel aan de monnik.

[The (teacher) pirate presents (gives) a key to the monk.]

27c) The pirate presents the burglar a hat.

28a) De (agent) schilder presenteert (overhandigt) de dokter een banaan.

[The (policeman) painter presents (hands) the doctor a banana.]

28b) De (agent) schilder presenteert (overhandigt) een banaan aan de dokter.

[The (policeman) painter presents (hands) a banana to the doctor.]

28c) The painter presents the pirate an apple.

29a) De (non) serveerster presenteert (overhandigt) de zwemmer een hoed.

[The (nun) waitress presents (hands) the swimmer a hat.]

29b) De (non) serveerster presenteert (overhandigt) een hoed aan de zwemmer.

[The (nun) waitress presents (hands) a hat to the swimmer.]

29c) The waitress presents the boxer a key.

30a) De (cowboy) soldaat presenteert (geeft) de matroos een taart.

[The (cowboy) soldier presents (gives) the sailor a cake.]

30b) De (cowboy) soldaat presenteert (geeft) een taart aan de matroos.

[The (cowboy) soldier presents (gives) a cake to the sailor.]

30c) The soldier presents the swimmer a gun.

31a) De (monnik) agent schenkt (presenteert) de clown een banaan.

[The (monk) policeman gives (presents) the clown a banana.]

31b) De (monnik) agent schenkt (presenteert) een banaan aan de clown.

[The (monk) policeman gives (presents) a banana to the clown.]

31c) The policeman gives the soldier a gun.

32a) De (non) danseres schenkt (presenteert) de kok een kan.

[The (nun) dancer gives (presents) the cook a jug.]

32b) De (non) danseres schenkt (presenteert) een kan aan de kok.

[The (nun) dancer gives (presents) a jug to the cook.]

32c) The dancer gives the doctor a book.

33a) De (leraar) inbreker schenkt (verkoopt) de kok een hoed.

[The (teacher) burglar gives (sells) the cook a hat.]

33b) De (leraar) inbreker schenkt (verkoopt) een hoed aan de kok.

[The (teacher) burglar gives (sells) a hat to the cook.]

33c) The burglar gives the nun a ball.

34a) De (piraat) kok schenkt (toont) de inbreker een taart.

[The (pirate) cook gives (shows) the burglar a cake.]

34b) De (piraat) kok schenkt (toont) een taart aan de inbreker.

[The (pirate) cook gives (shows) a cake to the burglar.]

34c) The cook gives the dancer a cup.

35a) De (agent) leraar schenkt (verkoopt) de schilder een boek.

[The (policeman) teacher gives (sells) the painter a book.]

35b) De (agent) leraar schenkt (verkoopt) een boek aan de schilder.

[The (policeman) teacher gives (sells) a book to the painter.]

35c) The teacher gives the soldier a jug.

36a) De (kok) monnik schenkt (toont) de inbreker een kan.

[The (cook) monk gives (shows) the burglar a jug.]

36b) De (kok) monnik schenkt (toont) een kan aan de inbreker.

[The (cook) monk gives (shows) a jug to the burglar.]

36c) The monk gives the swimmer an apple.

37a) De (serveerster) non schenkt (verkoopt) de matroos een kopje.

[The (waitress) nun gives (sells) the sailor a cup.]

37b) De (serveerster) non schenkt (verkoopt) een kopje aan de matroos.

[The (waitress) nun gives (sells) a cup to the sailor.]

37c) The nun gives the clown a banana.

38a) De (schilder) piraat schenkt (toont) de monnik een bal.

[The (painter) pirate gives (shows) the monk a ball.]

38b) De (schilder) piraat schenkt (toont) een bal aan de monnik.

[The (painter) pirate gives (shows) a ball to the monk.]

38c) The pirate gives the soldier a gun.

39a) De (danseres) serveerster schenkt (verkoopt) de soldaat een taart.

[The (dancer) waitress gives (sells) the soldier a cake.]

39b) De (danseres) serveerster schenkt (verkoopt) een taart aan de soldaat.

[The (dancer) waitress gives (sells) a cake to the soldier.]

39c) The waitress gives the clown a gun.

40a) De (inbreker) soldaat schenkt (presenteert) de danseres een geweer.

[The (burglar) soldier gives (presents) the dancer a gun.]

40b) De (inbreker) soldaat schenkt (presenteert) een geweer aan de danseres.

[The (burglar) soldier gives (presents) a gun to the dancer.]

40c) The soldier gives the monk an apple.

41a) De (agent) cowboy toont (overhandigt) de soldaat een banaan.

[The (policeman) cowboy shows (hands) the soldier a banana.]

41b) De (agent) cowboy toont (overhandigt) een banaan aan de soldaat.

[The (policeman) cowboy shows (hands) a banana to the soldier.]

41c) The cowboy shows the nun a ball.

42a) De (serveerster) danseres toont (overhandigt) de clown een kopje.

[The (waitress) dancer shows (hands) the clown a cup.]

42b) De (serveerster) danseres toont (overhandigt) een kopje aan de clown.

[The (waitress) dancer shows (hands) a cup to the clown.]

42c) The dancer shows the boxer a banana.

43a) De (monnik) danseres toont (schenkt) de soldaat een hoed.

[The (monk) dancer shows (gives) the soldier a hat.]

43b) De (monnik) danseres toont (schenkt) een hoed aan de soldaat.

[The (monk) dancer shows (gives) a hat to the soldier.]

43c) The dancer shows the clown a key.

44a) De (piraat) kok toont (geeft) de inbreker een kopje.

[The (pirate) cook shows (gives) the burglar a cup.]

44b) De (piraat) kok toont (geeft) een kopje aan de inbreker.

[The (pirate) cook shows (gives) a cup to the burglar.]

44c) The cook shows the swimmer a jug.

45a) De (danseres) leraar toont (overhandigt) de kok een boek.

[The (dancer) teacher shows (hands) the cook a book.]

45b) De (danseres) leraar toont (overhandigt) een boek aan de kok.

[The (dancer) teacher shows (hands) a book to the cook.]

45c) The teacher shows the pirate a hat.

46a) De (soldaat) monnik toont (schenkt) de bokser een kan.

[The (soldier) monk shows (gives) the boxer a jug.]

46b) De (soldaat) monnik toont (schenkt) een kan aan de bokser.

[The (soldier) monk shows (gives) a jug to the boxer.]

46c) The monk shows the dancer an apple.

47a) De (danseres) non toont (geeft) de matroos een appel.

[The (dancer) nun shows (gives) the sailor an apple.]

47b) De (danseres) non toont (geeft) een appel aan de matroos.

[The (dancer) nun shows (gives) an apple to the sailor.]

47c) The nun shows the doctor a cake.

48a) De (kok) schilder toont (schenkt) de monnik een bal.

[The (cook) painter shows (gives) the monk a ball.]

48b) De (kok) schilder toont (schenkt) een bal aan de monnik.

[The (cook) painter shows (gives) a ball to the monk.]

48c) The painter shows the soldier an umbrella.

Appendix B Additional Prime Sentences and Names of Target Pictures in Experiments 3-4

1a) De (non) serveerster toont (geeft) de zwemmer een banaan.

[The (nun) waitress shows (gives) the swimmer a banana.]

1b) De (non) serveerster toont (geeft) een banaan aan de zwemmer.

[The (nun) waitress shows (gives) a banana to the swimmer.]

1c) The waitress shows the pirate a jug.

2a) De (cowboy) soldaat toont (geeft) de danseres een geweer.

[The (cowboy) soldier shows (gives) the dancer a gun.]

2b) De (cowboy) soldaat toont (geeft) een geweer aan de danseres.

[The (cowboy) soldier shows (gives) a gun to the dancer.]

2c) The soldier shows the painter a book.

3a) De (monnik) agent verkoopt (overhandigt) de zwemmer een kopje.

[The (monk) policeman sells (hands) the swimmer a cup.]

3b) De (monnik) agent verkoopt (overhandigt) een kopje aan de zwemmer.

[The (monk) policeman sells (hands) a cup to the swimmer.]

3c) The policeman sells the painter a key.

4a) De (schilder) cowboy verkoopt (schenkt) de zwemmer een bal.

[The (painter) cowboy sells (gives) the swimmer a ball.]

4b) De (schilder) cowboy verkoopt (schenkt) een bal aan de zwemmer.

[The (painter) cowboy sells (gives) a ball to the swimmer.]

4c) The cowboy sells the doctor an apple.

5a) De (serveerster) danseres verkoopt (overhandigt) de dokter een sleutel.

[The (waitress) dancer sells (hands) the doctor a key.]

5b) De (serveerster) danseres verkoopt (overhandigt) een sleutel aan de dokter.

[The (waitress) dancer sells (hands) a key to the doctor.]

5c) The dancer sells the sailor a cup.

6a) De (soldaat) inbreker verkoopt (schenkt) de clown een taart.

[The (soldier) burglar sells (gives) the clown a cake.]

6b) De (soldaat) inbreker verkoopt (schenkt) een taart aan de clown.

[The (soldier) burglar sells (gives) a cake to the clown.]

6c) The burglar sells the doctor a gun.

7a) De (cowboy) kok verkoopt (schenkt) de inbreker een hoed.

[The (cowboy) cook sells (gives) the burglar a hat.]

7b) De (cowboy) kok verkoopt (schenkt) een hoed aan de inbreker.

[The (cowboy) cook sells (gives) a hat to the burglar.]

7c) The cook sells the soldier a ball.

8a) De (kok) leraar verkoopt (geeft) de clown een taart.

[The (cook) teacher sells (gives) the clown a cake.]

8b) De (kok) leraar verkoopt (geeft) een taart aan de clown.

[The (cook) teacher sells (gives) a cake to the clown.]

8c) The teacher sells the sailor a banana.

9a) De (piraat) monnik verkoopt (overhandigt) de kok een appel.

[The (pirate) monk sells (hands) the cook an apple.]

9b) De (piraat) monnik verkoopt (overhandigt) een appel aan de kok.

[The (pirate) monk sells (hands) an apple to the cook.]

9c) The monk sells the dancer a jug.

10a) De (danseres) non verkoopt (schenkt) de monnik een boek.

[The (dancer) nun sells (gives) the monk a book.]

10b) De (danseres) non verkoopt (schenkt) een boek aan de monnik.

[The (dancer) nun sells (gives) a book to the monk.]

10c) The nun sells the cook an umbrella.

11a) De (inbreker) piraat verkoopt (geeft) de soldaat een banaan.

[The (burglar) pirate sells (gives) the soldier a banana.]

11b) De (inbreker) piraat verkoopt (geeft) een banaan aan de soldaat.

[The (burglar) pirate sells (gives) a banana to the soldier.]

11c) The pirate sells the clown a book.

12a) De (leraar) schilder verkoopt (overhandigt) de monnik een appel.

[The (teacher) painter sells (hands) the monk an apple.]

12b) De (leraar) schilder verkoopt (overhandigt) een appel aan de monnik.

[The (teacher) painter sells (hands) an apple to the monk.]

12c) The painter sells the dancer a gun.

13a) De (agent) monnik geeft (presenteert) de inbreker een boek.

[The (policeman) monk gives (presents) the burglar a book.]

13b) De (agent) monnik geeft (presenteert) een boek aan de inbreker.

[The (policeman) monk gives (presents) a book to the burglar.]

13c) The monk gives the clown a key.

14a) De (inbreker) piraat geeft (toont) de monnik een bal.

[The (burglar) pirate gives (shows) the monk a ball.]

14b) De (inbreker) piraat geeft (toont) een bal aan de monnik.

[The (burglar) pirate gives (shows) a ball to the monk.]

14c) The pirate gives the dancer a jug.

15a) De (leraar) monnik overhandigt (presenteert) de zwemmer een boek.

[The (teacher) monk hands (presents) the swimmer a book.]

15b) De (leraar) monnik overhandigt (presenteert) een boek aan de zwemmer.

[The (teacher) monk hands (presents) a book to the swimmer.]

15c) The monk hands the clown a jug.

16a) De (piraat) soldaat overhandigt (verkoopt) de matroos een taart.

[The (pirate) soldier hands (sells) the sailor a cake.]

16b) De (piraat) soldaat overhandigt (verkoopt) een taart aan de matroos.

[The (pirate) soldier hands (sells) a cake to the sailor.]

16c) The soldier hands the dancer an apple.

17a) De (serveerster) danseres presenteert (geeft) de bokser een appel.

[The (waitress) dancer presents (gives) the boxer an apple.]

17b) De (serveerster) danseres presenteert (geeft) een appel aan de bokser.

[The (waitress) dancer presents (gives) an apple to the boxer.]

17c) The dancer presents the clown a cake.

18a) De (danseres) non presenteert (geeft) de kok een kopje.

[The (dancer) nun presents (gives) the cook a cup.]

18b) De (danseres) non presenteert (geeft) een kopje aan de kok.

[The (dancer) nun presents (gives) a cup to the cook.]

18c) The nun presents the boxer a jug.

19a) De (soldaat) cowboy schenkt (toont) de non een kan.

[The (soldier) cowboy gives (shows) the nun a jug.]

19b) De (soldaat) cowboy schenkt (toont) een kan aan de non.

[The (soldier) cowboy gives (shows) a jug to the nun.]

19c) The cowboy gives the boxer a hat.

20a) De (cowboy) schilder schenkt (presenteert) de monnik een appel.

[The (cowboy) painter gives (presents) the monk an apple.]

20b) De (cowboy) schilder schenkt (presenteert) een appel aan de monnik.

[The (cowboy) painter gives (presents) an apple to the monk.]

20c) The painter gives the doctor an umbrella.

21a) De (schilder) agent toont (overhandigt) de clown een bal.

[The (painter) policeman shows (hands) the clown a ball.]

21b) De (schilder) agent toont (overhandigt) een bal aan de clown.

[The (painter) policeman shows (hands) a ball to the clown.]

21c) The policeman shows the doctor a gun.

22a) De (leraar) piraat toont (schenkt) de kok een taart.

[The (teacher) pirate shows (gives) the cook a cake.]

22b) De (leraar) piraat toont (schenkt) een taart aan de kok.

[The (teacher) pirate shows (gives) a cake to the cook.]

22c) The pirate shows the monk a book.

23a) De (non) serveerster verkoopt (geeft) de clown een kan.

[The (nun) waitress sells (gives) the clown a jug.]

23b) De (non) serveerster verkoopt (geeft) een kan aan de clown.

[The (nun) waitress sells (gives) a jug to the clown.]

23c) The waitress sells the boxer a hat.

24a) De (agent) soldaat verkoopt (geeft) de piraat een taart.

[The (policeman) soldier sells (gives) the pirate a cake.]

24b) De (agent) soldaat verkoopt (geeft) een taart aan de piraat.

[The (policeman) soldier sells (gives) a cake to the pirate.]

24c) The soldier sells the swimmer an apple.