Tobias Ungerer*

Extending structural priming to test constructional relations: Some comments and suggestions

https://doi.org/10.1515/gcla-2022-0008

Abstract: Structural priming is a promising tool for testing similarity relations between constructions, but its applicability to larger-scale models of constructional networks is still limited. This article outlines the following two limitations of previous priming studies: first, they largely focus on priming between alternating constructions; and second, they often test the relations between instances of the same construction rather than between instances of different constructions. Three strategies are suggested for how future priming research could overcome these limitations. Concrete ideas for experimental setups are presented, and their benefits and limitations are addressed.

Keywords: Structural priming; Construction Grammar; constructional network; non-alternating constructions

1 Introduction

Cognitive linguists assume that speakers' grammatical knowledge is organised as a mental network of interrelated constructions (Croft 2001; Goldberg 1995; Langacker 1987). While these network relations may be of different kinds, one particular important type of link captures the degree of formal and/or functional similarity between constructions. These similarity relations have been given various names in different frameworks, including 'paradigmatic' links (Schmid 2020), 'taxonomic' relations (Diessel 2019), 'categorising' relations (Langacker 1987), 'relational' links (Jackendoff and Audring 2020) and 'inheritance' links (Goldberg 1995; Hudson 2007). In all of these models, the strength of the similarity links – which, for simplicity's sake, are henceforth used interchangeably with the term 'constructional relations' – is used to characterise key aspects of speakers' grammatical knowledge. For example, it is only when similarities

* **Corresponding author: Tobias Ungerer,** University of Edinburgh, t.ungerer@ed.ac.uk

among a group of words, phrases or sentences are strong enough that speakers are likely to subsume these units under a common schema or 'construction'. In this sense, the strength of the relations among lower-level units determines the organisation of speakers' constructional networks at higher levels of abstraction. Similarly, the notions of constructional 'families', 'micro-networks' and 'alternations' (the latter being understood as a generalisation over two semantically near-equivalent patterns) rely on the fact that the members of these sets share significant degrees of formal and/or functional similarity with each other.

The importance of constructional relations in cognitive-linguistic models of grammar raises the question of how the existence and strength of these relations can be assessed empirically. Among the psycholinguistic methods that have been used for this purpose (see Section 2.2 for more details), one paradigm has been highlighted as a particularly promising tool: structural priming. In Diessel's (2019: 204) words, "[s]tructural priming provides perhaps the best evidence for constructional relations". Priming effects occur when "processing a stimulus with particular characteristics affects subsequent processing of another stimulus with the same or related characteristics" (Branigan and Pickering 2017: 6). As such, they can be interpreted as reflexes of the activation spread in speakers' mental networks, which in turn is reflective of the connectivity patterns within those networks (Collins and Loftus 1975). "Structural" priming effects, which occur between units above the word level, can thus potentially shed light on the relations between phrase- and clause-level patterns that are typically the focus of constructionist analyses.[1]

Though the potential of structural priming is evident, some doubts remain as to whether the paradigm has yet reached the stage at which it can serve as a general methodology for testing constructional relations. In response to this question, Section 2 of the present paper will summarise the advantages that structural priming brings to the investigation of such relations. At the same time, however, it will also be argued that previous structural priming research is subject to two important limitations, which restrict its applicability to cognitive-linguistic models of constructional networks. Both of these limitations concern the empirical coverage of previous priming studies: first, most studies have focused on a relatively small set of (alternating) constructions; and second, they often test the relations between instances of the same construction rather than between instances of different constructions.

1 Besides the experimental methods discussed here, there are also a variety of corpus methods that can provide (at least indirect) evidence of constructional relations. Relevant techniques include, for instance, collostructional analysis (see Stefanowitsch [2013] for an overview) and semantic vector space analysis (Hilpert and Perek 2015). Priming, too, can be studied in corpora instead of controlled experiments (e.g., Gries 2005; Smet and Van de Velde 2017).

Section 3 will then outline some new ideas for how these limitations can be overcome and how structural priming could be extended to a wider range of constructions. Three strategies will be suggested: the first two involve novel applications of familiar production priming methods, while the third relies on an extension of lesser used comprehension techniques. Examples will be given both of how these strategies have already been – tentatively – implemented and to what other phenomena they could be applied in future studies. Section 4 summarises both the potential of these approaches as well as some of the outstanding challenges that will need to be met. Overall, the present paper is thus intended as a methodological think piece that sketches out some possible avenues for future priming investigations into the organisation of constructional networks.

2 Structural priming: advantages and limitations

Several cognitive-linguistic researchers have discussed the importance of structural priming for testing and refining models of constructional networks (e.g., Diessel 2019: 202–205; Goldberg 2006: 120–125; Perek 2015: 165–166). Sections 2.1 and 2.2 will summarise the arguments for why priming is a suitable tool for studying constructional relations and what advantages the paradigm has over alternative experimental methods. Despite its potential, however, Section 2.3 will then elaborate on two limitations that restrict the applicability of many previous priming findings to cognitive-linguistic theory.

2.1 Why use structural priming?

The main reason why priming effects are regarded as an important source of evidence for constructional relations is that they shed light on how patterns of activation and information exchange unfold within speakers' mental networks during individual usage events. Under a spreading activation account of language processing (Collins and Loftus 1975), priming effects can be explained in the following way: on encountering a linguistic stimulus, speakers not only activate their mental representation for the specific instance, but activation also spreads to neighbouring network units – which can either form part of the same abstract construction as the original stimulus, or instantiate other related constructions. As a result of this residual activation, speakers' subsequent processing of the same or similar constructions is facilitated (or, depending on the process, potentially inhibited, see Section 3.3).

In Bock's (1986) original structural priming study, for example, participants were more likely to produce double-object sentences after previous exposure to

a double-object prime like (1a) than after a *to*-dative prime like (1b). Similarly, participants produced more actives after active primes like (2a) than after passive primes such as (2b). This suggests that speakers represent different instances of the same construction as interrelated in their mental networks; these network links thus encode generalisations that correspond to the notion of an abstract constructional schema.

(1) a. *A rock star sold an undercover agent some cocaine.*
b. *A rock star sold some cocaine to an undercover agent.*

(2) a. *One of the fans punched the referee.*
b. *The referee was punched by one of the fans.*
(all from Bock [1986])

The use of structural priming to test constructional relations is also supported by evidence that priming effects are sensitive to both formal-syntactic and functional-semantic similarities between grammatical patterns. While early studies indicated that structural priming effects are primarily syntactic, reflecting the shared constituent structure of the stimuli (Bock and Loebell 1990; but see Ziegler et al. [2019] for potential counter-evidence), more recent investigations have suggested that priming effects can also arise from overlap in thematic roles (Hare and Goldberg 1999), event structure (Bunger et al. 2013), information structure (Bernolet et al. 2009) and animacy (Vasilyeva and Gámez 2015; see Ungerer [2021] for further examples and discussion). Moreover, Ziegler et al. (2018) have argued that priming effects may be additive, with stronger priming effects emerging between sentences that share several formal and/or functional properties than between sentences that overlap only on a single dimension. This aligns naturally with a cognitive-linguistic view of constructional relations as multi-dimensional and gradient in strength (Goldberg 2019; Trijp 2020).[2]

2 Another relevant aspect that can be informed by structural priming is the question of how similarities between abstract constructions are influenced by the specific lexical material of their slot fillers. For example, previous studies have illustrated that priming is stronger when primes and targets contain the same verb, the so-called 'lexical boost' effect (Pickering and Branigan 1998), which potentially suggests that speakers activate verb-specific subconstructions in addition to the abstract schemas they instantiate (see Ungerer [2022] for a discussion of this and other interpretations of the lexical boost). Moreover, it has been shown that priming is influenced by the degree of association (i.e., the collostructional strength) between verbs and constructions, with less typical prime verbs usually leading to larger priming effects than verbs which are prototypically associated with the construction (an 'inverse-frequency effect'; Bernolet and Hartsuiker [2010]; Jaeger and Snider [2013]).

2.2 Advantages over alternative methods

Structural priming has several advantages that set it apart from other experimental methods that have been used to test constructional relations (see also Ungerer [2022] for a detailed discussion). First, priming experiments provide implicit measures of processes that are assumed to be automatic, unconscious and resource-free (Branigan and Pickering 2017: 6). The paradigm thus avoids the challenges faced by explicit metalinguistic methods such as sorting tasks, in which participants are asked to group similar sentences into the same category (Bencini and Goldberg 2000; Gries and Wulff 2005; Perek 2012). As Perek (2012: 629) points out, these experiments leave open the question of whether speakers' sorting behaviour reflects their implicit grammatical knowledge or the ad-hoc categories that they may consciously form in response to the specific task.

A second advantage is that structural priming can, in principle, be applied to any kind of construction and tested in any type of speaker population. Priming effects have been observed in children as well as adults, in L1 speakers as well as non-L1 and bilingual speakers, and in neurotypical speakers as well as participants with aphasia, autism spectrum disorder and specific language impairment (see Branigan and Pickering [2017] for discussion). Other methods, in contrast, are often restricted to particular phenomena or participant groups. For instance, given the metalinguistic nature of the above sorting tasks, these techniques may be difficult to use with younger children or speakers that have limited working memory resources. Other methods, such as acquisition studies that investigate in what order the members of constructional families are acquired (Diessel and Tomasello 2005), are naturally restricted to children (or possibly L2 learners). Similarly, artificial learning experiments (Perek and Goldberg 2015, 2017) have been used to test how speakers generalise across novel clause-level constructions that contain nonce verbs (Tomasello and Brooks 1998); but clearly, these methods cannot be used to investigate already existing constructions in natural languages.

Finally, priming reflects how the activation patterns in speakers' mental networks are affected by individual linguistic stimuli in a way that seems difficult to demonstrate with other methods. In acquisition experiments (both natural and artificial), for instance, the learning effects accrue over longer periods of time and researchers can only observe the overall outcome of those cumulative processes. In priming experiments, on the other hand, a single exposure to a prime can already have an observable effect on speakers' behaviour. Moreover, by studying priming both in production and comprehension, researchers can not only examine the "outcomes" of individual activation processes (via speakers' production rates), but they can also track their exact time course by obtaining

"online" measures of speakers' real-time processing (such as reading times in comprehension; see Section 3.3).

2.3 Two limitations of previous priming research

In the light of these advantages, it is not surprising that structural priming is considered an important tool for investigating constructional relations. Nevertheless, as mentioned above, previous priming studies also display two important limitations that restrict the extent to which these findings can, to date, inform cognitive-linguistic models of constructional networks. These limitations will be outlined in more detail in the following; together, they motivate the suggested extensions of the priming paradigm discussed in Section 3.

The first limitation is that previous structural priming studies have focused on a relatively small set of constructions, while other types of patterns have been largely disregarded. In particular, most studies have so far tested constructional alternations, i.e., pairs of constructions that vary in their syntactic form but express near-equivalent meanings. In the domain of argument structure constructions, for instance, the by far most commonly studied phenomenon is the dative alternation, consisting of the double-object construction and the *to*-dative (see Bock's [1986] classic study described in Section 2.1). In Mahowald et al.'s (2016) meta-analysis of 69 production priming studies, 63% out of all reviewed experimental conditions instantiate the dative constructions (with actives/passives making up another 22% of the sample). Other argument structure constructions that have been (though less frequently) investigated are the members of the benefactive alternation (Bock 1989), the locative (or *spray/load*) alternation (Chang et al. 2003) and the "fulfilling" alternation (Ziegler and Snedeker 2018); see below for examples.

Relying on a relatively small set of target constructions is arguably unproblematic if the goal of the investigation is to illustrate general processing mechanisms that should (in theory) apply equally to all constructions. This has indeed been the purpose of many structural priming studies, which have, for instance, compared production processes with comprehension processes (Bock et al. 2007) and spoken with written production (Cleland and Pickering 2006), or assessed individual processing differences due to age (Hardy et al. 2020) and language disorders (Cho-Reyes et al. 2016). In these cases, reusing the same constructions across different studies is not only convenient but also makes the experiments more comparable. The situation is different, however, when the research goal is to investigate speakers' representations of specific constructions, and the relations between those constructions. Especially within the context of

cognitive-linguistic network models, it is strongly desirable to obtain priming data for a large and varied set of constructions, beyond the relatively narrow scope of alternations. Not only are constructional relations expected to differ depending on the phenomena involved, but the eventual goal of the research programme must also be to map out speakers' mental networks in their entirety, rather than restricting the analysis to smaller sections of these networks.

To understand why previous priming studies have favoured alternating constructions, it is necessary to take a closer look at their methodologies. The majority of structural priming studies to date have tested priming in production, with the two most popular methods being the picture description task and the sentence completion task (Mahowald et al. 2016). As suggested by Branigan and Pickering (2017: 7), these production methods usually "rely on the existence of structural alternatives". In a picture description task, for instance, participants need to have two (roughly) equally felicitous constructions at their disposal with which they can describe the target picture (e.g., the double-object and the *to*-dative construction in the case of 'transfer of possession' events). This technique therefore lends itself naturally to the investigation of (near-synonymous) alternating constructions. At the same time, these methodological considerations already hint at the fact that researchers may be able to extend priming to a wider range of constructions by using alternative techniques, especially by testing priming in comprehension (see Section 3.3). Moreover, while production methods may generally be biased towards studying constructional alternations, it remains to be seen whether some production techniques can nevertheless be applied to specific cases of non-alternating constructions (see Section 3.2).

The second major limitation of previous structural priming studies – in the context of cognitive-linguistic network models – is that most previously observed priming effects reflect similarities between instances of the *same* construction ("within-construction priming") rather than between instances of *different* constructions ("cross-constructional priming"). Consider again the results of Bock's (1986) study described in Section 2.1: the fact that participants produced more double-object sentences after double-object primes than after *to*-dative primes suggests that they encode similarity relations between instances of the double-object construction. As such, however, the results do not reveal anything about the relationship between the double-object construction and the *to*-dative. This is a major limitation when it comes to testing cognitive-linguistic accounts of constructional networks, since the most interesting relationships in these models are arguably those that hold between distinct (but partially similar) constructions.

Compared with within-construction priming effects, investigations of cross-constructional priming, i.e., priming between instances of distinct constructions,

have so far been relatively sparse (see Ungerer [2022] for an in-depth discussion of the relevant results). The most detailed study of such effects has been conducted by Ziegler and Snedeker (2018), who present several experiments that test priming effects between members of *different* argument structure alternations. The results of their Experiment 6, for example, indicate that speakers are more likely to describe a 'transfer of possession' event with the double-object construction after hearing a benefactive double-object prime like (3a) than after a *for*-dative prime like (3b). While the dative alternation and the benefactive alternation are often regarded as distinct phenomena (Levin 1993), Ziegler and Snedeker's findings suggest that speakers encode strong similarity relations between the two double-object members and/or between the two prepositional members of each alternation (see Bock [1989]; Chang et al. [2003] for similar results).

(3) a. *The girl fetched the cowboy the hammer.*
b. *The girl fetched the hammer for the cowboy.*
(both from Ziegler and Snedeker [2018])

Targeting another pair of alternations, Ziegler and Snedeker's (2018) Experiment 7 provides evidence that "theme-second fulfilling" primes such as (4a) prime speakers' double-object productions, compared with "theme-first fulfilling" primes like (4b). This cross-constructional effect was weaker, however, than within-construction priming between dative primes and dative targets, suggesting that speakers represent the fulfilling alternation and the dative alternation as partially similar but still distinct sets of constructions (see Hare and Goldberg [1999]; Cho-Reyes et al. [2016] for related results). Finally, Ziegler and Snedeker's Experiment 4 illustrates that the absence of cross-constructional priming, too, can be instructive: the fact that the two members of the locative (or *spray/load*) alternation in (5) did not prime participants' dative productions suggests that the locative and the dative alternation are not (or at best weakly) related in speakers' constructional networks.

(4) a. *The boy presented the athlete with the trophy.*
b. *The boy presented the trophy to the athlete.*

(5) a. *The girl loaded the van with the boxes.*
b. *The girl loaded the boxes in the van.*
(all from Ziegler and Snedeker [2018])

Together, these findings support the view that structural priming can provide relevant evidence about constructional relations. At the same time, Ziegler and Snedeker's (2018) study of cross-constructional priming is a relatively rare case within a literature that has primarily focused on within-construction priming

between instances of the same construction. This is evidenced, for example, by the fact that cross-constructional effects are excluded from Mahowald et al.'s (2016) meta-analysis of production priming studies, and that the distinction between within-construction and cross-constructional priming is not explicitly addressed in structural priming reviews (Branigan and Pickering 2017; Pickering and Ferreira 2008). In addition, while Ziegler and Snedeker (2018) investigate cross-constructional effects, they mostly restrict their analysis to priming between the members of constructional alternations, thus mirroring the first limitation discussed above (but see Section 3.1 for one exception among their experiments).

In summary, the preceding sections have addressed both the advantages of using structural priming to test constructional relations, and the limitations that constrain the ability of previous priming studies to inform large-scale models of constructional networks. In particular, the use of priming evidence in the context of cognitive-linguistic network models is limited by the fact that previous studies have focused primarily on alternating constructions and that they often target priming between instances of the same construction rather than priming between different but related constructions. To overcome these limitations, the crucial question is therefore how cross-constructional priming can be extended to a wider range of – particularly non-alternating – constructions. In the next section, three possible strategies that may enable such extensions will be discussed and illustrated.

3 Three strategies for extending structural priming

In this section, three potential strategies will be outlined for how structural priming can be extended to new types of constructional relations, in particular to links between non-alternating constructions. In each case, an example from the previous literature will be discussed in which the respective strategy has already been (tentatively) employed. In this sense, the approaches advocated here are not completely novel; but their precursors have been rather scarce, and they deserve to be extended to other types of constructions. For each of the three strategies, another phenomenon will therefore be suggested which could potentially be investigated with the respective approach. The primary purpose of these examples is thus to illustrate what kinds of further questions about constructional networks could be addressed with structural priming; naturally, the practicability of the individual ideas yet needs to be established.

3.1 Strategy 1: pairing non-alternating primes with alternating targets

As argued in Section 2.3, production priming methods such as the picture description task typically require that participants choose between two ways of encoding the same event, thus lending themselves to the investigation of alternating constructions. Strictly speaking, however, this constraint only applies to the target trials of the experiments, where participants are asked to describe the pictures. The prime sentences, on the other hand, are simply presented to participants (in either written or auditory form). As a result, the primes do not necessarily have to instantiate alternating constructions.

Based on this logic, a first and relatively simple strategy for *partially* extending priming to non-alternating constructions is to pair non-alternating primes with alternating targets. Such experiments involve at least three constructions, represented schematically in Figure 1. As the diagram shows, participants are presented with two alternating constructions A and B on prime trials and they choose between the same patterns A and B on target trials. In addition, however, they also encounter a third prime construction C, which does not participate in the alternation but which is nevertheless hypothesised to be related to one of the alternating targets (which it should therefore prime). The advantage of this approach is that researchers can continue to use well-established production methods like the picture description task; the difference from most previous applications of the method is that one of the prime constructions is a non-alternating pattern which is itself not available as a possible target.

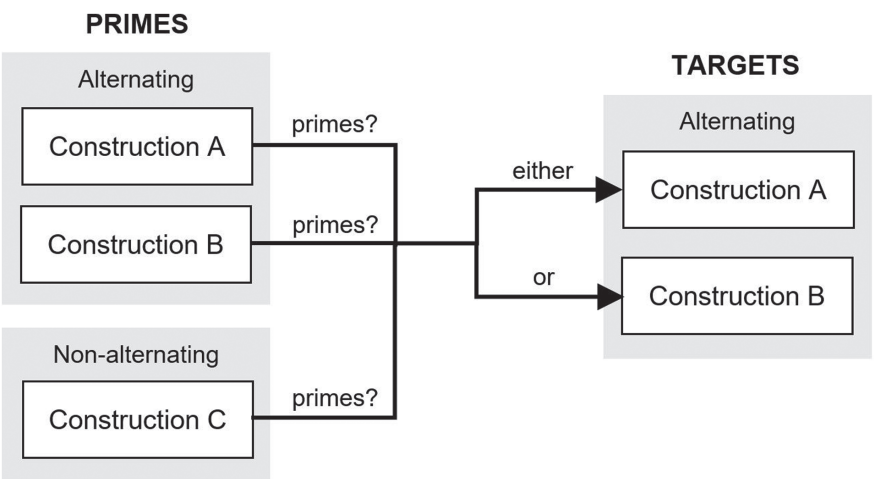

Figure 1: Schematic representation of Strategy 1, where a non-alternating prime construction is paired with alternating target constructions in a production setting.

The approach is illustrated by a few precursors in the literature, among them Bock and Loebell's (1990) study. Using a picture description task, the authors tested to what extent speakers' double-object and *to*-dative productions were primed by double-object sentences such as (6a), *to*-dative primes like (6b) and caused-motion sentences like (6c). Crucially, the latter construction does not alternate with either of the two dative constructions, since it expresses a distinct meaning of 'change of location' rather than 'transfer of possession'. At the same time, the caused-motion construction may be related to the *to*-dative given the syntactic similarity of the two constructions and a potential metaphorical connection between their meanings (Goldberg 1995). Bock and Loebell's caused-motion primes thus fulfil the role of construction C in the schematic scenario above, while the double-object and the *to*-dative construction correspond to constructions A and B. The crucial question in the study was whether caused-motion primes led to an increase in speakers' *to*-dative productions, thus suggesting that the two constructions are related in speakers' networks.

(6) a. *The wealthy widow sold the church an old Mercedes.*
b. *The wealthy widow gave an old Mercedes to the church.*
c. *The wealthy widow drove an old Mercedes to the church.*
(all from Bock and Loebell [1990])

The emphasis here is primarily on the logic of Bock and Loebell's (1990) design rather than on their specific results. With respect to the latter, the authors found that caused-motion primes led to an increase in participants' *to*-dative productions, in fact to a similar degree as *to*-dative primes did, suggesting that speakers represent a strong similarity relation between the two constructions. These results, however, stand in direct contrast to Ziegler and Snedeker's (2018) Experiment 11, in which they replicated Bock and Loebell's design with some changes among the stimulus materials. In Ziegler and Snedeker's experiment, no evidence emerged that caused-motion primes facilitated speakers' subsequent *to*-dative productions, thus casting doubt on the strength of the similarity relation between the constructions (see Ziegler and Snedeker [2018: 231–232] for a discussion of possible confounds in Bock and Loebell's materials, which may explain the discrepancies).

A suggestion for how future studies could extend this first strategy to other phenomena concerns the three constructions illustrated in (7), consisting of a double-object example in (7a), a *to*-dative in (7b) and what could be called an instance of the "predicative complement" construction (Himmelmann and Schultze-Berndt 2005) in (7c).

(7) a. *She gave her friend a book.*
b. *He sent a letter to his father.*
c. *He considered his teacher a fool.*

The predicative complement pattern corresponds to construction C in the schematic Figure 1: it does not alternate with the datives and in fact expresses a very distinct meaning (something along the lines of 'property ascription' rather than 'transfer of possession'). Nevertheless, as highlighted by examples (7a) and (7c), the predicative complement construction contains the same syntactic constituents as the double-object construction (NP–V–NP–NP). The two patterns therefore constitute what has been referred to as "homonymous constructions" (Ellis 2008) or "homostructions" (Percillier 2020): similar to lexical homonyms, they display identical surface forms, while being semantically distinct and etymologically unrelated (see Percillier [2020: 220–221], who shows that the two constructions had differential case marking in Old English).

Testing cross-constructional priming between the two constructions could provide evidence of whether the purely form-based relations between homostructions have some cognitive reality within speakers' constructional networks. This question is particularly relevant given that the overlap between the constructions is arguably quite 'superficial' and that the constructions differ in other of their form-related properties. Among the latter are the fact that the direct object of double-object sentences can be passivised while the predicative complement in the other construction cannot, and that the predicative complement slot can alternatively be filled with an adjective while this is not possible in the double-object construction.

In order to test the strength of the potential homostructional link, experimenters would need to compare the effects of the three prime constructions in (7) on speakers' subsequent dative productions.[3] If participants are sensitive to the formal similarities between homostructions, their double-object productions (relative to their *to*-dative productions) should increase after predicative complement primes, potentially at a similar rate as after double-object primes. On the other hand, the absence of such priming by predicative complement sentences would suggest that homostructional relations do not form part of speakers' grammatical knowledge. On a more general level, this type of experiment may help address the recurring question in cognitive-linguistic research of whether speakers can form

3 As pointed out by one of the editors, the priming effects in this kind of experiment (as well as the other scenarios discussed below) could be influenced by the collostructional attraction between the prime constructions and the specific verbs that occur in them. For example, Hampe's (2011) corpus results indicate that nominal predicative complements – as in example (7c) above – most commonly occur with verbs of naming such as *call*, while the verb *consider* used in the above example more typically combines with adjectival complements. By incorporating such collostructional attraction scores into the statistical analysis of the priming experiments, relevant conclusions could be drawn about the interaction between lexical and constructional information (see also note 2 above).

generalisations based on form only, or whether such "meaningless" schemas are cognitively implausible (Goldberg 2006: 166–182; Hilpert 2014: 50–57; Sommerer and Baumann 2021: 125–126).

3.2 Strategy 2: extending sentence completion to non-alternating constructions

A second strategy for extending structural priming to non-alternating constructions can be derived by taking another critical look at the view that production priming methods usually rely on the existence of structural alternatives (see Section 2.3). This assertion seems to be true in particular for picture description tasks, which specify a target event that can usually only be described with two alternating constructions. Other production methods, however, especially sentence completion tasks, may offer some more flexibility: in these experiments, participants are presented with target fragments that only partially specify an event. As a result, participants may sometimes complete these fragments with constructions that are not necessarily alternating variants of each other.

This is illustrated, for instance, by Gompel et al.'s (2012) study, who tested how intransitive primes like (8a) and monotransitive primes like (8b) affected participants' responses to target fragments such as (8c). The authors found that participants were more likely to complete the targets with an intransitive structure after intransitive primes, and with a transitive structure after transitive primes.

(8) a. *The ambulance driver and the policewoman were helping.*
b. *The ambulance driver was helping the policewoman.*
c. *When the boy scout was following...*
(all from Gompel et al. [2012])

Gompel et al.'s results as such are not central for the present context, given that they concern within-construction priming rather than cross-constructional priming. The main point here is that the study provides an example of a sentence completion experiment that tested participants' processing of non-alternating constructions. This is because the intransitive and the monotransitive construction do not encode the same event; rather, the monotransitive construction extends the intransitive construction with an additional argument role (or, conversely, the intransitive construction can be seen as a "subpart" of the monotransitive; cf. Goldberg 1995). A schematic representation of the second proposed strategy could therefore look like Figure 2. Focusing on the boxes with the full black lines for the moment, and ignoring the greyed-out boxes, the diagram captures the fact that participants are presented with two non-alternating prime

constructions A and B, the latter of which forms a larger extension of the former, and that they then choose between the same two constructions (i.e., non-extended pattern A vs. extended pattern B) when completing the target fragments.

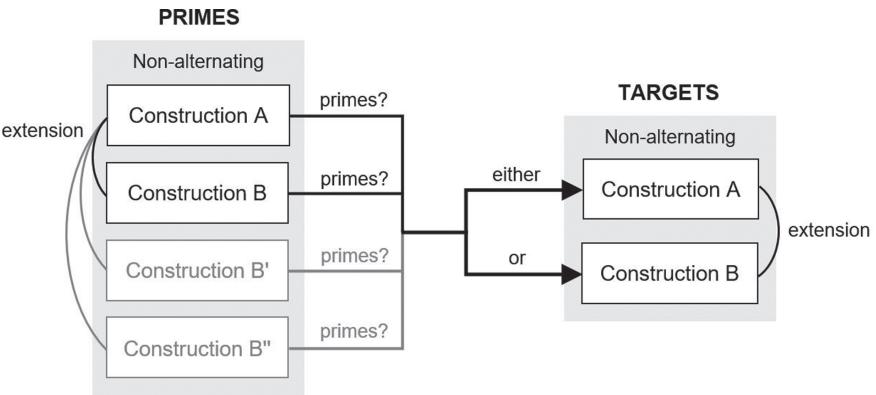

Figure 2: Schematic representation of Strategy 2, testing the effect of two or more primes on a target pair in which one construction forms a larger extension of the other.

In order to use this strategy to investigate cross-constructional relations, additional prime constructions could be added, marked by the grey boxes in Figure 2 (construction B′ and B″). One potential area in which such a design may be feasible concerns adverbial complementation patterns. As noted in reference works (Herbst et al. 2004; Quirk et al. 1985) and also discussed in the cognitive-linguistic literature (Bergs 2021; Hoffmann 2007), adverbials vary along a cline of how closely associated with the verb, and therefore how "obligatory" they are in the sentence. One case of such variation is illustrated by the examples in (9), whose adverbials become increasingly more obligatory. In (9a), *in the living room* is an optional adverbial that can be dropped without rendering the sentence infelicitous; in (9b), *in the cupboard* can be regarded as semi-obligatory since the sentence would seem grammatical but semantically incomplete without it; while in (9c), *in the drawer* is a fully obligatory element without which the sentence would be ungrammatical.[4] The obligatoriness of these adverbials plays an important

4 The difference between (9a) and (9b) can be illustrated with the "do so too" test (Huddleston 2002): *?The cleaner found a towel in the cupboard and so did his colleague in the bathroom* seems odd, suggesting that the adverbial in (9b) is quite closely connected to the verb. Compare this with the fully optional adverbial in (9a), where *The musician played her guitar in the living room and so did her friend on the veranda* is fully acceptable.

role in the long-standing debate about their status as complements versus adjuncts (which, as a result of the gradual differences, has also been reconceptualised as a continuum).

(9) a. *The musician played her guitar in the living room.*
b. *The cleaner found a towel in the cupboard.*
c. *The cook put the knife in the drawer.*

Priming may inform this discussion by providing evidence of whether or not speakers are sensitive to differences in the obligatoriness of the adverbials. For example, following the schematic representation in Figure 2, participants could be presented with bare monotransitive primes that contain no adverbial (construction A) and primes like (9a) which contain an optional adverbial and thus extend the bare pattern (construction B). In addition, participants could be confronted with two further prime types that contain either semi-obligatory adverbials as in (9b) or fully obligatory adverbials as in (9c). These two prime conditions are represented as constructions B′ and B″ in Figure 2 since they also form extensions of construction A, but they differ from construction B in terms of the obligatoriness of their adverbials. Following these four prime types, speakers could then be asked to complete target fragments such as (10). In this example, the verb *cut* requires an object (e.g., *the wood*); beyond this, however, participants could decide freely whether they want to add an optional adverbial (e.g., *in the forest*) or not.

(10) *The lumberjack cut…*

The question would be whether the likelihood that speakers use an optional adverbial in their target completions increases after an adverbial-containing prime, and whether the strength of such priming varies depending on the obligatoriness of the previously encountered adverbial. For example, it would seem feasible that optional adverbials are more strongly primed by other optional adverbials such as (9a) than by adverbials that are required by the argument structure of the verb, as in (9c) and perhaps to a lesser degree in (9b).

3.3 Strategy 3: testing priming in comprehension

The previous two strategies were based on extensions of production priming experiments beyond their traditional focus on alternating constructions. A third option is to move beyond production methods altogether and to test priming in comprehension instead, using methods such as self-paced reading and eye-tracking during reading. Not only do these methods have the advantage that researchers can pre-select the exact stimuli they want to test, rather than having

to elicit them from participants with the help of pictures or sentence fragments (which can be difficult for complex or infrequent constructions). Even more importantly for the present context, the benefit of comprehension methods is that they are not restricted to alternating constructions but can, in principle, be applied to any construction. This is because, in a reading task, participants do not choose between two alternative ways of encoding the same event; rather, they process each target sentence on its own terms and independently from other constructions.

This also highlights another feature of comprehension priming methods, namely that they provide separate outcomes (e.g., reading times) for each target construction individually. This contrasts with production methods, which typically yield proportions of one target type relative to the other. As discussed in detail by Ungerer (2022), one advantage of independent outcomes is that they make it easier to distinguish between within-construction priming and cross-constructional priming effects. This is illustrated in Figure 3, which provides a schematic representation of the third strategy. As the arrows in the diagram show, comprehension priming methods allow researchers not only to test two non-alternating constructions A and B, but the within-construction priming effects (from A to A and from B to B) can also be assessed separately from the cross-constructional priming effects (from A to B and from B to A).

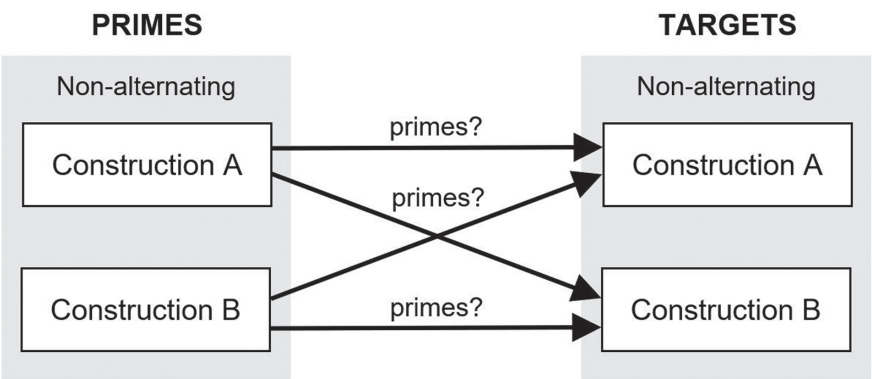

Figure 3: Schematic representation of Strategy 3, testing within-construction and cross-constructional priming between non-alternating constructions in a comprehension setting.

Comprehension methods have been increasingly used in structural priming over the last two decades (Branigan and Pickering 2017). They are, however, most often applied to phenomena that arguably do not lie at the heart of cognitive-linguistic research, such as garden-path sentences (Traxler and Tooley

2008) and structural ambiguities, for example between "high-attached" and "low-attached" prepositional phrases (Branigan et al. 2005). In addition, these studies have investigated within-construction priming effects rather than priming of constructional relations.

Recently, however, two experiments by Ungerer (2021; 2022) have provided examples of how comprehension methods can be used to study cross-constructional priming between English argument structure constructions. Ungerer (2021) examined priming between the caused-motion construction in (11a) and the resultative construction in (11b), while Ungerer (2022: Experiment 1) tested priming between the resultative construction in (12a) and the object-oriented depictive construction in (12b). Both studies used a special version of self-paced reading called the "maze task" (Forster et al. 2009), in which participants read sentences word by word while selecting between a correct sentence continuation and an incorrect distractor at every step. Moreover, both experiments made use of the fact that the two constructions can be used in temporarily ambiguous sentences; as a result, any potential priming effects were expected to emerge at the later sentence regions where the constructions are disambiguated.

(11) a. *Sarah swept the glass into the bin.*
b. *Sarah swept the floor clean.*
(both from Ungerer [2021])

(12) a. *Max cooked the chicken tender.*
b. *Gary cooked the chicken whole.*
(both from Ungerer [2022])

The results of the two experiments contrast in interesting ways. Ungerer's (2021) study yielded *symmetric inhibitory* priming between the two constructions: after caused-motion primes, participants responded more slowly to the postverbal regions of resultative targets, and vice versa. One possible interpretation of this result is that speakers perceive the caused-motion and the resultative construction as rather distinct, thus not supporting previous claims that the constructions are related via an asymmetric metaphor (Goldberg 1995). Ungerer's (2022) experiment, on the other hand, yielded *asymmetric facilitatory* priming: after depictive primes, participants responded faster to the final adjectives of resultative targets, but the same effect did not emerge in the other direction, i.e., from resultative primes to depictive targets. This suggests that speakers encode a strong similarity relation between the two "secondary predication" constructions, despite their semantic differences. Moreover, the asymmetry of the effect may be explained by the fact that less frequent constructions, such as the depictive, tend to give rise to stronger priming (the "inverse frequency effect"; Ferreira [2003]).

While the interpretation of comprehension priming effects can be intricate, the methods provide powerful tools for extending structural priming to a wider range of constructions. One phenomenon that could be investigated as a follow-up to the above-mentioned studies is the relationship between the caused-motion construction in (13a) and the *into*-causative in (13b). The *into*-causative is often regarded as a close relative, or even a subtype of, the caused-motion construction (Rudanko 2011), from which it most likely also emerged historically (Flach 2020). Nevertheless, present-day speakers may represent the *into*-causative and the caused-motion construction as distinct constructions, given their differences in constructional meaning ('X causes Y to do Z' vs. 'X causes Y to go Z'), the syntactic complexity of their complements (nominal vs. sentential) and the fact that the caused-motion construction allows a range of different prepositions (13a), while the *into*-causative is restricted to *into*.

(13) a. *She pushed the chair into / out of / across the room.*
b. *He coaxed his colleague into helping him with the project.*

The strength of the similarity relation between the constructions could be tested with the help of comprehension priming, using either traditional self-paced reading or its extension via the maze task described above. To avoid lexical confounds, it would be feasible to select caused-motion instances that contain a preposition other than *into*. If the two constructions share a common semantic ground, they should show signs of mutual facilitation. Moreover, if the caused-motion construction acts as a metaphorical source for the *into*-causative (Kim and Davies 2016), priming may be asymmetric, with stronger effects from caused-motion primes to *into*-causatives than vice versa.

4 Conclusion

This paper has addressed how structural priming can provide experimental support for cognitive-linguistic models of constructional networks, and ways in which the paradigm could be extended to new phenomena. It was argued that priming effects, by indexing patterns of activation spread, are potentially reflective of the similarity relations that exist between speakers' grammatical representations. At the same time, it was suggested that the insights that previous structural priming studies have provided about constructional relations are limited in two ways: first, most studies have focused on the relatively small set of alternating constructions; and second, these investigations are often

concerned with within-construction priming effects rather than cross-constructional priming. Three strategies were then proposed which may help extend priming to cross-constructional effects between non-alternating constructions. The first strategy involves pairing a non-alternating prime construction with alternating targets in a production setting; the second strategy applies sentence completion tasks to constructional pairs in which one patterns forms a larger extension of the other; while the third strategy makes use of comprehension methods such as self-paced reading to test a wider range of non-alternating constructions. Suggestions were made for how these strategies could be used in future studies to investigate, for instance, the relations between formally identical but semantically distinct homostructions, between different adverbial complementation patterns and between the caused-motion construction and the *into*-causative.

It is important to note that each of the proposed approaches has its specific advantages and limitations, thus lending itself to the investigation of some phenomena more than to others. For example, given that the first strategy combines non-alternating primes with alternating targets, it allows researchers to continue using popular production methods like the picture description task; but in return, the approach remains partially restricted to testing alternating constructions. The second strategy, too, uses a well-established production method, sentence completion, but it requires that one of the target constructions that are available to speakers forms a larger extension of the other (e.g., monotransitives with adverbials extend bare monotransitives). The third strategy affords researchers the additional flexibility provided by comprehension methods, which measure participants' processing of individual constructions rather than their choice between alternatives. At the same time, self-paced reading techniques are most suitable for comparing target constructions that diverge only at specific sentence regions (thus potentially forming temporarily ambiguous sentences). Moreover, comprehension priming effects are yet less well understood and may be less robust than in production (Branigan and Pickering 2017: 16–17).

With these caveats in mind, it will be up to future studies to examine how feasible the present suggestions for extending structural priming are and, quite possibly, to come up with additional and more effective strategies. The main goal of this paper has been to highlight *why* such extensions of previous priming studies are needed in a research programme whose goal it is to study speakers' constructional networks at large. Coming back to Diessel's (2019: 204) comment cited at the beginning, structural priming may thus not have quite yet provided "the best evidence for constructional relations"; rather, the paradigm may be among the strongest contenders for providing such evidence in the future.

References

Bencini, Giulia M. L. & Adele E. Goldberg. 2000. The contribution of argument structure constructions to sentence meaning. *Journal of Memory and Language* 43(4). 640–651.

Bergs, Alexander. 2021. Complements and adjuncts. In Bas Aarts, April McMahon & Lars Hinrichs (eds.), *The handbook of English linguistics*, 2nd edn., 145–162. Hoboken, NJ: Wiley-Blackwell.

Bernolet, Sarah & Robert J. Hartsuiker. 2010. Does verb bias modulate syntactic priming? *Cognition* 114(3). 455–461.

Bernolet, Sarah, Robert J. Hartsuiker & Martin J. Pickering. 2009. Persistence of emphasis in language production: A cross-linguistic approach. *Cognition* 112(2). 300–317.

Bock, Kathryn. 1986. Syntactic persistence in language production. *Cognitive Psychology* 18(3). 355–387.

Bock, Kathryn. 1989. Closed-class immanence in sentence production. *Cognition* 31(2). 163–186.

Bock, Kathryn, Gary S. Dell, Franklin Chang & Kristine H. Onishi. 2007. Persistent structural priming from language comprehension to language production. *Cognition* 104(3). 437–458.

Bock, Kathryn & Helga Loebell. 1990. Framing sentences. *Cognition* 35(1). 1–39.

Branigan, Holly P. & Martin J. Pickering. 2017. An experimental approach to linguistic representation. *Behavioral and Brain Sciences* 40. e282.

Branigan, Holly P., Martin J. Pickering & Janet F. McLean. 2005. Priming prepositional-phrase attachment during comprehension. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 31(3). 468–481.

Bunger, Ann, Anna Papafragou & John C. Trueswell. 2013. Event structure influences language production: Evidence from structural priming in motion event description. *Journal of Memory and Language* 69(3). 299–323.

Chang, Franklin, Kathryn Bock & Adele E. Goldberg. 2003. Can thematic roles leave traces of their places? *Cognition* 90(1). 29–49.

Cho-Reyes, Soojin, Jennifer E. Mack & Cynthia K. Thompson. 2016. Grammatical encoding and learning in agrammatic aphasia: Evidence from structural priming. *Journal of Memory and Language* 91. 202–218.

Cleland, Alexandra A. & Martin J. Pickering. 2006. Do writing and speaking employ the same syntactic representations? *Journal of Memory and Language* 54(2). 185–198.

Collins, Allan M. & Elizabeth F. Loftus. 1975. A spreading-activation theory of semantic processing. *Psychological Review* 82(6). 407–428.

Croft, William. 2001. *Radical Construction Grammar: Syntactic theory in typological perspective*. Oxford: Oxford University Press.

Diessel, Holger. 2019. *The grammar network: How linguistic structure is shaped by language use*. Cambridge: Cambridge University Press.

Diessel, Holger & Michael Tomasello. 2005. A new look at the acquisition of relative clauses. *Language* 81(4). 882–906.

Ellis, Nick C. 2008. The dynamics of second language emergence: Cycles of language use, language change, and language acquisition. *The Modern Language Journal* 92(2). 232–249.

Ferreira, Victor S. 2003. The persistence of optional complementizer production: Why saying "that" is not saying "that" at all. *Journal of Memory and Language* 48(2). 379–398.

Flach, Susanne. 2020. Constructionalization and the Sorites Paradox: The emergence of the *into*-causative. In Lotte Sommerer & Elena Smirnova (eds.), *Nodes and networks in Diachronic Construction Grammar* (Constructional Approaches to Language 27), 45–67. Amsterdam & Philadelphia: John Benjamins.

Forster, Kenneth I., Christine Guerrera & Lisa Elliot. 2009. The maze task: Measuring forced incremental sentence processing time. *Behavior Research Methods* 41(1). 163–171.

Goldberg, Adele E. 1995. *Constructions: A Construction Grammar approach to argument structure*. Chicago: University of Chicago Press.

Goldberg, Adele E. 2006. *Constructions at work: The nature of generalization in language*. Oxford: Oxford University Press.

Goldberg, Adele E. 2019. *Explain me this: Creativity, competition, and the partial productivity of constructions*. Princeton: Princeton University Press.

Gompel, Roger P. G. van, Manabu Arai & Jamie Pearson. 2012. The representation of mono- and intransitive structures. *Journal of Memory and Language* 66(2). 384–406.

Gries, Stefan Th. 2005. Syntactic priming: A corpus-based approach. *Journal of Psycholinguistic Research* 34(4). 365–399.

Gries, Stefan Th. & Stefanie Wulff. 2005. Do foreign language learners also have constructions? Evidence from priming, sorting, and corpora. *Annual Review of Cognitive Linguistics* 3. 182–200.

Hampe, Beate. 2011. Discovering constructions by means of collostruction analysis: The English Denominative Construction. *Cognitive Linguistics* 22(2). 211–245.

Hardy, Sophie M., Katrien Segaert & Linda Wheeldon. 2020. Healthy aging and sentence production: Disrupted lexical access in the context of intact syntactic planning. *Frontiers in Psychology* 11. 257.

Hare, Mary L. & Adele E. Goldberg. 1999. Structural priming: Purely syntactic? In Martin Hahn & Scott C. Stoness (eds.), *Proceedings of the 21st Annual Meeting of the Cognitive Science Society*, 208–211. Mahwah & London: Erlbaum.

Herbst, Thomas, David Heath, Ian F. Roe & Dieter Götz. 2004. *A valency dictionary of English: A corpus-based analysis of the complementation patterns of English verbs, nouns and adjectives*. Berlin & New York: Mouton de Gruyter.

Hilpert, Martin. 2014. *Construction Grammar and its application to English*. Edinburgh: Edinburgh University Press.

Hilpert, Martin & Florent Perek. 2015. Meaning change in a petri dish: Constructions, semantic vector spaces, and motion charts. *Linguistics Vanguard* 1(1). 339–350.

Himmelmann, Nikolaus P. & Eva F. Schultze-Berndt. 2005. Issues in the syntax and semantics of participant-oriented adjuncts: An introduction. In Nikolaus P. Himmelmann & Eva F. Schultze-Berndt (eds.), *Secondary predication and adverbial modification: The typology of depictives*, 1–68. Oxford: Oxford University Press.

Hoffmann, Thomas. 2007. Complements versus adjuncts: A Construction Grammar approach of English prepositional phrases. *Occasional Papers in Language and Linguistics* (University of Nairobi) 3. 92–119.

Huddleston, Rodney. 2002. The clause: Complements. In Geoffrey K. Pullum & Rodney Huddleston (eds.), *The Cambridge Grammar of the English Language*, 213–322. Cambridge: Cambridge University Press.

Hudson, Richard A. 2007. *Language networks: The new Word Grammar*. Oxford: Oxford University Press.

Jackendoff, Ray & Jenny Audring. 2020. *The texture of the lexicon: Relational Morphology and the Parallel Architecture*. Oxford: Oxford University Press.
Jaeger, T. Florian & Neal E. Snider. 2013. Alignment as a consequence of expectation adaptation: Syntactic priming is affected by the prime's prediction error given both prior and recent experience. *Cognition* 127(1). 57–83.
Kim, Jong-Bok & Mark A. Davies. 2016. The into-causative construction in English: A construction-based perspective. *English Language & Linguistics* 20(1). 55–83.
Langacker, Ronald W. 1987. *Foundations of Cognitive Grammar. Vol. 1: Theoretical prerequisites*. Stanford: Stanford University Press.
Levin, Beth. 1993. *English verb classes and alternations: A preliminary investigation*. Chicago: University of Chicago Press.
Mahowald, Kyle, Ariel James, Richard Futrell & Edward Gibson. 2016. A meta-analysis of syntactic priming in language production. *Journal of Memory and Language* 91. 5–27.
Percillier, Michael. 2020. Allostructions, homostructions or a constructional family? Changes in the network of secondary predicate constructions in Middle English. In Lotte Sommerer & Elena Smirnova (eds.), *Nodes and networks in Diachronic Construction Grammar* (Constructional Approaches to Language 27), 213–242. Amsterdam & Philadelphia: John Benjamins.
Perek, Florent. 2012. Alternation-based generalizations are stored in the mental grammar: Evidence from a sorting task experiment. *Cognitive Linguistics* 23(3). 601–635.
Perek, Florent. 2015. *Argument structure in usage-based construction grammar* (Constructional Approaches to Language 17). Amsterdam & Philadelphia: John Benjamins.
Perek, Florent & Adele E. Goldberg. 2015. Generalizing beyond the input: The functions of the constructions matter. *Journal of Memory and Language* 84. 108–127.
Perek, Florent & Adele E. Goldberg. 2017. Linguistic generalization on the basis of function and constraints on the basis of statistical preemption. *Cognition* 168. 276–293.
Pickering, Martin J. & Holly P. Branigan. 1998. The representation of verbs: Evidence from syntactic priming in language production. *Journal of Memory and Language* 39(4). 633–651.
Pickering, Martin J. & Victor S. Ferreira. 2008. Structural priming: A critical review. *Psychological Bulletin* 134(3). 427–459.
Quirk, Randolph, Sidney Greenbaum, Geoffrey Leech & Jan Svartvik. 1985. *A comprehensive grammar of the English language*. London: Longman.
Rudanko, Juhani. 2011. *Changes in complementation in British and American English: Corpus-based studies on non-finite complements in recent English*. Basingstoke: Palgrave Macmillan.
Schmid, Hans-Jörg. 2020. *The dynamics of the linguistic system: Usage, conventionalization, and entrenchment*. Oxford: Oxford University Press.
Smet, Hendrik De & Freek Van de Velde. 2017. Experimenting on the past: A case study on changing analysability in English *ly*-adverbs. *English Language & Linguistics* 21(2). 317–340.
Sommerer, Lotte & Andreas Baumann. 2021. Of absent mothers, strong sisters and peculiar daughters: The constructional network of English NPN constructions. *Cognitive Linguistics* 32(1). 97–131.
Stefanowitsch, Anatol. 2013. Collostructional analysis. In Thomas Hoffmann & Graeme Trousdale (eds.), *The Oxford Handbook of Construction Grammar*, 290–306. Oxford: Oxford University Press.

Tomasello, Michael & Patricia J. Brooks. 1998. Young children's earliest transitive and intransitive constructions. *Cognitive Linguistics* 9(4). 379–396.
Traxler, Matthew J. & Kristen M. Tooley. 2008. Priming in sentence comprehension: Strategic or syntactic? *Language and Cognitive Processes* 23(5). 609–645.
Trijp, Remi van. 2020. Making good on a promise: Multidimensional constructions. *Belgian Journal of Linguistics* 34. 357–370.
Ungerer, Tobias. 2021. Using structural priming to test links between constructions: English caused-motion and resultative sentences inhibit each other. *Cognitive Linguistics* 32(3). 389–420.
Ungerer, Tobias. 2022. *Structural priming in the grammatical network: A study of English argument structure construction*. Edinburgh: University of Edinburgh dissertation.
Vasilyeva, Marina & Perla B. Gámez. 2015. Exploring interactions between semantic and syntactic processes: The role of animacy in syntactic priming. *Journal of Experimental Child Psychology* 138. 15–30.
Ziegler, Jayden, Giulia Bencini, Adele E. Goldberg & Jesse Snedeker. 2019. How abstract is syntax? Evidence from structural priming. *Cognition* 193. 104045.
Ziegler, Jayden & Jesse Snedeker. 2018. How broad are thematic roles? Evidence from structural priming. *Cognition* 179. 221–240.
Ziegler, Jayden, Jesse Snedeker & Eva Wittenberg. 2018. Event structures drive semantic structural priming, not thematic roles: Evidence from idioms and light verbs. *Cognitive Science* 42(8). 2918–2949.