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It is there whether you hear it or not: Syntactic representation of missing arguments

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## Abstract

Many languages allow arguments to be omitted when they are recoverable from the context, but how do people comprehend sentences with a missing argument? We contrast a syntactically-represented account whereby people postulate a syntactic representation for the missing argument, with a syntactically-non-represented account whereby people do not postulate any syntactic representation for it. We report two structural priming experiments in Mandarin Chinese that showed that comprehension of a dative sentence with a missing direct-object argument primed the production of a full-form dative sentence (relative to an intransitive) and that it behaved similarly to a corresponding full-form dative sentence. The results suggest that people construct the same constituent structure for missing-argument sentences and full-form sentences, in accord with the syntactically-represented account. We discuss the implications for syntactic representations in language processing.

Keywords: Language processing, mental representation, ellipsis, argument structure, structural priming, Chinese

## 1. Introduction

In English, most sentences appear to be “complete”. For example, the verb *gave* takes three arguments, and most sentences contain phrases corresponding to each of those arguments. The sentence *The boy gave his essay to the teacher* is acceptable, whereas *The boy gave his essay* and *The boy gave to the teacher* are not acceptable, even though the recipient or the theme may be quite apparent from the context. But sometimes it is possible to omit phrases corresponding to arguments, as in *The charity needed support, so the man gave some money*. In fact, many other languages regularly allow omission of arguments. Thus, so-called *pro-drop* languages such as Italian regularly omit subject pronouns when their reference is clear from the context. In Mandarin Chinese, it is possible to omit not only phrases corresponding to subjects, but also phrases corresponding to objects (e.g., *Niuzai mai-le yiben shu, houlai song-gei-le shuishou*; lit., cowboy buy-ASP a book, later give-to-ASP sailor, meaning the cowboy bought a book and later gave the sailor the book).

What representations do people construct for such sentences? In particular, do they construct syntactic representations in which the missing elements are included or excluded? The question has long interested linguists and psycholinguists. Linguistic theories differ in the extent to which they assume that syntactic representations include elements that are missing from the uttered sentence. Most transformationally inspired accounts (following Chomsky, 1981; e.g., Haegeman, 1991) assume a range of missing elements, for example in *wh*-questions or passives (in which they are assumed to have “moved” elsewhere and to have left a trace) or as the subject of infinitives in English or finite verbs in other languages (in which case they are regarded as types of ‘empty’ pronouns). But other accounts assume that syntactic representations include many fewer missing elements or none at all (e.g., Pollard &

Sag, 1994; Steedman, 2000). Moreover, Sag and Fodor (1994) pointed out that most linguistic arguments for the syntactic realization of missing elements (e.g., ungrammaticality of contraction over such elements) have counter-evidence (e.g., *Who does Kim think'll be late?*).

Some psycholinguistic accounts have attempted to determine whether people construct representations of missing elements during comprehension. However, most of these studies employed reaction time related measures, which are often open to alternative explanations. For example, Bever and McElree (1988) found that people responded more quickly to a probe question at the end of sentences involving missing elements than to other sentences (see also MacDonald, 1989). But such results may be due to semantic or pragmatic facilitation of probe recognition by the sentence context rather than the re-activation of the missing element itself (e.g., McKoon & Ratcliff, 1994). Similarly, sentences that involve relationships between a *wh*-element and the verb can be explained both by accounts that involve missing elements (Gibson & Hickok, 1993) and by accounts that do not (Pickering & Barry, 1991; Traxler & Pickering, 1996). It does not seem that more recent research has managed to discriminate these accounts. To determine whether people build syntactic representations for missing elements in a sentence, we need a measure that more straightforwardly taps into syntactic representation.

Furthermore, in these cases, the claim that an element is missing depends on specific (and contentious) linguistic assumptions (e.g., movement). But in other cases, such as *The charity needed support, so the man gave some money*, it is quite apparent that an element is in some sense missing from the sentence, irrespective of any specific linguistic assumptions: The verb *gave* normally requires a prepositional phrase specifying a beneficiary. In this example, the beneficiary is present in the

semantics (the money is given to the charity), and so the outstanding question is whether an element corresponding to the beneficiary is present in the syntax or not. Structures involving missing arguments may therefore provide the clearest site for studying whether at least some missing elements are syntactically represented. Thus, in the current paper, we investigate the syntactic representation of missing arguments using structural priming, a paradigm that has been shown to tap into syntactic representations. More specifically, we ask whether the comprehension of a sentence with a missing element can prime the construction of an otherwise syntactically similar sentence without such an element.

## 2. Representing missing arguments during processing

To investigate whether people syntactically represent missing arguments, we focus on comprehension. A comprehender understands a sentence by mapping from a series of words or phrases, each with its own meaning, to a semantic representation of the entire sentence in accordance to the syntactic functions of the words or phrases. If the sentence contains a phrase corresponding to each of the arguments and predicates that make up the intended meaning, this mapping is straightforward: The comprehender has to identify each word, construct a syntactic representation relating these words together, and use this syntactic representation (together with available contextual and semantic information) in determining the appropriate compositional semantic representation. Some traditional models assumed that there is a stage of syntactic processing that strictly precedes semantic processing (e.g., Forster, 1979), but in fact utterances are interpreted semantically as soon as they are heard (e.g., Marslen-Wilson, 1973; Tanenhaus et al, 1995), and indeed semantic processing is partly predictive (e.g., Altmann & Kamide, 1999). This means that there cannot be a

temporarily extended period in which syntax is computed before semantics. However, such evidence for incremental and predictive semantic processing is consistent with comprehenders routinely computing a syntactic representation independently of the semantic representation, with the syntactic representation being used as a conventionalized and effective cue to identifying the thematic relations that hold between participants in an event. For instance, the syntactic analysis will enable the comprehender to interpret *the man* as the subject of an active structure and therefore the agent of the giving event in *The man gave some money to the charity*, but as the subject of a passive structure and therefore the recipient of the giving event in *The man was given some money by the charity*. In such non-elliptical sentences, the mapping from sentence constituents to syntactic and semantic representations tends to be straightforward.

However, the process is not so straightforward for sentences in which an argument is omitted, because there is no one-to-one mapping between the elements realised in the sentence and their interpretation. Thus to comprehend *the man gave some money* in *The charity needed support, so the man gave some money*, the comprehender must build a semantic representation incorporating a man playing an agentive role, money playing a theme role, and the charity playing a recipient role, in an event of giving – despite the fact that the sentence does not contain any overt element corresponding to the recipient role.

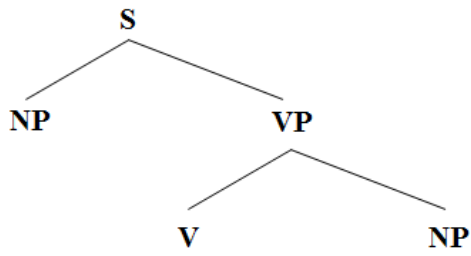
One possible account is that comprehenders build syntactic structures that correspond directly to the overt elements in the sentence; the missing argument is therefore not syntactically represented (and is only represented in the semantics; see Figure 1a). We term this the *syntactically-non-represented* account of missing argument sentences. Under this account, missing-argument sentences would have the

same semantic representations as their full-form equivalents, but different syntactic representations. In our example, the missing-argument sentence *the man gave some money* and its full-form equivalent *the man gave some money to the charity* would have the same semantic representation but different syntactic representations. The representation for the missing-argument sentence would contain phrases corresponding to *the man* and *some money* (serving respectively as the subject and object in the syntactic analysis, and the agent and theme in the semantic representation), yielding a structure such as NP-V-NP; whereas the full-form counterpart would contain phrases corresponding to *the man*, *some money* and *the charity*, yielding a (different) structure such as NP-V-NP-PP.

But under the alternative *syntactically-represented* account, comprehenders represent the missing argument syntactically (as well as semantically; see Figure 1b). Thus, a missing-argument sentence and its full-form counterpart have not only the same semantic representation but also the same syntactic representation (e.g., NP-V-NP-PP for both *The man gave some money* and *The man gave some money to the charity*). In this paper, our primary concern is in whether comprehenders syntactically represent missing arguments, rather than in the mechanisms that might lead to such syntactic representations, and we therefore focus on the syntactically-represented vs. non-represented accounts of the missing-argument sentences. We will return in the general discussion to the issue of the mechanisms that might underlie the processing of missing argument sentences.



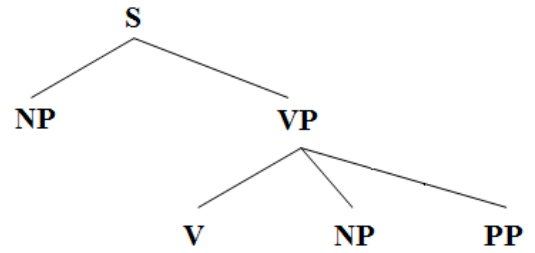
GIVE (MAN<sub>AGENT</sub>, SOME MONEY<sub>THEME</sub>, CHARITY<sub>RECIPIENT</sub>)



... *The man gave some money.*

1a

GIVE (MAN<sub>AGENT</sub>, SOME MONEY<sub>THEME</sub>, CHARITY<sub>RECIPIENT</sub>)



... *The man gave some money.*

1b

Figure 1: The syntactically-non-represented account (Figure 1a) and the syntactically-represented account (Figure 1b) of comprehending a missing-argument sentence such as *The man gave some money*. The italicized sentences represent the phonological/orthographic form of the to-be-comprehended sentence. In the syntactically-non-represented account, the semantic reference and thematic role of the missing argument are specified in the semantic representation, but the missing argument is not specified in the syntactic representation; in the syntactically-represented account, the semantic reference and thematic role of the missing argument are specified in the semantic representation, but in addition the missing argument is specified in the syntactic representation.

Counterparts of the syntactically-non-represented and syntactically-represented accounts can be found in the theoretical syntax literature for almost all types of elliptical phenomena, including missing arguments. Perhaps the most notable debate concerns whether there is syntactic structure underlying verb-phrase (VP) ellipsis (e.g., *Leslie kicked the ball, but Fran wouldn't*). While some syntacticians hold that VP ellipsis is phonologically null syntactic structure and involves the same syntactic representation as the overt counterpart (e.g., *Leslie kicked the ball, but Fran wouldn't kick the ball*) (e.g., Fiengo & May, 1994; Merchant, 2001), others argue that VP ellipsis serves as a proform that points to a discourse event and does not have any internal syntactic structure (e.g., Dalrymple, Sheiber, & Pereira, 1991; Hardt, 1993). A similar debate surrounds the representation of missing arguments. Cummins and Roberge (2005) argued that transitive and ditransitive verbs project syntactic representations for their object regardless of whether the objects are overtly expressed in the sentence. For example, the missing direct object of the ditransitive verb *give* is syntactically represented in a sentence such as *Paul gave to Amnesty International* (see also Cummins & Roberge, 2004; Roberge, 1991; Rizzi, 1986). Other accounts, however, do not assume any syntactic representation for missing arguments; instead, absence of an argument (e.g., the object) is treated as a property of the lexical semantics of the verb (e.g., Goldberg, 2001; Velasco & Muñoz, 2002).

Psycholinguistics has also seen similar debate between the syntactically-non-represented and syntactically-represented accounts in the comprehension of elliptical sentences. Much research, for instance, has investigated how people comprehend sentences with missing VPs. Some such research suggests that comprehenders may build syntactic representations that contain a representation of the elided VP, such as after *wouldn't* in *Leslie kicked the ball, but Fran wouldn't*

(Garnham, 1987; Mauner, Tanenhaus, & Carlson, 1995b; Murphy, 1985; Tanenhaus & Carlson, 1990). However, other studies have found that variations in the amount of ‘missing’ material that must be syntactically represented does not affect processing difficulty (Frazier & Clifton, 2001; Martin & McElree, 2008); these findings seem to be more consistent with the syntactically-non-represented account.

Some other research has investigated cases that are more relevant to the focus of the current paper, involving the interpretation of sentences containing missing arguments. But the emphasis in these experiments has been on whether comprehenders infer missing arguments, not on the way in which missing arguments might be represented (i.e., whether they are syntactically instantiated). For example, Mauner, Tanenhaus, and Carlson (1995a) suggested that comprehenders infer agentive arguments when they comprehend short passives (e.g., *The ship was sunk to collect a settlement from the insurance company*) on the basis of evidence from a self-paced reading paradigm in which participants found a rationale clause more sensible following a short passive than following an intransitive, in which no agent is implied (e.g., *The ship sank to collect a settlement from the insurance company*). Moreover, rationale clauses were judged equally sensible following a short passive as following a full passive (e.g., *The ship was sunk by its owners to collect a settlement from the insurance company*). As the successful interpretation of the rationale clause depends on the agentive argument from the preceding clause, these findings suggest that comprehenders infer the agentive argument when they comprehend short passives. Such inferences appear to be based on the lexical semantics associated with the verb rather than conceptual knowledge about the world (Mauner & Koenig, 2000).

These findings are compatible with both the syntactically-non-represented and syntactically-represented accounts. For instance, comprehenders may not postulate a

syntactic representation for a missing argument, instead representing it only in the semantic representation (on the basis of the verb's lexical semantic information). Alternatively, they may syntactically represent arguments that are lexically encoded (e.g., the agent argument) but not overtly expressed in the sentence (e.g., the *by*-phrase in short passives). In sum, current findings do not discriminate between the syntactically-non-represented and syntactically-represented accounts. To contrast these accounts, we turn to structural priming, a paradigm that has been extensively used to explore syntactic representations.

### 3. Structural priming and the construction of syntactic representations during comprehension

Structural priming is the phenomenon whereby exposure to a certain syntactic structure facilitates the use of the same syntactic structure (see Pickering & Ferreira, 2008, for a review). For example, people are more likely to produce a prepositional-object (PO) dative sentence such as *The girl is handing a paintbrush to the boy* after hearing and repeating another otherwise unrelated PO dative sentence such as *The rock star sold some cocaine to the undercover agent* than after a semantically equivalent double-object (DO) dative sentence such as *The rock star sold the undercover agent some cocaine* (Bock, 1986). Importantly, structural priming is dissociable from semantic, lexical, or prosodic repetition between the prime sentence and the target response (Bock, 1989; Bock & Loebell, 1990; Pickering & Branigan, 1998). It has been observed in many constructions (Bock, 1986; Branigan, Pickering, & McLean, 2005; Chang, Bock, & Goldberg, 2003; Cleland & Pickering, 2003; Ferreira, 2003; Griffin & Weinstein-Tull, 2003; Hartsuiker & Westenberg, 2000; Scheepers, 2003) and languages (e.g., Cai, Pickering, Yan, & Branigan, 2011;

Hartsuiker & Kolk, 1998; Scheepers, 2003), as well as between languages (Hartsuiker, Pickering, & Veltkamp, 2004), and occurs in both spoken and written language (e.g., Bock, 1986; Pickering & Branigan, 1998), and indeed between speaking and writing (Cleland & Pickering, 2006).

Structural priming also occurs during language comprehension. Several studies have shown that participants tend to interpret consecutive sentences in the same way (Arai, van Gompel, & Scheepers, 2007; Branigan et al., 2005) or are faster to comprehend sentences that have the same structure as a previously comprehended sentence (Traxler, 2008). Other studies have found priming between comprehension and production, with participants being more likely to produce a structure after comprehending a sentence with that structure than a sentence with a different structure (Bock, Dell, Chang, & Onishi, 2007; Branigan, Pickering, & Cleland, 2000), and to interpret a sentence in a particular way after producing a sentence with the corresponding structure (Branigan et al., 2005). More importantly, producing a prime sentence and comprehending a prime sentence bias structural choices in subsequent language production to comparable extents and a prime sentence facilitates subsequent re-use of the same structure to a similar extent in production and comprehension, suggesting that structural priming taps into modality-independent syntactic representations (Bock et al., 2007; Tooley & Bock, 2014). Structural priming effects therefore appear to be informative for linguistic theories as well as psycholinguistic theories (Branigan, Pickering, Liversedge, Stewart, & Urbach, 1995).

In fact, many studies have capitalized on the amodal nature of structural priming to investigate syntactic representation and processing by examining how comprehension affects subsequent language production. Ivanova, Pickering, McLean, Branigan, and Costa (2012) used a comprehension-to-production paradigm to show

that participants construct the same fully specified syntactic representation for dative sentences containing novel verbs or intransitive verbs as for sentences containing (known) ditransitive verbs (even when this representation was not supported by the verb's argument structure). In their study, participants were equally likely to produce a dative sentence (PO or DO) irrespective of whether the prime sentence that they had just comprehended was a grammatical sentence containing a known verb (e.g., *The waitress gives the book to the monk*) or contained a novel verb (e.g., *The waitress brunks the book to the monk*) or intransitive verb (yielding an ungrammatical sentence; e.g., *The waitress exits the book to the monk*).

Most importantly, Cai et al. (2013) investigated whether people construct a syntactic representation of the elided VP when they comprehend VP ellipsis. If so, this syntactic representation should give rise to structural priming, in the same way as the full-form sentence does. Cai et al. therefore examined the extent to which Mandarin speakers would produce DO or PO descriptions for pictures depicting dative events after reading a prime in which a PO or DO clause was followed by a clause containing a VP ellipsis (e.g., *Fuwuyuan xiang jie-gei shuishou naba qiang / jie naba qiang gei shuishou; yinwei haipa reshi, chushi que bu xiang* [The waitress would like to lend the sailor the gun / lend the gun to the sailor; being afraid of getting into trouble, the chef would not like to]), and compared it with a prime in which the same first clause was followed by a full-form DO or PO (hence two DOs/POs in the prime) and a prime in which the first clause was followed by an intransitive baseline (hence one DO/PO in the prime). They found people re-used the DO/PO structure from the prime sentence to a greater extent following full-form primes than following VP ellipsis primes or intransitive baseline primes (the latter of which did not differ), suggesting that the VP ellipsis prime contained only one DO/PO prime (i.e., the first clause) and

there was no priming from the VP ellipsis in the second clause. Cai et al. therefore concluded that comprehenders do not instantiate a syntactic representation for the missing element when they read VP ellipsis sentences.

However, in such sentences the missing element is an entire VP (corresponding to a predicate plus its arguments). It remains unclear how people process sentences involving omission of a single argument, and specifically whether they syntactically instantiate an elided argument (as the syntactically-represented account predicts) or not (as the syntactically-non-represented account predicts). Using a similar rationale to Cai et al. (2013), we predict that if comprehenders syntactically reconstruct, then they should assign the same constituent structure to a missing-argument sentence as to its full-form counterpart. Thus, a missing-argument sentence should give rise to the same pattern of structural priming as its full-form counterpart (and should yield more full-form responses of the same type than an intransitive baseline prime). If comprehenders do not syntactically instantiate the missing argument, then they should assign different constituent structures to a missing-argument sentence and to its full-form counterpart. Missing-argument prime sentences should therefore yield fewer full-form responses than full-form prime sentences do.

We tested these predictions using missing-argument sentences in Mandarin Chinese. Mandarin is classified as a pro-drop language; that is, a subject or an object of the verb can sometimes be omitted if it is recoverable from the preceding context (e.g., Xu, 2003). Mandarin has a dative alternation, similar to the alternation in English (see Cai et al., 2011); for convenience, we will refer to these as the Mandarin DO and PO constructions (given the surface resemblance to the English PO/DO structures). In both the DO construction (1a) and the PO construction (1b), the verb takes three arguments, the subject (the agent *niuzai*, “cowboy”), the direct object (the

theme *naben shu*, “the book”), and a third argument (the recipient *shuishou*, “sailor”), which is the indirect object in (1a) or the oblique object in (1b). The theme argument, however, can be omitted if it is recoverable from the context, resulting in a missing-argument-DO (1c) or a missing-argument-PO (1d).

It is uncontroversial that Mandarin DO and PO sentences differ in syntactic structure, though the precise details of the relevant structures are under debate (e.g., Her, 2006; Huang & Ahrens, 1999; Li & Thompson, 1981). Most accounts analyse *gei* in Mandarin DO sentences as a grammaticalized element of a compound verb (e.g., *song-gei*), and *gei* in Mandarin PO sentences as a preposition. Evidence for these analyses comes from their behaviour with respect to aspect markers. Mandarin verbs can standardly be combined with an aspect marker; for example, the aspect marker *-le* directly follows the verb to express completion of the action/event denoted by the verb (e.g., *wo qu*, “I go”; *wo qu-le*, “I went”). Crucially, in the Mandarin DO construction, *-le* must follow *V-gei* (e.g., *V-gei-le*); it cannot separate the verb and *gei*, suggesting that *V-gei* forms a constituent. In contrast, in the Mandarin PO construction *-le* directly follows the verb (e.g., *V-le NP gei NP*); it cannot follow *gei*. In this paper we therefore assume the structures in Figure 2. (Note that even under an alternative analysis in which *gei* in DO sentences is treated as a co-verb, (1a) and (1b) still involve two distinct syntactic structures.) Observations that Mandarin DO sentences structurally prime DO sentences, and PO sentences structurally prime PO sentences, further confirm that the two constructions have distinct syntactic structures (Cai et al., 2011, 2013; Cai, Pickering, & Branigan, 2012).

In addition, we used intransitive sentences (e.g., 2) as a baseline condition, as this construction has been typically used as a reference condition in structural priming studies because it bears no relationship to either of the target structures (Bock &



Griffin, 2000; Cai et al., 2012; Pickering, Branigan, & McLean, 2002).

1a. Niuzai mai-le yiben shu hou song-gei-le shuishou naben shu. (**DO**)

cowboy buy-ASP a book later give-ASP sailor the book

(The cowboy bought a book and later gave the sailor the book.)

1b. Niuzai mai-le yiben shu hou song-le naben shu gei shuishou. (**PO**)

cowboy buy-ASP a book later give-ASP the book to sailor.

(The cowboy bought a book and later gave the book to the sailor.)

1c. Niuzai mai-le yiben shu hou song-gei-le shuishou. (**missing-argument-DO**)

cowboy buy-ASP a book later give-ASP sailor

(The cowboy bought a book and later gave the sailor.)

1d. Niuzai mai-le yiben shu hou song-le gei shuishou. (**missing-argument-PO**)

cowboy buy-ASP a book later give-ASP to sailor.

(The cowboy bought a book and later gave to the sailor.)

2. Banqiu xuanshou zai dapengti. (**Intransitive**)

cricket player be sneeze

(The cricket player was sneezing).

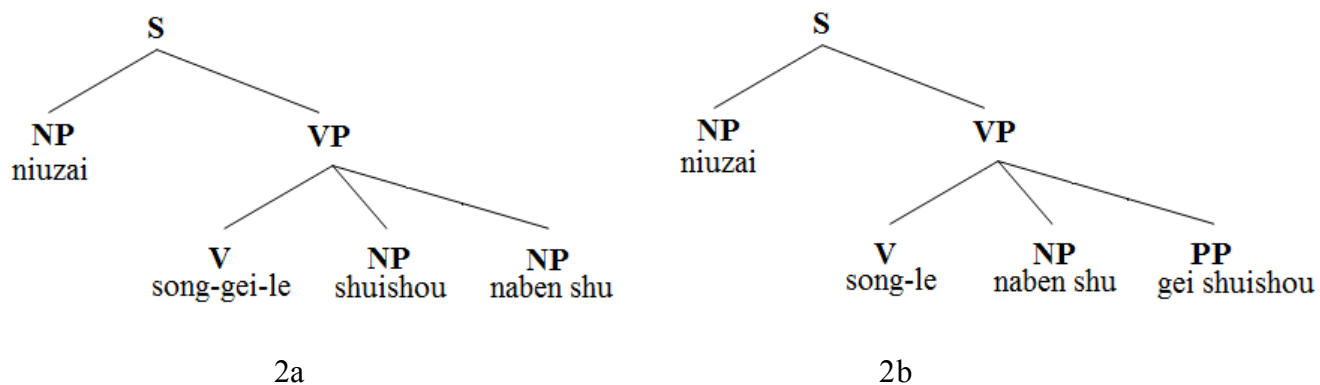


Figure 2: Tree structures of the Mandarin DO sentences (Figure 2a) and PO sentences (Figure 2b) assumed in the current study. In Figure 2a, *Niuzai song-gei-le shuishou naben shu* literally means “cowboy give-ASP sailor the book”; in Figure 2b, *Niuzai song-le naben shu gei shuishou* literally means “cowboy give-ASP the book to sailor”.

In our experiments, participants heard a *prime sentence* (1a-d or 2), then viewed a *match picture*, and decided whether the match picture was described by the prime sentence (*picture-matching task*). They then viewed a *description picture*, for which they had to produce a *target description*. Our dependent measure was the structure of the target description that they produced. The syntactically-represented and non-represented accounts differ in their predictions regarding structural priming from missing-argument-DO and missing-argument-PO. According to the syntactically-represented account, missing-argument-DO and DO sentences have the same constituent structure and therefore should induce the same pattern of priming effects (and similarly for missing-argument-PO and PO sentences). More specifically, a missing-argument-DO prime and a DO prime should induce DO responses to the same extent and to a greater extent than an intransitive baseline prime such as (2). Similarly, a missing-argument-PO prime and a PO prime should induce PO responses to the same extent, and to a greater extent than an intransitive baseline prime. The

syntactically-non-represented account, however, does not postulate syntactic representations for missing arguments and thus predicts missing-argument-DO and missing-argument-PO to have different constituent structures from DO and PO respectively. Therefore, they should behave like an intransitive baseline (and differently from their full-form counterparts).

Note that our reasoning assumes that structural priming is due to repetition of syntactic structure. In fact, some aspects of thematic roles can also be primed, though typically to a lesser extent than syntactic structure (Bernolet, Hartsuiker, & Pickering, 2009; Cai et al., 2012). We return to this issue in the General Discussion.

#### 4. Experiment 1

In this experiment, we tested whether the missing argument in a missing-argument-DO sentence is syntactically represented by observing whether missing-argument DO prime sentences behave similarly to DO primes or instead similarly to intransitive primes. Thus, Experiment 1 compared the priming of DO and PO responses following DO, PO, missing-argument-DO, and intransitive primes (i.e., 1a-c and 2). We predicted a standard priming effect for DO and PO primes, with more DO (and fewer PO) responses following DO primes than following intransitive primes, and fewer DO (and more PO) responses following PO primes than following intransitive primes. If the syntactically-represented account is correct, we predict missing-argument-DO primes to behave similarly to DO primes; if the syntactically-non-represented account is correct, we predict missing-argument-DO primes to behave differently to DO primes (and similarly to intransitive primes).

## 4.1. Method

### 4.1.1. *Participants*

Forty-eight native speakers of Mandarin Chinese from the South China Normal University community were paid 15 RMB (roughly \$2.5) to take part.

### 4.1.2. *Materials*

We constructed 32 sets of experimental prime sentences such as those in (1a-c) and (2) and 96 filler prime sentences. The experimental dative prime sentences (DO, PO, and missing-argument-DO) were constructed using 14 dative verbs (see Appendix). They always contained two clauses. For the missing-argument-DO sentences, the second clause had a missing theme which could be recovered from the context of the first clause. The intransitive baseline sentences consisted of a single clause expressing an intransitive event. Seventy-two of the filler prime sentences consisted of one or two clauses involving an intransitive or transitive verb (24 one-clause and 48 two-clause sentences, e.g., *Wupo zai liuhan*, “the witch was sweating”; *Chushi hen xingfun, juqi-le yiba qiang*, “the chef was excited and held up a gun”). The remaining 24 filler prime sentences were single-clause DO sentences (e.g., *Chushi huang-gei youyong xuanshou yige shuihu*, “the chef returned the swimmer a jug”). These DO fillers were included in order to boost the production of DO responses (see also Cai et al., 2012, 2013).<sup>1</sup> All prime sentences were read by a female native speaker of Mandarin and recorded as wav files. Each prime sentence was associated with a match picture and a description picture (see Figure 3).

Half of the match pictures depicted an event that was described in one of the clauses of the prime sentence; the other half differed from what was depicted in one of

the clauses of the prime sentence in one event participant (the agent, theme, or recipient in dative events, the agent, or patient in transitive events, and always the agent in the intransitive event). For the DO, PO, and missing-argument-DO experimental prime sentences (which had a contextual clause and a dative clause, see (1)), the match picture always depicted the event in the dative clause (in the matching trials) or disagreed with it in one event participant (in the mismatching trials); for the intransitive baseline sentences, the match picture depicted an (matching or mismatching) intransitive event.

The description picture depicted a new event that had no overlapping people or objects with those in either the prime sentence or the match picture. The description picture associated with an experimental sentence depicted a dative event which could be described using a dative construction and always involved the same act (e.g., giving) as in the dative versions of the experimental prime sentences (i.e., except for the intransitive condition). We included a sentence preamble (a subject NP plus a verb stem) beneath the picture so that the description could be grammatically continued as only a DO or PO sentence; this was to discourage the use of other possible constructions, specifically the *ba*-construction and the topic-construction (see Cai et al., 2012). Of the 96 filler description pictures, 64 depicted a transitive event (e.g., a cowboy punching a priest) and 32 depicted an intransitive event (e.g., a cowboy walking). Forty of the 96 filler description pictures had the same act (e.g., walking) as that in their corresponding transitive and intransitive filler prime sentences (but not in the DO filler prime sentences). Thus, across the 128 experimental and filler sets of materials, half (40 filler sets and 24 experimental sets) had the same act across the dative versions of the prime sentences and the description pictures. The materials were divided into four lists such that each list included one prime sentence from an

experimental prime set. Each list consisted of two blocks whose order was counterbalanced across participants.

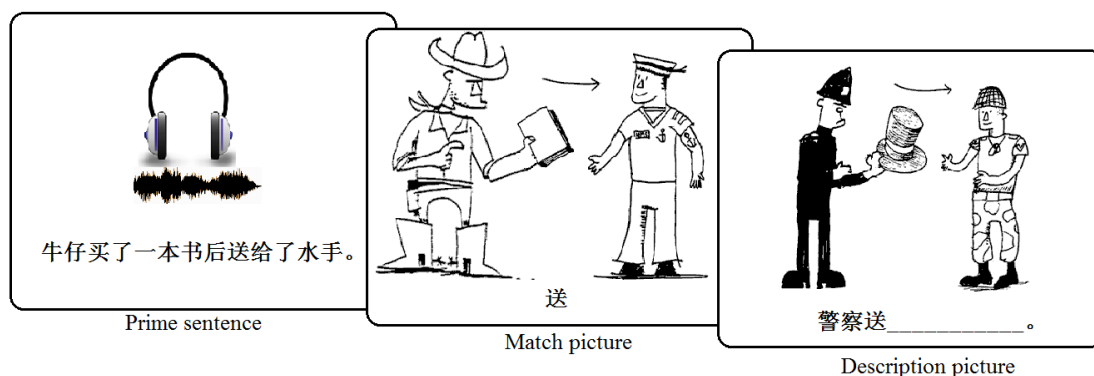


Figure 3: An example trial in Experiment 1. The spoken prime sentence means “The cowboy bought a book and later gave the sailor the book”; the Chinese character provided in the match picture means “give” and corresponds to the action in the picture. The description picture has a preamble literally meaning “the policeman give \_\_\_\_\_.”

#### 4.1.3. Procedure

Participants were tested individually in a cubicle. After giving their written consent, they were familiarized with the figures (e.g., a cowboy, a book) that were to appear in the experiment. In each trial of the experiment, participants first heard a prime sentence and immediately afterwards saw a match picture. They then judged whether the match picture depicted an event described in the prime sentence by pressing the *F* key (for a positive response) or the *J* key (for a negative response). A description picture then appeared and participants described it in a single sentence using the sentence preamble provided. Their description was digitally recorded. The order of the trials was individually pseudo-randomized, with the constraint that every two experimental trials were separated by 2-4 filler trials. A practice session of 3 trials

preceded the main experiment. The experiment was run on DMDX (Forster & Forster, 2003) and lasted about 40 min.

#### 4.1.4. *Scoring*

Descriptions were coded as DO, PO, or Other responses (as in Cai et al., 2011, 2012). A description was coded as a DO response if the sentence preamble was grammatically continued in such a way that the verb was followed first by an NP denoting the recipient and another NP denoting the theme, and as a PO response if the verb was first grammatically followed by an NP denoting the theme and then a propositional phrase (headed by the preposition *gei*) denoting the recipient; otherwise, it was coded as an Other response.

## 4.2. Results and discussion

Participants were highly accurate in the matching task, with an accuracy of 93.5% in the trials, and 92.1% for the DO prime, 96.1% for the PO prime, 94.8% for the missing-argument-DO prime and 88.3% for the intransitive prime. Out of the 1536 descriptions, 26% (400) were DO responses, 67% (1027) were PO responses, and 7% (109) were Other responses. Table 1 gives the distribution of these responses and the proportion of DO responses out of DO and PO responses as a function of prime type. We used logit mixed effects (LME) regressions to model the shift from one level of the dependent variable (e.g., PO responses) to the other (e.g., DO responses) as a function of prime type in terms of the logit of the odds between the dependent two levels (Baayen, Davidson, & Bates, 2008; Jaeger, 2008). Note that the dependent variable was all the trial-level target responses (DO or PO), though for exposition's sake we report only the proportion of DO responses (which is complementary to the

proportion of PO responses; i.e., the latter can be obtained by subtracting the DO proportion from 100%). We used the maximal random effect structure justified by the data and included any random slope effect that significantly improved the model fit. Model fit was not significantly improved by the inclusion of the participant slope ( $\chi^2(9) = 9.94$ ,  $p = .36$ ) or the item slope ( $\chi^2(9) = 7.70$ ,  $p = .56$ ), so the final LME model included prime type as the fixed effect and random participant and item intercepts. Prime type significantly improved the model fit ( $\chi^2(3) = 64.74$ ,  $p < .001$ ), suggesting that there is a main effect of prime type. Pairwise comparisons (Table 2) revealed most DO responses following the DO and missing-argument-DO primes (which did not differ), next following the intransitive prime, and fewest following the PO prime. Analyses of the Other responses revealed that their distribution was not affected by prime type ( $\chi^2(3) = 5.15$ ,  $p = .16$ ).

Table 1: Response counts and proportion of DOs out of DOs and POs by prime type in Experiment 1.

Prime type	DO	PO	Other	prop DO
DO	127	236	21	0.35
missing-argument-DO	117	239	28	0.33
Intransitive	94	255	35	0.27
PO	62	297	25	0.17



Table 2: Pairwise comparisons among primes in Experiment 1.

	$\beta$	SE	z	p
DO vs. missing-argument-DO	.31	.23	1.34	= .18
DO vs. Intransitive	.87	.24	3.61	< .001
DO vs. PO	1.92	.26	7.35	< .001
missing-argument-DO vs. Intransitive	.56	.24	2.32	= .02
missing-argument-DO vs. PO	1.61	.26	6.22	< .001
Intransitive vs. PO	1.05	.26	4.08	< .001

The results replicate previously observed priming effects for the canonical dative constructions (e.g., English: Bock, 1986; Mandarin: Cai et al., 2012), with DO primes inducing more DO responses (and fewer PO responses) than the intransitive primes and PO primes inducing fewer DO responses (and more PO responses) than intransitive primes. Critically, missing-argument-DO primes induced more DO responses (and fewer PO responses) than intransitive and PO primes, and did not differ from DO primes. The fact that missing-argument-DO primes induced more DO responses than intransitive and PO primes suggests that missing-argument-DO primes share (some) syntactic representation with DO primes. However, the lack of a difference between missing-argument-DO primes and DO primes does not itself demonstrate that they have the same syntactic representation.

To test whether they have the same syntactic representation (and hence yield the same priming behaviours), we turned to the Bayes factor, which enabled us to quantify the likelihood of different models/hypotheses given the observations (Jeffreys, 1998; Kass & Raftery, 1995; Wagenmakers, 2007). We built a null-difference model in which the two primes were assumed to have the same

priming effects, and a difference model in which the two primes were assumed to have different priming effects (assuming a uniform prior). In other words, we pit the likelihood of the null hypothesis that the missing-argument DO and the full-form DO do not differ in priming against that of the alternative hypothesis that they do differ. Following Wagenmakers (2007) and Masson (2011), we used the Bayesian Information Criterion (BIC) in the models (633.9 for the null-difference model and 638.7 for the difference model) to compute the Bayes factor as  $e^{(638.7 - 633.9)/2} = 11.02$ , which can be seen as positive to strong evidence for the null-difference model (Wagenmakers, 2007). In other words, given our observations, the hypothesis that the two primes had the same priming effect is about 11 times more likely than the hypothesis that they had different priming effects. The Bayesian inference result, together with the statistical pattern we observed from our LME analyses, is consistent with the hypothesis that missing-argument-DO sentences have the same constituent structure as DO sentences and hence that the missing theme argument in sentences such as (1c) is syntactically represented.

But is it possible that the similar priming pattern between the missing-argument prime and the full-form prime was caused by something other than identical constituent structure? For instance, when participants read a missing-argument prime sentence and then subsequently saw the associated match picture, they may have spontaneously generated a full-form version of the prime sentence on the basis of the picture in front of them, which then gave rise to priming of full-form sentences. Also, full-form DOs may be less natural than missing-argument-DOs in Mandarin because of the repeated name penalty (Gordon, Grosz & Gilliom, 1993) associated with repetition of the theme, which might then lead to reduced priming effect for full-form DOs.

To investigate these possibilities, we analyzed the RTs and accuracy in the picture-matching task. In the experiment, participants immediately saw the match picture after the offset of the prime sentence. If participants, on seeing the match picture, had spontaneously generated a full-form DO sentence (in response to the match picture) after comprehending a missing-argument-DO sentence, we should expect longer RTs in the matching task for missing-argument-DOs than for DOs and POs, on the assumption that such structure generation would not be cost-free. If full-form DO and PO sentences suffer from unnaturalness, we should then expect participants to have performed less accurately in matching DO and PO prime sentences to the match pictures than matching missing-argument DO prime sentences to the match pictures. Thus, we compared the RTs and accuracy among the DO, PO, and missing-argument-DO primes (the intransitive prime was excluded because it involved a different match picture from the other three and was not relevant to this issue). LME modelling on the RTs (with no random slopes included as they did not improve model fit via model comparison) suggested no difference in RTs among the three prime types (DO = 2803 ms, PO = 2876 ms, missing-argument-DO = 2848 ms;  $\chi^2(2) = .89$ ,  $p = .648$ ). LME modelling (with random participant slope for prime type) also showed no difference in accuracy among the three primes (DO = 92.1%, PO = 96.1%, missing-argument-DO = 94.8%;  $\chi^2(2) = 3.58$ ,  $p = .167$ ). These results provide no evidence that participants spontaneously generated full-form DOs when they made match decisions after comprehending missing-argument-DO primes, and further suggest that participants did not find the full-form sentences unnatural. We therefore propose that missing-argument-DO and full-form DO sentences primed similarly because they have the same constituent structure, with the missing argument being syntactically represented in missing-argument-DOs.

## 5. Experiment 2

We now tested whether the missing argument in missing-argument-PO sentences is also syntactically represented so that missing-argument-PO sentences would have the same constituent structure as PO sentences. If so, PO and missing-argument-PO sentences should similarly prime the production of dative sentences. Thus, in Experiment 2, we replaced the missing-argument-DO condition (1c) with the missing-argument-PO condition (1d).

### 5.1. Method

Experiment 2 was identical to Experiment 1 except for the change in conditions. A further 48 participants from the same population as Experiment 1 were paid to take part.

### 5.2. Results and discussion

Participants had an overall accuracy of 94% in the matching task, with 94% for the DO prime, 93% for the PO prime, 93% for the missing-argument-PO prime, and 93% for the intransitive baseline. Out of all the 1536 descriptions, 11% (173) were DO responses, 85% (1298) were PO responses, and 4% (65) were Other responses. Table 3 presents a summary of the distribution of these responses for different primes and the proportion of DOs out of the sum of DOs and POs. LME model comparisons showed that neither participant slope ( $\chi^2(9) = 6.60$ ,  $p = .68$ ) nor item slope ( $\chi^2(9) = 3.27$ ,  $p = .95$ ) significantly improved the model fit, so the final LME model included prime type as the fixed effect and participant and item intercepts as random effects. Prime type had a main effect ( $\chi^2(3) = 55.89$ ,  $p < .001$ ). Pairwise comparisons (see

Table 4) revealed most DO responses following the DO prime, next following the intransitive prime, and fewest DO responses following the missing-argument-PO and PO primes, which did not differ. Again, the Bayes factor computed from BICs ( $e^{(260.1 - 253.5)/2} = 27.11$ ) provided strong evidence for the null difference in priming effects between missing-argument-PO and PO primes. In other words, given our observations, the hypothesis that missing-argument-PO and PO had the same priming effect is about 27 times more likely than the hypothesis that they had different priming effects. Analyses of Other responses again did not reveal a significant main effect of prime type ( $\chi^2(3) = 4.27, p = .23$ ).

Table 3: Response counts and proportion of DOs out of DOs and POs by prime type in Experiment 2.

Prime type	DO	PO	Other	prop DO
DO	70	297	17	0.19
Intransitive	48	317	19	0.13
missing-argument-PO	28	346	10	0.07
PO	27	338	19	0.07

Table 4: Pairwise comparisons among primes in Experiment 2.

	$\beta$	SE	z	p
DO vs. Intransitive	.79	.28	2.81	<.01
DO vs. missing-argument-PO	1.99	.35	5.77	<.001
DO vs. PO	2.08	.35	5.89	<.001
Intransitive vs. missing-argument-PO	1.20	.36	3.39	<.001
Intransitive vs. PO	1.29	.36	3.57	<.001
missing-argument-PO vs. PO	.09	.40	.23	=.82

The results show that missing-argument-PO sentences behaved similarly to PO sentences in priming and induced fewer DO responses than DO sentences and the intransitive baseline. As in Experiment 1, LME modelling (with random participant slope for prime type) showed no difference in RTs in the matching task among the three dative primes (DO = 2566 ms, PO = 2739 ms, missing-argument-PO = 2454 ms;

$\chi^2(2) = 4.23, p = .121$ ); LME modelling on accuracy (with no random slopes) showed that the three primes also did not differ in accuracy (DO = 94.1%, PO = 93.1%, missing-argument-PO = 92.6%;  $\chi^2(2) = .854, p = .652$ ). As in Experiment 1, these results suggests that the priming pattern we observed in Experiment 2 could not be attributed to differences in naturalness of the missing-argument primes and the full-form primes, or to participants spontaneously generating full-form sentences at seeing the match picture after comprehending missing-argument sentences. Instead, we propose that missing-argument-PO sentences primed PO responses in the same way as PO sentences did because they share the same constituent structure.

The claim that DOs and POs with a missing argument have the same constituent structure as, and hence yield similar priming effects to, full-form DOs and POs was further supported by the observation that Experiment 1 produced more DO responses (and fewer PO) responses than Experiment 2 (28% DO responses and 72% PO responses in Experiment 1 vs. 12% DO responses and 88% PO responses in Experiment 2;  $\beta = 1.67, SE = .58, z = 2.91, p = .004$ , with no random slopes included in the LME model). In particular, such a difference in DO and PO responses between the two experiments was also observed for the intransitive baseline primes, with more DO (and fewer PO) responses following the intransitive baseline in Experiment 1 (27% DO responses and 73% PO responses) than in Experiment 2 (13% DO responses and 87% PO responses) ( $\beta = 1.74, SE = .79, z = 2.21, p = .027$ , with no random slopes included in the LME model). This difference most likely reflects a cumulative priming effect (e.g., Kaschak, Loney, & Borreggine, 2006) associated with

replacement of the missing-argument-DO condition by the missing-argument-PO condition in Experiment 2; hence Experiment 1 contained 50% experimental sentences that primed DO responses and 25% that primed PO responses, whereas Experiment 2 contained 25% experimental sentences that primed DO responses and 50% that primed PO responses.

## 6. General discussion

In two experiments, we examined the nature of syntactic representations that people construct when comprehending sentences in which some elements are not overtly realized. We found that comprehending sentences in which one argument was omitted affected people's subsequent syntactic choices in production in the same way as comprehending sentences in which all arguments were overtly expressed. Experiment 1 found that people were more likely to describe a picture of a dative event using a DO target description (vs. a PO target description) following both a full-form DO prime and a DO prime with a missing argument than following an intransitive prime or a PO prime. Experiment 2 found that people were less likely to produce a DO target description (vs. a PO target description) following both a full-form PO prime and a PO prime with a missing argument than following an intransitive prime or DO prime. Furthermore, the replacement of the missing-argument-DO prime with the missing-argument-PO prime induced a general decrease in DO responses, an effect reflecting the long-term priming effect of the PO-inducing missing-argument-PO prime. The results are consistent with the proposal



that comprehenders construct the same syntactic representations for missing-argument DO and PO sentences as for full-form DO and PO sentences.

Previous research has established that when people encounter missing-argument sentences, they are able to make inferences about the missing information (specifically, thematic roles) based on lexical semantic information associated with the verb, and so are able to interpret the sentences successfully (e.g., Mauener et al., 1995a). But this research left open the question of whether comprehenders instantiate the missing information at the level of syntactic structure, or at the level of semantic structure. Our results are consistent with the syntactically-represented account. Under this account, comprehenders build syntactic representations for sentences based not only on the words that they encounter, but also – in some cases – on information that can be derived from the context. These syntactic representations are thus “complete”, in the sense that they contain components corresponding to all of the arguments of the verb, whether or not they are expressed. In other words, people instantiate a syntactic representation for missing arguments. Our results do not support the alternative syntactically-non-represented account, according to which comprehenders build syntactic structures that represent only overtly realized arguments (i.e., “incomplete” syntactic representations), and use context to instantiate a semantic representation of any missing arguments.

We now turn to alternative explanations of our results. First, we note that the PO and PO-missing-argument sentences share the form *verb-le* and the independent form *gei*; whereas the DO and DO-missing-argument sentences share the form

verb-*gei-le*. Priming obviously could not therefore be due to repetition of words, because *gei* and *le* occur in all conditions. More importantly, Cai et al. (2012) found that sentences with the structure NP<sub>Theme</sub> NP<sub>Agent</sub> verb-*gei-le* NP<sub>Recipient</sub> (which involve topicalization of the theme NP, but are otherwise similar to DO sentences) prime PO sentences (involving verb-*le* NP *gei* NP) rather than DO sentences (involving verb-*gei-le* NP NP), with respect to an intransitive baseline. Therefore there is no indication of priming of the form verb-*gei-le*, or of a “bound” (vs. an “unbound”) *gei* (see also Bock, 1989, and Pickering & Branigan, 1998, for evidence that repetition of closed class elements does not contribute to structural priming).

A different alternative explanation relates to the repetition of mappings between thematic roles and syntactic structure across sentences (Bernolet et al., 2009; Cai et al., 2012; Chang et al., 2003). In particular, Cai et al. (2012) demonstrated that structural priming in Mandarin has more than one locus, relating not only to choice of constituent structure, but also to mapping of thematic roles onto syntactic positions (grammatical functions and word order). Thus speakers are more likely to produce full-form PO sentences after experiencing full-form PO sentences because they persist both in their choice of constituent structure and in their mapping of thematic roles onto syntactic positions (e.g., mapping of the theme to the indirect object, mapping of the theme before the recipient). Although such thematic priming effects tend to be small (Chang et al., 2003), and may in fact be overridden by constituent structure priming when the two effects are in opposition (Pickering et al., 2002), it is therefore possible that missing-argument sentences prime full-form sentences on the basis of

shared mappings between thematic roles and syntactic positions.

However, priming based on shared thematic mappings could only occur if the missing argument had some representation in the syntax to which such mappings could occur. Thus even if the locus of priming were at the level of thematic role mappings, the pattern of effects still implies that missing arguments are syntactically represented in comprehension.

Finally, we can rule out an explanation of our results based on repetition of thematic emphasis (e.g., repeating emphasis on the theme from prime to target; Vernice, Pickering, & Hartsuiker, 2012), because in Mandarin PO and DO sentences do not differ in emphasis with respect to the theme versus recipient roles (Cai et al., 2012). In summary, it appears that comprehenders can syntactically represent missing arguments.

Of course, this conclusion is supported by the equivalence in priming effects between missing-argument sentences and their full-form counterparts. An important caveat is that our finding of equivalence in priming effects is not in itself directly informative about the underlying source of those effects; in theory, speakers' tendency to produce a full-form DO target to the same extent after hearing a missing-argument DO prime as after hearing a full-form DO prime (Experiment 1) need not involve drawing on the same representations. That is, it is possible that the full-form DO primed the production of full-form DO responses because of the repetition of constituent structure, but that the missing-argument DO primed the production of full-form DO responses because of the repetition of other aspects of structure.

This alternative explanation faces the problem of identifying *what* other aspects of structure might lead to equivalent priming. In other words, if full-form DO and missing-argument DO primes do not share constituent structure, then it is unclear what other aspect of structure would prime full-form DO responses following missing-argument DO primes but would not similarly prime full-form DO responses following full-form DO primes (Experiment 1). For example, any thematic locus of priming from missing-argument DO sentences to full-form DO sentences would also exist from full-form DO sentences. Exactly the same argument holds for missing-argument PO sentences and full-form PO sentences (Experiment 2). Thus the best-supported account of our results is that missing-argument sentences have the same syntactic representation as their full-form counterparts.

### 6.1. *Syntactic representation of missing elements*

Our experiments bear on the long-standing linguistic issue of the representation of missing elements. As we have noted, linguistic theories differ in the extent to which they assume that syntactic representations include elements that are not expressed. Some theories assume that there are no such elements (e.g., Steedman, 2000), others assume the syntactic representation of the trace of a *wh*-constituent such as *which man* (e.g., Gazdar et al., 1985), and others assume an extensive range of such elements (e.g., Chomsky, 1981). Our data support the existence of syntactic representations for one kind of obligatory missing argument in Mandarin.

Other evidence suggests that people syntactically represent optional missing

arguments in English. Messenger, Branigan, and McLean (2012) found that adults (and children) were more likely to produce full passive sentences (involving an agent-patient verb, where the *by*-phrase specified the agent) following comprehension of short passive primes than active primes (involving theme-experiencer verbs); this finding suggests that people not only infer the meaning of the missing *by*-phrase when they comprehend short passives (Maurer et al., 1995a), they also syntactically represent it (note that the priming in Messenger et al. cannot be due to repetition of thematic mappings).<sup>2</sup>

However, although our results provide evidence for some missing elements, other evidence from priming suggests that the range of missing elements is quite limited (and not compatible with Chomsky, 1981). Thus, Bock and Loebell (1990) found that intransitive locative sentences (e.g., *The foreigner was loitering by the blinking traffic lights*) primed full passives (i.e., containing *by*-phrases) to the same extent as full passive primes. These findings suggest that people syntactically represent passives and intransitive locatives in the same way. They therefore do not support syntactic representation of a post-verbal “trace” of an argument associated with the theme of the passive; see also Bock, Loebell, and Morey (1992). The body of findings is therefore consistent with linguistic theories that assume syntactic representation of a restricted range of missing arguments, but not with ones that assume an extensive range or no missing arguments at all. It also suggests that the representation of missing arguments is not restricted to typologically similar languages: Mandarin and English differ substantially in the extent to which they

permit missing arguments (e.g., Mandarin regularly allows both subject and objects to be omitted, whereas English does not), yet both languages show syntactic representation of missing arguments.

Our results also contrast with recent findings that comprehenders do not appear to instantiate syntactic structure associated with VP ellipsis: Cai et al. (2013) found that reading a Mandarin DO or PO sentence involving an elided VP did not prime production of DO or PO sentences respectively. This suggests that they do not syntactically represent the elided VP – in other words, that they do not represent its internal structure (i.e., V PP PP or V PP NP). We propose that comprehenders do not do not do this because none of the arguments are expressed. In contrast, comprehenders in our experiments encounter one of the arguments. They therefore need to activate syntactic information (of some kind) associated with the internal structure of the VP, and we have provided evidence that the syntactic information that they activate corresponds to the PO or the DO construction. More generally, future priming studies may be able to determine the specific types of missing element that are syntactically represented, and whether there are cross-linguistic differences in representation.

## *6.2. The construction of syntactic representations in missing argument sentences*

Our findings appear to support the more general proposal that comprehenders compute autonomous syntactic representations. It is important to stress that this claim is compatible with the strong evidence that comprehenders determine the

meaning of utterances as soon as they encounter them (e.g., Marslen-Wilson, 1973) or even predictively (e.g., Altmann & Kamide, 1999). It is quite possible for comprehenders to compute syntactic representations as each new word (or morpheme) is encountered, and if necessary to predict upcoming syntactic representations at that point (e.g., Staub & Clifton, 2006). Each new syntactic representation is associated with a semantic representation – and if the syntactic representation is computed predictively, then the semantic representation will be computed predictively as well (e.g., Arai et al., 2007). Context is of course also used incrementally (e.g., Altmann & Steedman, 1988), and is therefore compatible with our evidence that it can affect the construction of the syntactic representation.

But what mechanisms underlie the construction of syntactically represented missing arguments? We make the straightforward proposal that when comprehenders understand sentences, they use the incoming material and context to compute a syntactic representation without delay and, most likely, predictively. This representation is immediately fed into the development of an associated semantic representation. This leads to the autonomous existence of a syntactic representation (augmented by context) but no temporally extended stage at which a syntactic representation is unaccompanied by a semantic representation.

The flow of information is indicated in Figure 4 (which makes no assumptions about the extent of prediction during comprehension), using the Mandarin missing-argument sentence example *Niuzai mai-le yiben shu hou song-gei-le shuishou* (lit. cowboy buy-ASP a book, and later give-ASP sailor; see 1c). Before

comprehending the missing-argument clause, the comprehender has constructed a mental model of the context (i.e., cowboy buying a book). At hearing *song-gei-le shuishou* (give-<sub>Asp</sub> sailor), the comprehender combines the utterance with the context to construct a three-argument syntactic representation that includes an NP argument corresponding to the book in the context. (This is possible because *gave* is a three argument verb, the utterance contains only two arguments, and an appropriate third argument is present in the context). This representation then feeds into the semantic representation at the top of Figure 4, which includes three entities that correspond to the arguments in the syntactic representation (with the book playing the theme role in the semantic representation).<sup>3</sup> The same processing mechanism applies to the missing-argument PO sentence in Mandarin and, in fact, to missing-argument sentences in other languages such as English (e.g., *The charity needed support; the man gave some money*).



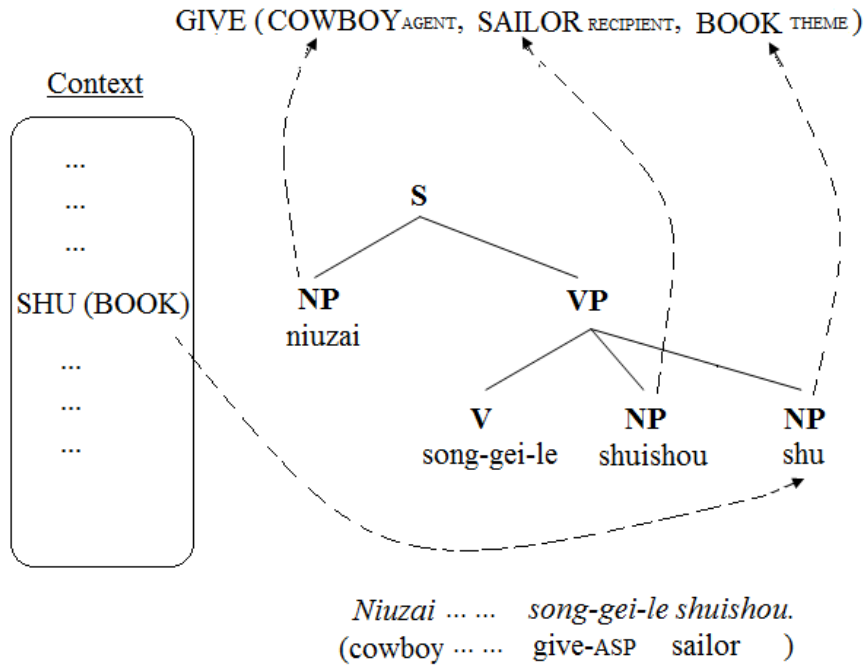


Figure 4: Information flow in the comprehension of a missing-argument sentence, using the Mandarin example *Niu zai mai-le yiben shu hou song-gei-le shu shou* (lit. cowboy buy-ASP a book, and later give-ASP sailor).

## 7. Conclusion

Our study showed that comprehension of a sentence with a missing argument (the direct object) affects people's subsequent syntactic choices in the same way and to the same extent as comprehension of a full-form counterpart. This finding suggests that missing-argument sentences can have the same constituent structure as a full-form sentence, and hence that comprehenders build syntactic representations for missing arguments.

## Endnote

<sup>1</sup> A pilot study without DO filler sentences yielded a very low proportion of DO responses. Cai et al. (2013), which had a very similar design and composition of prime sentences and also included additional DO filler sentences, found that DO responses constituted only 14.6% of all target responses.

<sup>2</sup> In a potentially relevant study, Griffin and Weinstein-Tull (2003) found that participants were more likely to recall a finite complement target sentence (e.g., *The police suspected that Joan was the criminal*) as an object-raising sentence (e.g., *The police suspected Joan to be the criminal*) after they recalled an object-raising prime sentence (e.g., *A teaching assistant reported the exam to be too difficult*) than an object-control prime sentence (e.g., *Rover begged his owner to be more generous with food*) or a subject-control prime sentence (e.g., *Jenny actually intended to be a runner in the race*) (and the latter two did not differ). These results are not compatible with priming from the syntactic structure of overt (non-missing) elements, because object-raising and object-control sentences do not differ in this regard. They could arise from syntactic differences in the representation of missing elements in control and raising sentences. But it is also possible that they are due to thematic differences: In raising sentences, each NP fills only one thematic role (e.g., *Joan* is not the theme of *suspect*), whereas in control sentences, one NP fills two thematic roles (e.g., *his owner* is both the theme of *beg* and the experiencer of *be more generous*).

<sup>3</sup> It is also conceivable that comprehenders construct a semantic representation that

includes the missing argument, and then use this to reconstruct a syntactic representation including the missing argument (e.g., they may detect that the theme argument in the semantic representation does not have a corresponding syntactic representation, and as a consequence insert a PP in the syntactic structure.) Critically, even under this account it would still remain the case that comprehenders compute syntactic representations that include missing arguments, in accord with the syntactically-represented account.

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