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Evidence from structural priming

The independence of syntactic processing in Mandarin: Evidence from structural priming

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Abstract

Although it is generally accepted that syntactic information is processed independently of semantic information in languages such as English, there is less agreement about whether the same is true in languages such as Mandarin that have fewer reliable cues to syntactic structure. We report five experiments that used a structural priming paradigm to investigate the independence of syntactic processing in Mandarin. In a recognition memory task, Mandarin native speakers described ditransitive events after repeating prime sentences with a double object (DO) or prepositional object (PO) structure. Participants tended to repeat syntactic structure across prime and target sentences. Critically, this tendency occurred whether or not semantic features (animacy of the recipient) were also repeated across sentences, both when the verb was repeated and when it was not. We conclude that Mandarin speakers compute independent syntactic representations during language processing.

Highlights

- Processing models of Mandarin dispute whether syntax is represented independently.
- Five experiments investigated structural priming of dative structures in Mandarin.
- Priming occurred even when animacy features were not repeated between prime and target.
- Syntactic processing in Mandarin involves independent syntactic representations.

What kinds of representations do people use when processing language, and do speakers of different languages use the same kinds of representation? Most modern theories of language comprehension assume that there are independent levels of representation concerned with different types of information, but that these representations interact extensively and rapidly. Most evidence relates to the relationship between syntactic structure and semantics. For example, comprehenders quickly make use of the plausibility of alternative interpretations (i.e., making use of semantics) to adjudicate among syntactic analyses (e.g., Trueswell, Tanenhaus, & Garnsey, 1994). However, such theories nevertheless assume that levels of representation such as syntax and semantics are constructed independently (e.g., MacDonald, Pearlmutter, & Seidenberg, 1994). Although there is considerable evidence for interaction between levels, few theories have taken the further step of assuming that comprehenders construct an integrated syntactic-semantic representation (e.g., McClelland, St. John, & Taraban, 1989). In language production, almost all theories assume independent representations, whether they support extensive interaction (Dell, 1986) or not (Levelt, 1989).

However, most psycholinguistic work has focused on particular classes of language in which there are generally reliable cues for identifying syntactic structure. For example, in Indo-European languages such as English and German, comprehenders can use cues such as word order and morphology (e.g., inflections on nouns and verbs) to determine the syntactic relations between words and phrases. In accord with this, there is some evidence that in such languages, syntactic information may be weighted more strongly than other information. Some of this evidence comes from ERP studies examining the occurrence of the N400, a negativity indexing on-line semantic integration that occurs 300-500ms after the onset of a semantically anomalous word

(Kutas & Hillyard, 1980; for a review, see Kutas & Federmeier, 2011). Several studies of German and French sentence comprehension found that N400 effects did not occur following a semantically anomalous word when that word was also anomalous in terms of syntactic category (e.g., *Das Türschloß wurde im gegessen* 'The door lock was in-the eaten'; Friederici, Gunter, Hahne, & Mauth, 2004; Friederici, Steinhauer, & Frisch, 1999; Hahne & Friederici, 2002; Isel, Hahne, Maess, & Friederici, 2007). These results suggest that syntactic information outweighs semantic information in these languages, with failure to resolve syntactic category information 'blocking' semantic integration processes (Friederici, 2011).

Similarly, research on language production in languages such as English suggests a separation between semantic and syntactic processing. For example, patterns of speech errors show that speakers produce syntactically well-formed utterances that are nevertheless semantically anomalous (e.g., *It'll get fast a lot hotter if you put the burner on*; see Garrett, 1980). Bock, Loebell, and Morey (1992) showed a similar separation of semantic and syntactic processing in an experiment in which participants described pictures of transitive events involving inanimate agents and animate patients following active or passive primes with either an inanimate agent and an animate patient or vice versa. They tended to repeat syntactic structure (active or passive) and whether the subject of the sentence was animate or not, but there was no interaction between these effects. This suggests that decisions about assignment of animacy and decisions about syntactic structure are made independently during production.

In other languages, however, the extent to which syntactic information is processed independently of semantic information is less clear. For example, languages such as Mandarin have fewer reliable cues to syntactic structure. Mandarin contains a high proportion of words whose syntactic class is ambiguous, analogous to *fight* (noun)

versus *fight* (verb) in English. In English, syntactic class can regularly be determined from immediate context (e.g., *to fight* vs. *the fight*). But this is far less common in Mandarin. Mandarin also does not morphologically mark syntactic category or syntactic features such as person, number, case, or tense, but neither does it have a rigid word order. Information about verb tense and aspect, word-class subcategorization, and phrase grouping is conveyed by markers that need not be adjacent to the elements that they mark (Chu, 1998; Li & Thompson, 1981) and, importantly, these markers are often ambiguous (e.g., regarding which verb they mark).

Together, these characteristics mean that the same sentence can often have very different interpretations (e.g., *Yaosile lieren de gou, Savage-LE hunter DE dog, this sentence* can mean either that the hunter was savaged by the dog or that the dog was savaged by someone, depending on the context). In addition, the potential for ambiguity is greatly enhanced because the spoken language includes extensive homophony (e.g., the word *shi*4 [where 4 indicates 4th tone] has 40 different meanings) and the written language includes many words that can involve one or more characters so that sequences of characters (which do not have spacing indicating word boundaries) can potentially be grouped in different ways that yield very different meanings (see Yang, Perfetti, & Liu, 2010).

Researchers have highlighted the potential implications of such ambiguity for language processing, focusing almost exclusively on comprehension. Hoosain (1991) argued that comprehenders of Mandarin must rely extensively on lexico-semantic relationships between neighboring words to correctly identify syntactic categories, phrase grouping, thematic roles, and verb tense. More generally, researchers have argued that semantic and contextual cues play a greater role than grammatical cues in

determining who does what to whom during comprehension (e.g., Li, 1996; Li, Bates, & MacWhinney, 1993).

Evidence to support this claim comes from studies investigating the role of animacy in comprehension of Mandarin sentences. Specifically, compared to English, comprehenders make greater use of animacy as a cue in Mandarin (Cai & Dong, 2007; Chen, Chen, & He, 2012); for example, when comprehending sequences of words that included nonsense verbs (e.g., *lightning girl pesit*), animacy accounted for 77% of the total variance in Mandarin native speakers' interpretations (with word order accounting for 13%), whereas in English native speakers animacy accounted for only 17% of the total variance (with word order accounting for 86%; Cai & Dong, 2007). Other research suggests that Mandarin comprehenders may rely more on animacy cues than syntactic (word order) cues (Li, Bates, & MacWhinney, 1993; Li, 1996; Miao, 1981; Miao et al., 1986). For example, Li et al. had participants listen to sentences involving two nouns and a verb in different orders (e.g., *xi damen nanhai, wash door boy*), and then choose between two pictures to indicate their interpretation of the sentence. Participants tended to rely more on animacy than word order to determine which noun was the agent. When animacy and word order conflicted, participants tended to choose the animate noun as the agent; animacy also had a stronger effect than word order on reaction times. Some researchers have therefore claimed that sentence processing in Mandarin is essentially semantically and contextually driven, with syntactic processes playing a substantially reduced role relative to languages such as English (Chu, 1998; Li & Thompson, 1981).

But such findings are of course compatible with two possibilities. First, Mandarin sentence processing might involve an integrated level of representation incorporating both syntax and semantics. Alternatively, it might involve separate syntactic and

semantic representations, but the degree or extent of interaction between the levels would be greater than in English.

Studies using imaging and electrophysiological paradigms might in principle distinguish these possibilities. However, studies investigating the neural substrates of syntactic and semantic processing in Mandarin have yielded conflicting results. In an fMRI study, Luke, Liu, Wai, Wan, and Tan (2002) asked Mandarin-English bilingual participants to make syntactic and semantic (plausibility) judgements for Mandarin sentences. They found no regions that were concerned with syntax to the exclusion of semantics, and argued that this contrasted with studies using monolingual English speakers. In contrast, Wang et al. (2008) found that sentences containing both syntactic and semantic anomalies yielded greater activity in Broca's area (left BA44) than sentences containing only semantic anomalies, and concluded that this area is specifically implicated in syntactic processing in Mandarin (as has been claimed for English; e.g., Caplan, 2006; Embick et al., 2000).

In addition, a number of studies using electrophysiology found that Mandarin sentences involving combined syntactic/semantic anomalies elicited components consistent with the detection of both syntactic and semantic anomalies (Liu et al., 2010; Ye, Luo, Friederici, & Zhou, 2006; Yu & Zhang, 2008; Zhang et al., 2010, 2013). This contrasts with studies in German and French (Friederici et al., 2004; Friederici et al, 1999; Hahne & Friederici, 2002; Isel et al., 2007). For example, Zhang et al. (2010) observed an N400 effect (indexing semantic processing) as well as a P600 effect (indexing syntactic processing) in SVO sentences and SOV sentences involving the particle *ba* (expressing affect) that contained combined syntactic category/semantic anomalies (e.g., *Nühai chile hen qunzi he shoutao, The girl ate extremely skirt and glove*; *Wei Li ba xinxiande yali manman de gangqing le liangge, Wei Li ba fresh pears slowly*

piano LE two). Zhang et al. (2013) found similar results for SOV sentences containing combined syntactic transitivity/semantic anomalies (e.g., *fangdichan zhejia jituan zuijin jinian huilai le sanchu, Real estate this corporation during recent several years came back LE three places*). These results suggest that semantic processing was not contingent upon successful syntactic processing. But although they support the importance of semantic processes in Mandarin sentence processing, they do not demonstrate whether people construct syntactic representations that are independent of semantic content. These results provide some evidence that syntactic and semantic representations might be processed differently in Mandarin than in languages such as English and German. But to investigate whether Mandarin speakers compute integrated syntactic and semantic representations, we need to consider evidence that is informative about representation. One possibility is to turn to theoretical linguistics, and in fact some linguists claim that syntactic and semantic structure are intimately connected in Mandarin (Lu, 1997; Ma, 1998; Shao, 1998; Xing, 1995; Xu, 2000; Zhang, 1997a, b). The motivation for this claim comes in part from the implications of the extensive ambiguity in Mandarin (see Yang et al., 2010, discussed above). But the main motivation comes from theoretical accounts that argue that Mandarin makes fewer syntactic/semantic distinctions than do accounts of English and related languages. For example, Li and Thompson (1978, 1981) assume a functional account in which word order is primarily determined by semantic and pragmatic factors rather than by grammatical relations. This account is further elaborated by LaPolla (1990, 1995), who argued that the syntactic categories of subject and direct object do not exist in Mandarin. Theoretical linguistic accounts of English and related languages standardly characterize generalizations about word order (or alternatively constituent structure) with reference to grammatical relations, even accounts such as that proposed by Culicover and Jackendoff (2005) who explicitly seek

to minimize representational strata. But LaPolla provides extensive evidence that the generalizations that are explained by grammatical relations in English cannot be explained in this way in Mandarin, and instead require reference to semantic and pragmatic factors.

However, although such accounts provide theoretical arguments why syntactic and semantic information might be integrated in Mandarin, they are based on acceptability judgments and do not provide clear evidence about the representations that are implicated during language processing. We therefore turn to structural priming.

Using structural priming to investigate syntactic representations in Mandarin

Structural priming is the phenomenon whereby exposure to a particular structure facilitates subsequent reuse of the same structure. Branigan, Pickering, Stewart, Liversedge and Urbach (1995) argued that priming effects are in principle informative about representation: By systematically manipulating the dimensions that two stimuli have in common, and examining whether priming occurs, it is possible to draw inferences about the nature of the underlying representation. Bock (1986) reported priming effects based on repetition of constituent structure (i.e., syntactic priming). When participants repeated sentences and described pictures under the guise of a running recognition memory task, they were more likely to use a sentence that used a *double object* (DO) structure to describe a picture of a dative event (e.g., *The girl is handing the man a paintbrush*) after repeating an unrelated sentence that also used a DO structure (e.g., *The rock star sold the undercover cop some cocaine*) than after repeating a sentence that used a *prepositional object* (PO) structure (*The rock star sold some cocaine to the undercover cop*). Such syntactic priming effects do not require repetition of content words (although priming is stronger when the verb is repeated: the *lexical*

boost; Pickering &Branigan, 1998) or closed-class words (Bock, 1989). Nor are they based upon metrical structure: Bock and Loebell (1990) showed that sentences with the same metrical structure and syntactic structure led to priming (e.g., *Susan brought a book to Stella* primed *The girl hands a paintbrush to the man*) but sentences with the same metrical structure but different syntactic structure did not (*Susan brought a book to study* did not prime *The girl hands a paintbrush to the man*).

Structural priming also occurs in language comprehension (Arai, Scheepers, & Van Gompel, 2007; Branigan, Pickering, & McLean, 2005). Branigan, Pickering, and Cleland (2000) showed that priming occurs from comprehension to subsequent production (and Branigan et al., 2005, found priming from production to comprehension). These results suggest that priming reflects facilitation of representations that are shared between production and comprehension, and therefore suggest that comprehension-to-production priming can be used to investigate the representations that are constructed during comprehension (see Ivanova, Pickering, Branigan, McLean, & Costa, 2012, for discussion).

Importantly, these syntactic priming effects appear to be independent of the repetition of particular semantic content. Thus, several studies have shown that priming occurs between sentences that describe different event types. Bock and Loebell (1990) found that sentences involving location thematic roles (e.g., *The woman drove her Mercedes to the church*) were as effective as PO sentences in eliciting PO targets. Moreover, active sentences involving agent-location thematic roles (e.g., *The foreigner was loitering by the broken traffic light*) primed passive sentences involving patient-agent thematic roles (*The boy was stung by the bee*) to the same extent that passive primes did. Messenger, Branigan, McLean, and Sorace (2012) found that participants were equally primed to produce passive descriptions for agent-patient events by

comprehending agent-patient, theme-experiencer, and experiencer-theme passives (e.g., *the witch is being hugged/scared/ignored by the sheep*; see also Messenger et al., 2011).

Bock et al.'s (1992) priming study showed independent priming effects that did not interact for syntactic structure (choice of active versus passive, e.g., *The alarm clock is waking the boy*s vs. *The boy is being woken by the alarm clock*) and semantic-to-syntactic mappings (choice of animate or inanimate entity as sentence subject; *Five people carried the boat*s vs. *The boat carried five people*). Bernolet, Hartsuiker and Pickering (2009) examined syntactic priming between Dutch and English, and also found effects that were independent of animacy (but did not find any tendency to repeat animacy mappings to grammatical relations). Carminati, Van Gompel, Scheepers, and Arai (2008) similarly found that priming in the comprehension of English PO/DO sentences was independent of repetition of animacy. Taken together, the results suggest that neither relational semantic content (relating to event type) nor non-relational semantic content (relating to individual entities' inherent properties) contributes to processing of constituent structure in English (or Dutch). Overall, the studies suggest that English speakers construct representations that are specified for syntactic but not semantic information. But what do Mandarin speakers do?

Structural priming effects appear to occur in similar ways in all languages (that have been tested), and several studies have been conducted in Mandarin. Thus, Cai and colleagues found priming for dative (PO/DO) sentences in Mandarin (Cai, Pickering, & Branigan, 2012; Cai, Pickering, Wang, & Branigan, 2015; Cai, Pickering, Yan, &Branigan, 2011). Cai et al. (2011) used a sentence/picture-verification paradigm. On prime trials, participants heard a prime sentence describing a dative event involving an animate agent, an animate recipient, and an inanimate theme (e.g., *Niuzai huan-gei shuishou*

yitiao xiangjiao, cowboy return sailor a banana; 'the cowboy returns the sailor a banana'), and decided whether the sentence matched a presented picture. On target trials, they saw a picture of another dative event involving a different animate agent, animate recipient, and inanimate theme, and a sentence fragment that they had to repeat and complete (e.g., *Jingcha di…, policeman pass;* 'the policeman passed…'. Participants' completions revealed structural priming, in that they produced more PO descriptions after PO primes than DO primes.

Cai et al. (2011) showed that this tendency was enhanced when the verb was repeated across prime and target, and moreover that it occurred in Cantonese as well as in Mandarin (and between the two languages). Cai et al. (2012) replicated priming for PO/DO sentences, but also demonstrated priming of mappings both between thematic roles and grammatical relations, and between thematic roles and word order positions, thereby indicating that semantic representations are accessed during sentence processing in Mandarin (as in other languages). Cai et al. (2015) showed further that both PO and DO sentences with 'missing' arguments (e.g., PO sentence: *Niuzai mai-le yiben shuhou song-le gei shuishou, cowboy buy LE a book later give LE to sailor*; 'The cowboy bought a book and later gave to the sailor') primed PO and DO sentences to the same extent as (full form) PO and DO prime sentences. Cai et al. (2012) also showed that their results could not be explained in terms of differences in emphasis associated with the two structures (see Vernice et al., 2012). Their results therefore provide evidence for a level of representation in Mandarin production and comprehension that encodes syntactic information.

However, we do not know whether this level of representation in Mandarin encodes only syntactic information (as in English), or whether it encodes syntactic information alongside other, non-syntactic information. In Cai et al.'s (2011, 2012,

2015) experiments, primes and targets were matched for semantic content, and it is therefore not possible to identify whether semantic information was implicated in priming. For example, the agent and recipient were always animate (and the theme was always inanimate), and the prime and target were therefore equated on a semantic dimension that, as we have noted, appears to play an influential role in Mandarin sentence processing that may override syntactic (word order) cues (Cai & Dong, 2007; Chen, Chen, & He, 2012; Li, Bates, and MacWhinney, 1993; Li, 1996; Miao 1981; Miao et al., 1986;).

It therefore follows that semantic information such as animacy might be encoded alongside syntactic information: For example, Mandarin speakers might construct representations such as VP[V NPI_{INAN} PP_{ANIM}], in which syntactic information about phrasal category is represented alongside semantic information about animacy (such as animate or inanimate). If so, participants should tend to repeat syntax when prime and target are matched for animacy, but not when they are not matched for animacy (because different representations would be implicated, e.g., VP[V NPI_{INAN} PP_{ANIM}] in one case vs. VP[V NPI_{ANIM} PP_{ANIM}] in the other).

Alternatively, Mandarin sentence processing might involve the construction of syntactic structures that are independent of semantic information (e.g., VP[V NP PP]), with semantic information being specified separately, for example alongside thematic role information in a purely semantic representation (e.g., $Agent_{ANIM}$, $Theme_{INAN}$, $Recipient_{ANIM}$). In that case, participants should tend to repeat syntax when prime and target are matched for animacy and when they are not (because the same representations would be implicated in both cases, e.g., VP[V NP PP]). On this account, any small differences in priming when sentences are matched versus mismatched for animacy could be due to additional loci for priming (see General Discussion).

Therefore, if priming occurs when animacy is not repeated across prime and target, it would support an account involving independent syntactic representations. If priming occurs when animacy is repeated across prime and target, but does not occur when animacy is not repeated, it would support an account involving representations that integrate syntactic and semantic information.

We now report five studies that manipulated animacy within a syntactic priming paradigm in order to investigate the independence of syntactic representations in Mandarin. In our experiments, participants read and repeated prime sentences and described target pictures under the guise of a recognition-memory experiment (Bock, 1986). We manipulated the syntactic structure of the prime sentences (PO vs. DO). We also manipulated animacy, so that the prime involved either an animate or an inanimate recipient (with an animate agent and inanimate theme); targets always involved animate recipients (see also Carminati et al., 2008). Our dependent measure was the structure of participants' target descriptions (PO vs. DO).

In Experiment 1, we established that priming occurs for both PO and DO sentences when the verb is repeated, relative to an unrelated baseline (i.e., showed that priming is a two-way effect). Experiments 2 and 3 also used primes and targets in which the verb was repeated. In Experiment 2, we compared priming when only syntactic structure was repeated across prime and target with priming when both syntactic structure and animacy features were repeated across prime and target. Experiment 3 replicated Experiment 2 with a stronger animacy manipulation. Experiments 4 and 5 examined whether the effects found in Experiments 1 and 2 would hold when the verb was not repeated between prime and target. In all experiments, we expected that when animacy features were matched across prime and target, participants would repeat the syntactic structure of the prime sentence in their target description (i.e., would show

syntactic priming effects). Our main question was whether speakers would also repeat syntactic structure when animacy features were not matched across prime and target.

Experiment 1

Experiment 1 attempted to determine whether there was a two-way priming effect for PO and DO structures using a recognition-memory structural priming paradigm (Bock, 1986). Participants first read and repeated sentences and described pictures. In a subsequent test phase, they read PO, DO, or intransitive (baseline) sentences (and made a recognition judgment), and then completed sentence fragments to describe pictures of dative events. We assumed that the intransitive sentences would not prime either PO or DO target descriptions, and therefore served as an appropriate baseline (see Pickering, Branigan, & McLean, 2002). The dative primes and targets involved animate agents and recipients and inanimate themes.

Method

Participants

Twenty-four Mandarin speakers were paid to participate in this experiment. The participants ranged in age from 17 to 24 years (mean = 20.29, SD=1.55).

Materials

We constructed 30 sets of experimental prime sentences such as those in (1a), (1b), and (1e), together with90 filler sentences. Each prime sentence was paired with a target picture. *PO* and *DO* prime sentences (such as 1a-b) involved one of 15 dative verbs; intransitive *baseline* prime sentences (such as 1e)involved one of 22 intransitive verbs. Experimental target pictures depicted a ditransitive action that corresponded to the verb used in the dative primes. The name of the agent and the verb were printed below

the picture in Chinese characters (e.g., *The girl gives*…); see Table1. The PO and DO primes and the target pictures involved three entities (an animate agent, animate recipient, and inanimate theme); the baseline primes involved one entity (an animate agent). Prime sentences and target pictures always involved different agents, recipients, and themes (Figure 1). In the target picture, the theme always appeared in the center. In half of the target pictures, the agent was on the left and the recipient was on the right; in the remaining target pictures, the positions of the agent and the recipient were reversed.

The filler sentences were transitive (e.g., *fuqin biaoyang le zhege nanhai*, *"The father praised the boy"*); filler pictures depicted a transitive event involving an agent and an patient, in which the agent were always animate; in one third of fillers, the patient was animate; in the other two thirds, it was inanimate. The name of the agent and the verb were printed below the picture in Chinese character (e.g., *fuqin biaoyang le,* "The father praised"). In half of the filler pictures, the agent was on the left; in the other half, the agent was on the right (figure 2).

Table1: Example prime sentences (Experiments 1-2):

Prime Condition	Example
1a. PO-An	*Mingxing song le changpian gei nage zhuli*. The superstar give LE record to that assistant. ("The superstar gave the record to that assistant.")
1b. DO-An	*Mingxing song-gei zhuli yizhang changpian*. The superstar give-to assistant one record.

	(“The superstar gave the assistant a record.”)
1c. PO-In	*Mingxing song le changpian gei nage gongsi.* The superstar give LE record to that company. (“The superstar gave the record to that company.”)
1d. DO-In	*Mingxing song-gei gongsi yizhang changpian.* The superstar give-to company one record. (“The superstar gave the company a record.”)
1e. Baseline	Wupo zou le. The witch go LE. (“The witch has gone.”)

We created three lists, such that each list contained equal numbers of experimental items in each condition, and one version of each item. Across lists, each version of the item occurred once. Hence each list contained 30 experimental trials (10 with DO primes, 10 with PO primes and 10 with baseline primes) and 90 filler trials.

Procedure

Participants were randomly assigned to one of the three lists. They were told that the experiment investigated the relationship between memory and language production. They were first shown pictures of each of the individual objects that would appear in the set of target pictures together with their name on a computer screen. Once they reported that they were familiar with the pictures and the names, the experiment began. The experiment included a study phase and a test phase, using a procedure

similar to Bock (1986). In the study phase, participants were asked to memorize a set of sentences and pictures that were presented to them. In the subsequent test phase, they were asked to identify which sentences and pictures they had encountered in the study phase. This procedure was adopted to avoid participants from detecting the relationship between prime sentences and subsequent target pictures; in fact, none of the participants reported noticing the relationship between prime sentences and target pictures.

In the study phase, participants completed 30 trials (5 PO, 5 DO, 5 Baseline, and 15 filler). Each trial comprised a sentence and a picture. All of the experimental pictures (i.e., non-filler pictures) in the study phase were presented again in the test phase; however, experimental sentences that appeared in the test phase had not been presented in the study phase.

For each trial, a fixation cross appeared for 500 ms, then the prime sentence appeared in the centre of the screen. After participants had memorised the sentence, they pressed the space bar, which triggered the presentation of a blank screen for 200 ms, followed by presentation of the pictures. Similarly, after participants had memorised the picture, they pressed the space bar. There was a blank screen for 200ms, then the next trial began.

The test phase included 10 practice trials, 30 experimental trials, and 90 filler trials. Experimental trials were separated by 2-4 filler trials. The procedure in the test phase was similar to the study phase, except that participants read aloud the sentences and then made a yes/no judgment for whether they had seen the sentence before; and described pictures by completing the sentence fragment beneath it and then made a yes/no recognition judgment. The experiment lasted approximately 1 hour.

Scoring

Responses were scored as a *DO* response if the sentence preamble was grammatically continued such that the verb was followed first by an NP denoting the recipient and then by an 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 prepositional phrase (headed by the preposition *gei*) denoting the recipient; otherwise, it was coded as an *Other* response.

Results

Table 2 shows frequency of PO, DO and Other target responses by condition. We analysed the data using Generalized logistic mixed models (GLMM) with crossed random effects for participants and items, using the glmer program of the lme4 package (Bates & Maechler, 2010) in R. The dependent variable was the number of DO responses (DO = 1, PO = 0). To determine whether there was a main effect of prime type, we compared the full model that treated prime type as a fixed effect with the null model that excluded prime type as a fixed effect, using the maximal random effects structure justified by the design that allowed model convergence(Barr, Levy, Scheepers, & Tily, 2013). The best fit model included a random intercept and a random slope for prime type. It produced a significantly better fit for the data than the null model (likelihood ratio test: χ^2=67.99, p<.001). Hence, there was a significant main effect of prime type. Pairwise comparisons (Table 3) indicated that participants produced significantly more DO responses following DO primes than following PO or baseline primes. They produced fewer DO responses (hence, more PO responses) following PO primes than following baseline primes.

Table 2

Experiment 1: Frequency of PO, DO and Other target responses by condition

Prime	PO-An	DO-An	Baseline
DO	51	130	86
PO	188	108	152
Other	1	2	2
Proportion DO	.21	.54	.36

Table 3

Experiment 1: Results of pair-wise comparisons on DO responses

Prime pairs	Estimate	*SE*	*Z*	*P*
DO-An vs. PO-An	1.79	.23	7.77	＜.001
DO-An vs. baseline	.93	.21	4.43	＜.001
baseline vs. PO-An	.86	.23	3.80	＜.001

Discussion

Experiment 1 showed a two-way priming effect for PO and DO structures in Mandarin using a recognition-memory paradigm: When describing dative events that involved the same action (hence, verb) and the same animacy features as a sentence that they had just read and repeated, participants were more likely to use a DO structure after reading a DO sentence than after a PO sentence or an intransitive (baseline) sentence, and more likely to use a PO structure after reading a PO sentence than after a DO sentence or an intransitive (baseline) sentence. These results replicated previous evidence for syntactic priming of dative structures in Mandarin (e.g., Cai et al., 2012), using a different paradigm.

Experiment 2

Experiment 1 found two-way syntactic priming in Mandarin using a recognition-memory paradigm, when the verb and animacy features were held constant across prime and target. In Experiment 2, we investigated whether priming would occur when the verb was held constant and the animacy features of the recipient did or did not match. We therefore manipulated the syntactic structure (PO vs. DO) and animacy

features (animate vs. inanimate recipient) of the prime. Thus we compared participants' target descriptions for events involving an animate recipient (e.g., a girl giving a painter flowers) after reading PO sentences involving an animate recipient [*PO-An*, (1a) – as in Experiment 1] or an inanimate recipient [*PO-In*, (1c)]. We also compared their target descriptions after reading DO sentences involving an animate recipient [*DO-An*, (1b) – as in Experiment 1] or an inanimate recipient [*DO-In*, (1d)]. If Mandarin speakers construct syntactic representations that are independent of animacy information during sentence processing, then participants should tend to repeat structure across prime and target even if animacy features are not repeated. If Mandarin speakers construct representations during sentence processing that simultaneously encode syntactic and animacy information, then participants should repeat structure only when the prime and target repeat animacy features. Specifically, as the target had an animate recipient, participants should show priming only when the prime also had an animate recipient and not when it had an inanimate recipient.

Participants

Thirty-five further Mandarin speakers were paid to participate in this experiment. The participants ranged in age from 19 to 27 years (mean = 21.54, SD=2.23).

Materials, Procedure, and Scoring

Materials were the same as those used in Experiment 1, with the addition of two further prime conditions involving inanimate recipients (see Table 1: 1c and 1d; see Appendix).We created five lists, each containing 30 experimental trials (6 with PO-An primes,6 with DO-An primes, 6 with PO-In primes, 6 with DO-In primes, and 6 with

Baseline primes) and 90 filler trials. The target picture and the filler materials were the same as in Experiment 1. Participants were randomly assigned to one of the five lists. The procedure and scoring were as in Experiment 1.

Results

Table 4 reports target responses by condition. The primary concern in this experiment was whether the tendency to repeat syntactic structure would occur when animacy features were not repeated. Our main analyses therefore focused on prime type and animacy, in a model that included prime type (PO vs. DO) and animacy (animate vs. inanimate recipient) as fixed factors, with participant and item as random factors. The best fit model included a random intercept and random slopes for prime type and animacy. It showed a main effect of prime type (Estimate =2.09, SE = .36, z = 5.86, p < .001), but not a main effect of animacy (Estimate =.07, SE = .18, z = .39, p > .1), nor a prime type by animacy interaction (Estimate =.51, SE = .34, z = 1.48, p > .1).

In addition, we wished to determine whether the inanimate conditions both differed from the baseline as the animate conditions did in Experiment 1. We therefore carried out further analysis in a model that included prime type (DO-An, DO-In, PO-An, PO-In, Baseline) as a fixed factor and included a random slope for prime type in addition to the random intercept. The best fit model produced a significantly better fit for the data than the null model, hence there was a significant main effect of prime (likelihood ratio test:χ^2=141.47, p<.001). Pair-wise comparisons (Table 5) indicated that as in Experiment1, participants produced more DO responses following DO-An and DO-In primes than following Baseline primes. Furthermore, they produced fewer DO responses following PO-An and PO-In primes than following Baseline primes.

Table 4: Experiment 2: Target responses by condition

prime	PO-An	DO-An	PO-In	DO-In	baseline
DO	47	135	57	127	106
PO	163	75	153	82	101
Others	0	0	0	1	3
Proportion DO	.22	.64	.27	.60	.50

Table 5: Experiment 2: Results of pair-wise comparisons on DO responses

Prime pairs	Estimate	SE	Z	p
DO-An vs. Baseline	.64	.21	3.01	＜.01
DO-In vs. Baseline	.46	.21	2.19	＜.05
Baseline vs. PO-An	1.39	.23	6.12	＜.001
Baseline vs. PO-In	1.12	.22	5.08	＜.001

Discussion

Experiment 2 found priming with PO and DO sentences when animacy features were matched across prime and target, as in Experiment 1. Importantly, it also showed priming when prime and target differed in animacy features, with the prime involving an inanimate recipient (e.g., *company*) and the target involving an animate recipient (e.g., *painter*). Moreover, the magnitude of priming did not differ whether the prime and target matched or mismatched in animacy features. These results suggest that the representations over which priming occurred were not distinguished by animacy, and are therefore consistent with an account in which Mandarin speakers construct independent syntactic representations during sentence processing.

This conclusion may however be premature, because the recipient entities were collectives. For example, as in English (Bock, Butterfield, Cutler, Cutting, Eberhard, & Humphreys, 2006), *company* is normally interpreted in Mandarin as referring to an (inanimate)collective entity, but it can be interpreted as referring to the set of (animate) individuals who together make up that collective entity. A stronger test of the independent representation of syntactic structure and animacy would therefore be to demonstrate the same effects when such a collective interpretation is not possible. Experiment 3 therefore used the same design as Experiment 2, but used materials in which inanimate recipient could not be interpreted collectively (i.e., only permitted an inanimate interpretation).

Experiment 3

Participants

Thirty-five further Mandarin speakers were paid to participate in this experiment. The participants ranged in age from 18 to 27 years (mean = 20.11, SD=2.31).

Materials, Procedure, and Scoring

We constructed 30 further sets of materials. As in Experiment 2, these involved five prime conditions (PO-An, DO-An, PO-In, DO-In, Baseline; 2a-e). In the PO-In and DO-In conditions, the recipients were always nouns expressing locations, which must be interpreted as inanimate in Mandarin (Table 6). We used nine ditransitive verbs that were repeated between prime and target (we could not use the same range of verbs as in Experiments 1 and 2 because the inanimate recipients were not compatible with all of them; see Appendix). A further 30 intransitive sentences were used as baseline primes. We created five lists, each containing 30 experimental trials (6 with PO-An primes,6 with DO-An primes, 6 with PO-In primes, 6 with DO-In primes, and 6 with Baseline primes) and 90 filler trials. The filler materials were the same as in Experiment 1. Participants were randomly assigned to one of the five lists.The procedure and scoring were as in Experiment 1.

Table 6: Example prime sentences (Experiment 3)

Condition	Examples
2a. PO-An	*Huanbaozhe song le yixie zhibei gei shiming.* The environmentalist give LE some plant to citizens. ("The environmentalist gave some plant to the citizens.")
2b. DO-An	*Huanbaozhe song-gei shiming yixie zhibei.* The environmentalist give-to citizens some plant. ("The environmentalist gave the citizens some plant.")
2c. PO-In	*Huanbaozhe song le yixie zhibei gei shamo*. The environmentalist give LE some plant to desert. ("The environmentalist gave some plant to the desert.")
2d. DO-In	*Huanbaozhe song-gei shamo yixie zhibei.* The environmentalist give-to desert some plant. ("The environmentalist gave the desert some plant.")
2e. Baseline Prime	*Wupo zou le*. The witch go LE. ("The witch has gone.")

Results

Table 7 reports target responses by condition. Target responses were analysed as in Experiment 2, with prime type (PO vs. DO) and animacy (animate vs. inanimate recipient) as fixed factors, and participant and item as random factors. The best fit

model included a random intercept and random slopes for prime type and animacy. It showed a main effect of prime type (Estimate =1.54, SE = .27, z = 5.71, p < .001), but not a main effect of animacy (Estimate =.01, SE = .17, z = .08, p > .1), nor a prime type by animacy interaction (Estimate =.41, SE = .33, z = 1.25, p > .1).

Follow-up analysis including prime type (DO-An, DO-In, PO-An, PO-In, Baseline) as a fixed factor. The best fit model included a random intercept and random slope for prime type. It showed a main effect of prime type (likelihood ratio test:χ^2=90.58, p<.001). Pair-wise comparisons (Table 8) indicated that, as in Experiments1 and 2, participants produced more DO responses following DO-An primes and DO-In primes than following Baseline primes, and fewer DO responses following PO-An and PO-In primes than following Baseline primes.

Combined analysis of Experiment 2 and Experiment 3

To compare priming effects between Experiments 2 and 3, we conducted 2 x 2 x 2 analyses in which experiment (Experiment 2 vs. 3), prime type (PO vs. DO) and animacy (animate vs. inanimate recipient) were treated as fixed factors, and participant and item as random factors. The best fit model included a random intercept and random slopes for prime type and animacy. It showed a main effect of prime type (Estimate =1.80, SE = .22, z = 8.23, p < .001) and a marginal prime type by animacy interaction (Estimate =.45, SE = .24, z = 1.88, p = .06), but not a main effect of experiment (Estimate =.05, SE = .23, z = .22, p>.1), nor a main effect of animacy (Estimate =.03, SE = .12, z = .23, p>.1), nor interactions between experiment by prime type (Estimate =.44, SE = .43, z = 1.04, p>.1), experiment by animacy (Estimate =.06, SE = .23, z = .25, p>.1), or experiment by prime type by animacy (Estimate =.09, SE = .47, z = .19, p>.1).

Table 7: Experiment 3: Target responses by condition

prime	PO-An	DO-An	PO-In	DO-In	Baseline
DO	54	124	60	116	91
PO	156	86	150	94	119
Others	0	0	0	0	0
Proportion DO	.26	.59	.29	.55	.43

Table 8: Experiment 3: Results of pair-wise comparisons on DO responses

Prime pairs	estimate	SE	Z	p
DO-An vs Baseline	.73	.21	3.43	＜.001
DO-In vs Baseline	.55	.21	2.61	＜.01
Baseline vs PO-An	.91	.23	4.02	＜.001
Baseline vs PO-In	.74	.22	3.36	＜.001

Discussion

Experiment 3 replicated the results of Experiment 2 using items in which the inanimate recipient entities did not have a collective interpretation: Participants tended to repeat syntactic structure across sentences, and this tendency occurred both when animacy features were matched across prime and target, and when they were not matched. Combined analyses showed no difference in priming between Experiments 2 and 3.[1] The evidence for priming when animacy features were not repeated provides further support for the conclusion that Mandarin speakers construct representations that encode syntactic information separately from semantic information, and that they do not construct representations that simultaneously encode syntactic and semantic

information. In the General Discussion we consider possible explanations for the marginal tendency for priming to be stronger across Experiments 2 and 3 when animacy features were matched than when they were not (15% vs 11%).

All-in-all, Experiments 1-3 established that Mandarin speakers tend to repeat syntactic structure across sentences, and that this tendency occurred when animacy features were not repeated. In these experiments, the prime and target always involved the same verb and hence described events involving some overlap in meaning (although the agent, theme, and recipient entities were always different). A stronger test of the independence of syntactic and semantic representations in Mandarin sentence processing would be if priming occurred when prime and target involved different events as well as different agent, theme, and recipient entities. In Experiments 4 and 5, we therefore investigated whether we found similar patterns of results to Experiments 1 and 2 under conditions in which prime and target involved different verbs.

Experiment 4

Experiment 4 replicated Experiment 1, but using prime-target pairings in which the action and entities differed across prime and target. If priming occurred under these circumstances, it would support the proposal that priming of Mandarin datives is a two-way effect, serving as the basis for the animacy manipulation in Experiment 5.

Participants

Twenty-four further Mandarin speakers were paid to participate in this experiment. The participants ranged in age from 19 to 25 years (mean = 21.04, SD=1.55).

Materials, Procedure, and Scoring

We constructed 30 new PO-An and DO-An prime sentences, and combined these with the baseline primes and target pictures used in Experiments 1 and 2 to create 30 sets of materials in which the prime sentences and associated target pictures involved different actions (see Table 9; 3a,b,e). We created three lists, each containing 30 experimental trials (10 with DO primes, 10 with PO primes, and 10 with baseline primes) and 90 filler trials which were from experiment 1. Participants were randomly assigned to one of the three lists.The procedure was as in Experiment 1.

Table 9: Experiments 4 and 5: Example prime sentences

Condition	Examples
3a. PO-An	*Mingxing mai le changpian gei nage zhuli*. The superstar bought LE record to that assistant. (The superstar bought the record to that assistant.)
3b. DO-An	*Mingxing mai-gei zhuli yizhang changpian*. The superstar bought-to assistant one record. (The superstar bought that assistant a record.)
3c. PO-In	*Mingxing mai le changpian gei nage gongsi*. The superstar bought LE record to that company. (The superstar bought the record to that company.)
3d. DO-In	*Mingxing mai-gei gongsi yizhang changpian.* The superstar bought-to company one record.

	(The superstar bought that company a record.)
3e. Baseline	*Wupo zou le*.
Prime	The witch go LE. (The witch has gone.)

Results

Table 10 reports target responses by condition. The model including a random intercept and a random slope for prime type produced a significantly better fit for the data than the null model (likelihood ratio test:χ^2=7.83, p<.05). Hence, there was a significant main effect of prime type. Pairwise comparisons (Table 11) indicated that participants produced significantly more DO responses following DO-An primes than following PO-An primes and marginally more DO responses following DO-An primes than following baseline primes. They produced fewer DO responses (hence, more PO responses) following PO-An primes than following baseline primes.

Table 10: Experiment 4: Target responses by condition

Prime	PO-An	DO-An	Baseline
DO	87	128	109
PO	151	110	130
Others	2	2	1
Proportion DO	.36	.53	.45

Table 11: Experiment 4: Results of pair-wise comparisons on DO responses

Prime pairs	estimate	SE	Z	p
DO-An vs PO-An	.84	.28	2.98	＜.01
DO-An vs baseline	.35	.20	1.72	=.09
baseline vs PO-An	.49	.25	1.99	＜.05

Discussion

Experiment 4 found similar effects to Experiment 1 when the prime and target involved different verbs. Priming was weaker than in Experiment 1 (Experiment 1: 18% vs. Experiment 4: 8%). This pattern of weaker priming when the verb was not repeated than when it was repeated constitutes a demonstration of the lexical boost effect, which has been found in Mandarin and other languages (e.g., Branigan et al., 2000; Cai et al., 2012; Hartsuiker et al., 2008; Pickering & Branigan, 1998), though not to our knowledge with the running recognition memory paradigm.

Experiment 5

Experiment 5 replicated Experiment 2 by comparing priming for PO/DO sentences in Mandarin when prime and target matched or mismatched in animacy features, and the verb differed between prime and target.

Participants

Thirty-five further Mandarin speakers were paid to participate in this experiment. The participants ranged in age from 19 to 25 years (mean = 21.09, SD=1.70).

Materials, procedure and scoring

The materials were the same as those used in Experiment 4, with the addition of two further prime conditions involving inanimate recipients (see Table 9; 3a-e). We created five lists, each containing 30 experimental trials (6 with DO-An primes, 6 with DO-In primes, 6 with PO-An primes, 6 with PO-In primes, and 6 with Baseline primes) and 90 filler trials. Filler trials were the same as in Experiment 1.Participants were randomly assigned to one of the five lists. The procedure was as in Experiment 1.

Results

Table 12 reports target responses by condition. Target responses were analysed as in Experiment 2, using a model that included prime type (PO vs. DO) and animacy (animate vs. inanimate recipient) as fixed factors, with participant and item as random factors. The best fit model included a random intercept and random slopes for prime type and animacy. It showed a main effect of prime type (Estimate =.56, SE = .16, z = 3.60, $p < .001$), but not a main effect of animacy (Estimate =.05, SE = .16, z = .32, $p>.1$), nor a prime type by animacy interaction (Estimate =.28, SE = .30, z = .92, $p>.1$).

Follow-up analysis including prime type (DO-An, DO-In, PO-An, PO-In, Baseline) as a fixed factor with a random intercept and random slope for prime type showed that the best fit model included a main effect of prime type (likelihood ratio test:χ^2=17.42, $p<.01$). Pair-wise comparisons (Table 13) indicated that participants produced fewer DO responses following PO-An primes and PO-In primes than following Baseline primes.

Table 12: Experiment 5: Target responses by condition

prime	PO-An	DO-An	PO-In	DO-In	Baseline
DO	81	111	82	103	108
PO	128	99	128	107	102
Others	1	0	0	0	0
Proportion DO	.39	.53	.39	.49	.51

Table 13: Experiment 5: Results of pair-wise comparisons on DO responses

Prime pairs	estimate	SE	z	p
DO-An vs baseline	.06	.20	.31	.75
DO-In vs baseline	-.10	.20	-.50	.62
baseline vs PO-An	.57	.21	2.74	＜.01
baseline vs PO-In	.55	.21	2.65	＜.01

Discussion

Experiment 5 replicated Experiment 2 under conditions where the verb was not repeated between prime and target: Priming occurred (though this effect was only significant for PO structures) when animacy features were repeated and when they were not repeated. These results provide further evidence that Mandarin sentence processing involves construction of representations that specify syntactic but not semantic information.

Combined analysis of Experiment 2 and Experiment 5

To determine whether priming was increased when the prime and target involved the same verb (hence described the same event type), we conducted a combined analysis of data from Experiment 2 (repeated verb) and Experiment 5 (non-repeated verb). We treated experiment (Experiment 2 vs. 5), prime type (PO vs. DO) and animacy (animate vs. inanimate recipient) as fixed factors, with participant and item as random factors. The best fit model included a random intercept and random slopes for prime type and animacy. It showed a main effect of prime (Estimate =1.24, SE = .17, z = 7.16, $p < .001$) and an experiment by prime type interaction (Estimate =1.32, SE =.34, z = 3.87, $p < .001$), but no main effect of experiment (Estimate =.12, SE =.21, z = .60, $p > .1$) or animacy (Estimate =.01, SE =.11, z = .04, $p > .1$), nor an experiment by animacy interaction (Estimate =.10, SE =.22, z = .46 $p>.1$), prime type by animacy interaction (Estimate =.34, SE =.23, z = 1.52, $p > .1$), or experiment by prime type by animacy interaction (Estimate =.18, SE =.45, z = .40 $p>.1$). Pair-wise comparison showed that priming was larger when the verb was repeated, both when animacy features were repeated across prime and target, and when they were not. This tendency held following both DO primes and PO primes (Table 14).

The combined analysis confirms a lexical boost to priming, and demonstrates that priming was stronger when prime and target involved the same verb but not when they involved the same animacy features.

Table 14: Combined analysis of Experiment 2 and Experiment 5: Results of pair-wise comparisons on DO responses

Prime pairs	Estimate	SE	z	P
PO-An(Exp2) vs. PO-An(Exp5)	-.85	.28	-3.02	< .01
PO-In (Exp2) vs. PO-In(Exp5)	-.60	.28	-2.15	< .05
DO-An (Exp2) vs. DO-An (Exp5)	.53	.27	1.96	< .05
DO-In (Exp2) vs. DO-In (Exp5)	.52	.27	1.94	=.05

General Discussion

In five experiments, we used a structural priming paradigm to investigate whether Mandarin speakers construct independent syntactic representations during sentence processing. In experiments that were presented as a recognition memory test, participants read and repeated dative sentences, then repeated and completed descriptions of dative events. In all five experiments, participants showed a consistent tendency to repeat the structure of a sentence that they had previously read in their subsequent picture description. Thus participants were more likely to produce DO descriptions after reading DO sentences than after PO sentences, and more likely to produce PO descriptions after PO sentences than after DO sentences, both when the verb was repeated across prime and target (Experiments 1-3) and when it was not (Experiments 4-5). Prior exposure to a PO or DO structure also raised the likelihood of producing that structure relative to an intransitive baseline when the verb was repeated (Experiments 1-3); the same tendency held for PO structures when the verb was not repeated (Experiments 4-5). Priming was stronger when the verb was repeated than when it was not repeated.

Critically, however, this tendency to repeat syntax occurred when semantic features were not repeated across prime and target. In Experiment 2, priming occurred when the prime and target involved the same verb but different animacy features (with respect to the recipient); moreover, there was no difference in magnitude of priming when animacy features were the same across prime and target as when they were different. This effect held for both PO and DO structures relative to each other and relative to an intransitive baseline. Experiment 3 replicated this finding with a stronger manipulation of animacy, in which the recipient could not be interpreted in a way that incorporated any animacy features. Experiment 5 showed priming when the verb and the animacy of the recipient differed between prime and target, and the magnitude of priming was as strong under these conditions as when the prime and target involved the same animacy features. This effect held both for PO and DO structures relative to each other, and for PO structures relative to an intransitive baseline.

These results provide evidence that sentence processing in Mandarin involves representations that are specified for syntactic information independently of animacy information. Thus, although previous theoretical linguistic research has suggested that semantic information is fundamental in determining Mandarin word order (e.g., La Polla, 1995), and previous psycholinguistic studies have demonstrated that animacy plays an important role in Mandarin sentence processing (e.g., Miao 1981, 1986; Li, et al., 1993; Li, 1996), animacy information does not appear to be represented as an intrinsic part of the syntactic representation. If it had been, we would have expected no priming when the prime and target differed in animacy features, contrary to our findings.

Priming without verb repetition is indicative of the repetition of abstract (non-lexicalized) representations. The fact that we found abstract priming without animacy

repetition demonstrates that these abstract representations are syntactic rather than syntactic/semantic. In other words, this finding provides the strongest support for the claim that the processing of Mandarin involves the computation of autonomous syntactic representations.

None of the analyses of individual experiments showed an interaction between priming and animacy, and paired comparisons showed no difference in priming when animacy features were repeated versus when they were not. However, the combined analysis of Experiments 2 and 3 showed a marginal prime type by animacy interaction. The magnitude of this marginal effect (4%) was smaller than the significant boost to priming that we found when the verb was repeated across prime and target (13%). Given that priming occurred in the absence of animacy repetition, the presence or absence of this interaction does not affect our conclusions.

On the basis of previous research, we can suggest two possible explanations for this interaction. First, it might reflect a semantic boost to syntactic priming of the sort reported by Cleland & Pickering (2003), who found that syntactic priming for noun phrase structure was enhanced when the prime and target involved semantically related nouns than when they did not (see also Bernolet, Colleman, & Hartsuiker, 2014). But these experiments used nouns that were closely related (e.g., *sheep* vs. *goat*) rather than simply repeating whether they referred to animate entities or not. Alternatively, it may have a similar locus to Bock, Loebell, and Morey's (1992) finding that mappings of animacy features to grammatical functions could be primed in English.

Note that our conclusions concern representations constructed during comprehension but that our dependent measures are based on production. One might argue that comprehenders construct a single integrated representation but that only the syntactic properties of this representation are susceptible to priming in production.

This would mean that comprehenders might construct V NP_{ANIM} PP_{INAN} but the locus of priming would be V NP PP. But this account would imply that the syntactic (e.g., V NP PP) and semantic (animacy) components would not in fact be collapsed into an integrated representation. In fact this account would correspond to one in which syntactic and semantic representations are dissociated (though they may jointly constrain aspects of comprehension – for example, a rule of anaphoric interpretation might make reference to both representations).

In sum, our results suggest that, as in languages with stronger cues to syntactic structure such as English and German, Mandarin speakers compute independent syntactic representations during language processing. Of course, our results do not show that the processes by which these representations are computed are the same across languages. Indeed, processing evidence suggests that there may be important differences between such languages in the ways in which syntactic information and semantic information are brought to bear during processing (e.g., Cai & Dong, 2007; Zhang et al., 2010, 2013). Nevertheless, they suggest that the representational basis of language processing may be the same across languages with very different characteristics, with a fundamental distinction between the representation of information about structure and the representation of information about meaning.

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Notes

[1] To rule out a concern that semantic acceptability might have affected the results of Experiment 3 (because the inanimate entities were implausible recipients), we had twenty further participants rate the semantic acceptability of the inanimate recipient sentences from Experiment 3 on a five-point scale (with five being the most semantically acceptable). The mean acceptability was 3.74 (SD=0.65). Importantly, there was no significant correlation between the semantic acceptability of each sentence and its corresponding priming effect ($r=0.03$, $p=.80$), suggesting that variations in semantic acceptability did not influence priming.

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Appendix

Experimental materials. In the first sentence, the first braces show the animate/inanimate PO conditions; the second braces show the animate/inanimate DO conditions. The second sentence shows the baseline condition. The third sentence shows the DO version of the target.

	Experiments 1 and 2	Experiments 4 and 5	Experiment 3
1	妈妈抱(了西瓜给那个阿姨/商店)(给阿姨/商店一个西瓜) Mother handed {the watermelon to that aunt/store}{the aunt/store a watermelon} 领导到了 The leader arrived 医生抱给女孩一个花盆 The doctor handed the girl a flowerpot	妈妈送(了西瓜给那个阿姨/商店)(给阿姨/商店一个西瓜) Mother gave {the watermelon to that aunt/store}{the aunt/store a watermelon} 领导到了 The leader arrived 医生抱给女孩一个花盆 The doctor handed the girl a flowerpot	专家还(了一片绿洲给牧民/沙漠)(给牧民/沙漠一片绿洲)The expert returned{an oasis to the herdsman/desert}{the herdsman/ desert an oasis} 领导到了 The leader arrived 女孩还给歌手一份歌谱 The girl returned the singer a musical score
2	皇上赐(了珠宝/佛经给那个官员/祠庙)(给官员元/祠庙一箱珠宝/佛经)The emperor granted {the jewelry/ Buddhist texts to that officials/temple}{the officials/ temple a case of jewelry/a roll	富翁还(了轮船/汽车给那个海盗/工厂)(给海盗/工厂一艘轮船/一辆汽车)The rich man returned{the steamer/car to that pirate/factory}{the pirate/factory a steamer/car}	牧民赠(了一些肥料给邻居/草原)(给邻居/草原一些肥料)The herdsman bestowed-upon {some manure to the neighbor/prairie}{the neighbor/prairie some manure}

of Buddhist texts}

	工人下班了 The worker got off work	工人下班了 The worker got off work	工人下班了 The worker got off work
	王子赐给公主一个皇冠 The prince granted the princess a crown	王子赐给公主一个皇冠 The prince granted the princess a crown	王子赠给公主一个皇冠 The prince bestowed-upon the princess a crown
3	书记还(了桌子给那个大叔/商店)(给大叔/商店一张桌子)The clerk returned {the desk to that uncle/store}{the uncle/store a desk}	皇上赏(了珠宝/佛经给那个官员/祠庙)(给官员/祠庙一箱珠宝/佛经)The emperor awarded {the jewelry/ Buddhist texts to that officials/temple}{the officials /temple a case of jewelry/a roll of Buddhist texts}	飞行员抛(了一些炸弹给敌人/冰川)(给敌人/冰川一些炸弹)The pilot threw {some bombs to the enemy/glacier}{the enemy/glacier some bombs}
	敌人跑了 The enemy ran away	敌人跑了 The enemy ran away	敌人跑了 The enemy ran away
	女孩还给歌手一份歌谱 The girl returned the singer a musical score	女孩还给歌手一份歌谱 The girl returned the singer a musical score	道士抛给女巫一串炮竹 The taoist priest threw the witch a string of firecrackers
4	富翁借(了轮船/汽车给那个海盗/工厂)(给海盗/工厂一艘轮船/一辆汽车)The rich man lent{the steamer/car to that	富翁退(了房子/名画给那个秘书/店铺)(给秘书/店铺一套房子/一幅名画)The rich man restored {the house/famous	登山队留(了一串足迹给领队/雪山)(给领队/雪山一串足迹)The mountaineering team left {a string of footprints to

	pirate/ factory}{the pirate/factory a steamer/car}	painting to that secretary/ shop}{the secretary/ shop a house/a famous painting}	the leader/ snowy mountain }{the leader/snowy mountain a string of footprints}
	妈妈笑了 Mother smiled 修女借给渔夫一把雨伞 The nun lent the fisher an umbrella	妈妈笑了 Mother smiled 修女借给渔夫一把雨伞 The nun lent the fisher an umbrella	妈妈笑了 Mother smiled 画家留给鼓手一台空调 The painter left the drummer an air condition
5	经理/富翁买(了房子/名画给那个秘书/店铺)(给秘书/店铺一套房子/一幅名画)The manager/The rich man bought {the house /famous painting to that secretary/the shop}	书记赔(了木材给那个土豪/工厂)(给土豪/工厂一些木材)The clerk compensated {the timber to that local tyrant/factory} {the local tyrant/factory some timber}	游客丢(了一些硬币给乞丐/湖泊)(给乞丐/湖泊一些硬币)The tourists tossed {some coins to the beggar/lake}{the beggar/lake some coins}
	爸爸累了 Father was tired 护士买给男孩一束鲜花 The nurse bought the boy a flower	爸爸累了 Father was tired 护士买给男孩一束鲜花 The nurse bought the boy a flower	爸爸累了 Father was tired 公主丢给农民一个宝石 The princess tossed the farmer a gem
6	书记卖(了木材给那个土豪/工厂)(给土豪/工厂一些木材)The clerk sold {the timber to that local tyrant/factory}{the	厂商赠(了冰箱/粮食给那个顾客/军队)(给顾客/军队一台冰箱/一些粮食)The manufacturer bestowed-upon	女巫交(了一个灵魂给上帝/地狱)(给上帝/地狱一个灵魂)The witch submitted {a soul to the god/hell}{the god/hell

	local tyrant/factory some timber}	{the refrigerator/grain to that customer/army}{the customer/army a refrigerator/some grain}	a soul}
	敌人阵亡了 The enemy die 修女卖给医生一套沙发 The nun sold the doctor a sofa	敌人阵亡了 The enemy die 修女卖给医生一套沙发 The nun sold the doctor a sofa	敌人阵亡了 The enemy die 车手交给司机一个车牌 The racing driver submitted the chauffeur a license plate
7	厂商赔(了冰箱/粮食给那个顾客/军队)(给顾客/军队一台冰箱/一些粮食)The manufacturer compensated {the refrigerator/grain to that customer/army}{the customer/army a refrigerator/some grain}	老板租(了汽车给那个经理/工厂)(给经理/工厂一辆汽车)The employer rent {the car to that manager/factory}{the manager/factory a car}	考察团送(了一座电站给村民/峡谷)(给村民/峡谷一座电站)The exploratory mission gave {a power station to the villagers/valley}{the villagers/valley a power station}
	小矮人笑了 The dwarf smiled 空姐赔给交警一个喇叭 The airline stewardess compensated the traffic police a trumpet	小矮人笑了 The dwarf smiled 空姐赔给交警一个喇叭 The airline stewardess compensated the traffic police a trumpet	小矮人笑了 The dwarf smiled 官员送给渔夫一个宝石 The official gave the fisher the gem
8	老板配(了汽车给那个经理/工厂)(给经理/工厂一辆汽车	明星买(了唱片给那个助理/公司)(给助理/公司一张唱片)The	探险队配(了一些物资给居民/北极)(给居民/北极一些物

	)The employer distributed {the car to that manager/department}{the manager/department a car}	star bought {the record to that assistant/company}{the assistant/company a record}	资)The expedition distributed {some materials to the residents/the north pole}{ the residents/the north pole some materials}
	小宝宝醒了 The little baby woke up	小宝宝醒了 The little baby woke up	小宝宝醒了 The little baby woke up
	国王配给将军一辆大炮 The king distributed the general a cannon	国王配给将军一辆大炮 The king distributed the general a cannon	国王配给将军一辆大炮 The king distributed the general a cannon
9	明星送(了唱片给那个助理/公司)(给助理/公司一张唱片)The star gave {the record to that assistant/company}{the assistant/company a record}	老爷配(了聘礼/礼服给那个地主/乐队)(给地主/乐队一份聘礼/一件礼服)The milord distributed {the bride-price/the full dress to that landlord/band}{the landlord/band a bride-price/a full dress}	科学家带(了一个卫星给首领/宇宙)(给首领/宇宙一个卫星)The scientist brought {a satellite to the chieftain/universe}{the chieftain/universe a satellite}
	巫婆走了 The witch went out	巫婆走了 The witch went out	巫婆走了 The witch went out
	女孩送给画家一束鲜花 The girl gave the painter a flower	女孩送给画家一束鲜花 The girl gave the painter a flower	护士带给男孩一束鲜花 The nurse brought the boy the flower
10	老爷退(了聘礼/礼服给那个地	书记借(了桌子给那个大叔/商	开发商还(了一片安宁给居民

	主/商场)(给地主/商场一份聘礼/一件礼服)The milord restored {the bride-price/the full dress to that landlord/market}{the landlord/market a bride-price/a full dress}	店)(给大叔/商店一张桌子)The clerk lent {the desk to that uncle/store}{the uncle/store a desk}	/荒岛)(给居民/荒岛一片安宁)The developers returned {a peace to the residents/uninhabited island}{the residents/uninhabited island a peace}
	员工升职了 The staff got promoted	员工升职了 The staff got promoted	员工升职了 The staff got promoted
	爷爷退给厨师一个火腿 Grandfather restored the chef a ham	爷爷退给厨师一个火腿 Grandfather restored the chef a ham	空姐还给交警一个喇叭 The airline stewardess returned the traffic police a trumpet
11	将军交(了书信给那个下属/军队)(给下属/军队一封书信)The general submitted {the letter to that subordinate/army}{the subordinate/army a letter}	老板还(了合同给那个律师/公司)(给律师/公司一份合同)The employer returned {the contract to that lawyer/company}{the lawyer/company a contract}	酋长赠(了一些牛羊给牧民/草原)(给牧民/草原一些牛羊)The chieftain bestowed-upon {some flocks and herds to the herdsmen/prairie}{the herdsmen/prairie some flocks and herds}
	妹妹哭了 The sister cried	妹妹哭了 The sister cried	妹妹哭了 The sister cried
	车手交给司机一个车牌 The racing driver submitted the chauffeur a license plate	车手交给司机一个车牌 The racing driver submitted the chauffeur a license plate	天使赠给女孩一个糖果 The angel bestowed-upon the girl a candy

12	皇上赏(了银子给那个将军/王府)(给将军/王府一箱银子)The emperor awarded {the silver to that general/palace of a prince}{the general/palace of a prince a box of silver} 客人饿了 The guest was hungry 官员赏给渔夫一个宝石 The official awarded the fisher a gem	老板借(了场地给那个厂商/商场)(给厂商/商场一个场地)The employer lent {the site to that manufacturer/market}{the manufacturer/market a site} 客人饿了 The guest was hungry 官员赏给渔夫一个宝石 The official awarded the fisher a gem	天神留(了一堆灰烬给村民/火山)(给村民/火山一堆灰烬)The god left {a heap of ashes to the villagers/volcano}{the villagers/volcano a heap of ashes} 客人饿了 The guest was hungry 修女留给渔夫一把雨伞 The nun left the fisher an umbrella
13	老板租(了场地给那个厂商/商场)(给厂商/商场一个场地)The employer rent the site to that manufacturer/market}{the manufacturer/market a site} 小明病了 XiaoMing was ill 裁缝租给模特一件衣服 The dressmaker rent the model a piece of clothing	皇上赐(了银子给那个将军/王府)(给将军/王府一箱银子)The emperor granted {the silver to that general/palace of a prince}{the general/palace of a prince a box of silver} 小明病了 XiaoMing was ill 裁缝租给模特一件衣服 The dressmaker rent the model a piece of clothing	科学家丢(了一个难题给人类/宇宙)(给人类/宇宙一个难题)The scientist tossed {a problem to the human/universe}{the human/universe a problem} 小明病了 XiaoMing was ill 财神丢给球员一些钞票 The god of wealth tossed the footballer some bills
14	大臣赠(了礼物给那个公主/教	大臣买(了礼物给那个公主/教	人类交(了一份答卷给上帝/

	堂)(给公主/教堂一份礼物)The minister bestowed-upon {the gift to that princess/church}{ the princess/church a gift} 弟弟醒了 The young brother woke up 天使赠给女孩一个糖果 The angel bestowed-upon the girl a candy	堂)(给公主/教堂一份礼物)The minister bought {the gift to that princess/church}{ the princess/church a gift} 弟弟醒了 The young brother woke up 天使赠给女孩一个糖果 The angel bestowed-upon the girl a candy	宇宙)(给人类/宇宙一份答卷)The human submitted {a paper to the god/universe}{the god/universe a paper} 弟弟醒了 The young brother woke up 裁缝交给模特一件衣服 The dressmaker submitted the model a piece of clothing
15	铁匠留(了店铺给那个徒弟/社区)(给徒弟/社区一间店铺)The blacksmith left {the store to that apprentice/community}{ the apprentice/community a store} 妹妹跌倒了 The younger sister fell down 画家留给鼓手一台空调 The painter left the drummer an air condition	铁匠交(了店铺给那个徒弟/社区)(给徒弟/社区一间店铺)The blacksmith submitted {the store to that apprentice/community}{ the apprentice/community a store} 妹妹跌倒了 The younger sister fell down 画家留给鼓手一台空调 The painter left the drummer an air condition	环保者送(了一些植被给市民/沙漠)(给市民/沙漠一些植被)The environmentalists gave {some vegetation to the citizens/desert}{the citizens/desert some vegetation} 妹妹跌倒了 The younger sister fell down 女孩送给画家一束鲜花 The girl gave the painter a flower
16	叔叔抱(了篮球给那个男孩/学	叔叔送(了篮球给那个男孩/学	科考队配(了一个基站给专家

	校)(给男孩/学校一个篮球)The uncle handed {the basketball to that boy/school}{the boy/school a basketball}	校)(给男孩/学校一个篮球)The uncle gave {the basketball to that boy/school}{the boy/school a basketball}	/北极)(给专家/北极一个基站)The scientific expedition team distributed {a base station to the experts/the north pole}{the experts/the north pole a base station}
	巫婆上当了 The witch was cheated	巫婆上当了 The witch was cheated	巫婆上当了 The witch was cheated
	奶奶抱给车手一个椰子 Grandmother handed the racing driver a coconut	奶奶抱给车手一个椰子 Grandmother handed the racing driver a coconut	导演配给司机一辆的士 The director distributed the driver a taxi
17	将军赐(了宝剑/佛像给那个侍卫/寺庙)(给侍卫/寺庙一把宝剑/一尊佛像)The general granted {the sword/Buddha to that bodyguards/temple}{the bodyguards/temple a sword/a figure of Buddha}	保安借(了钥匙给那个户主/公司)(给户主/公司一串钥匙)The security lent {the key to that head of a household/company}{the head of a household/company a key}	水手带(了一些污染给渔民/海洋)(给渔民/海洋一些污染)The sailor brought {some pollution to the fishermen/sea}{the fishermen/sea some pollution}
	孩子睡了 The child was asleep	孩子睡了 The child was asleep	孩子睡了 The child was asleep
	皇后赐给骑士一个小岛 The queen granted the knight a	皇后赐给骑士一个小岛 The queen granted the knight a	爷爷带给厨师一个火腿。 Grandfather brought the chef

	small island	small island	the ham
18	保安还(了钥匙给那个户主/公司)(给户主/公司一串钥匙)The security returned {the key to that head of a household/company}{the head of a household/company a key}	将军赏(了宝剑/佛像给那个侍卫/寺庙)(给侍卫/寺庙一把宝剑/一尊佛像)The general awarded {the sword/Buddha to that bodyguards/temple}{the bodyguards/temple a sword/a figure of Buddha}	总统赠(了一件礼物给市民/火星)(给市民/火星一件礼物)The president bestowed-upon {a gift to the citizens/Mars}{ the citizens/Mars a gift}
	小明跌倒了 Xiao Ming fell down	小明跌倒了 Xiao Ming fell down	小明跌倒了 Xiao Ming fell down
	警察还给孕妇一本护照 The policeman returned the pregnant woman a passport	警察还给孕妇一本护照 The policeman returned the pregnant woman a passport	歌手赠给空姐一台钢琴 The singer bestowed-upon the airline stewardess a piano
19	老板借(了合同给那个律师/公司)(给律师/公司一份合同)The employer lent {the contract to that lawyer/company}{the lawyer/company a contract}	将军留(了书信给那个下属/军队)(给下属/军队一封书信)The general left {the letter to that subordinate/army}{the subordinate/army a letter}	小孩抛(了一块石头给村民/池塘)(给村民/池塘一块石头)The child threw {a stone to the villagers/pond}{the villagers/pond a stone}
	消防员牺牲了 The fireman was sacrificed	消防员牺牲了 The fireman was sacrificed	消防员牺牲了 The fireman was sacrificed
	财神借给球员一些钞票 The	财神借给球员一些钞票 The	奶奶抛给车手一个椰子

	god of wealth lent the footballer some bills	god of wealth lent the footballer some bills	Grandmother threw the racing driver a coconut
20	经理买(了名画/电脑给那个贵妇/部门)(给贵妇/部门一幅名画/一台电脑)The manager bought {the famous painting/computer to that lady boutique/department}{the lady boutique/department a famous painting/a computer}	经理抱(了名画/电脑给那个贵妇/部门)(给贵妇/部门一幅名画/一台电脑)The manager handed {the famous painting/computer to that lady boutique/department}{the lady boutique/department a famous painting/a computer}	祖先留(了一些宝藏给子孙/峡谷)(给子孙/峡谷一些宝藏)The ancestor left {some precious deposits to the descendants /valley}{the descendants/valley some precious deposits}
	姨妈退休了 The maternal aunt retired	姨妈退休了 The maternal aunt retired	姨妈退休了 The maternal aunt retired
	歌手买给空姐一台空调 The singer bought the airline stewardess an air condition	歌手买给空姐一台空调 The singer bought the airline stewardess an air condition	修女留给医生一套沙发 The nun left the doctor a sofa
21	贩子卖(了药材给那个商人/商店)(了商人/商店一些药材)The dealer sold {the medicinal materials to that merchant/store}{the merchant/store some medicinal materials}	贩子赔(了药材给那个商人/商店)(了商人/商店一些药材)The dealer compensated {the medicinal materials to that merchant /store} store {the merchant/store some medicinal materials}	敌人丢(了一个导弹给红军/荒岛)(给红军/荒岛一个导弹)The enemy tossed {a bomb to the Red Army/uninhabited island}{the Red Army/uninhabited island a bomb}

	爸爸来了 Father came 爷爷卖给渔夫一张渔网 Grandfather sold the fisher a fishing net	爸爸来了 Father came 爷爷卖给渔夫一张渔网 Grandfather sold the fisher a fishing net	爸爸来了 Father came 超人丢给小新一个球拍 The superman tossed Xiaoxing a racket
22	班长赔(了字典给那个同学/班级)(给同学/班级一本字典)The monitor compensated {the dictionary to that classmate/class}{the classmate/class a dictionary}	班长赠(了字典给那个同学/班级)(给同学/班级一本字典)The monitor bestowed-upon {the dictionary to that classmate/class}{the classmate/class a dictionary}	工程师交(了一份报告给主管/电站)(给主管/电站一份报告)The engineer submitted {a report to the supervisor/power station}{the supervisor/power station a report}
	小明跑了 Xiao Ming ran away 导演赔给模特一枚戒指 The director compensated the model a ring	小明跑了 Xiao Ming ran away 导演赔给模特一枚戒指 The director compensated the model a ring	小明跑了 Xiao Ming ran away 司机交给邮差一辆货车 The driver submitted the postman a truck
23	皇上配(了轿子给那个大臣/王府)(给大臣/王府一顶轿子)The emperor distributed {the sedan chair to that minister/palace of a prince}{the minister/palace of a prince a sedan chair}	皇上租(了轿子给那个大臣/王府)(给大臣/王府一顶轿子)The emperor rent {the sedan chair to that minister/palace of a prince}{the minister/palace of a prince a sedan chair}	群众送(了一些物资给灾民/草原)(给灾民/草原一些物资)The masses gave {some materials to the victims/prairie}{the victims/prairie some materials}

	巫婆上当了 The witch was tricked 导演配给司机一把钥匙 The director distributed the driver a key	巫婆上当了 The witch was tricked 导演配给司机一把钥匙 The director distributed the driver a key	巫婆上当了 The witch was tricked 仙女送给牧童一个海螺 The fairy gave the shepherd boy a conch
24	红军送(了粮食给那个大娘/战区)(给大娘/战区一些粮食)The Red Army gave {the grain to that aunt/war zone}{the aunt/war zone some grain} 叔叔来了 The uncle came 仙女送给牧童一个海螺 The fairy gave the shepherd boy a conch	法官赐(了金钱给那个证人/团队)(给证人/团队一些金钱)The judge granted {the money to that witness/team}{the witness/team some money} 叔叔来了 The uncle came 仙女送给牧童一个海螺 The fairy gave the shepherd boy a conch	专家配(了一个探测仪给队员/火山)(给队员一个探测仪)The experts distributed {a detecting instrument to the team member/volcano}{the team member/volcano a detecting instrument} 叔叔来了 The uncle came 导演配给保姆一把 The director distributed the nanny a key
25	主任退(了货物给那个老总/工厂)(给老总/工厂一批货物)The director restored {the cargo to that general manager/factory}{the general manager/factory a batch of	主任配(了货物给那个老总/工厂)(给老总/工厂一批货物)The director distributed {the cargo to that general manager/factory}{the general manager/factory a batch of	考察队带(了一些标本给专家/北极)(给专家/北极一些标本)The expedition brought {some specimens to the experts/north pole}{the experts/north pole some

	cargo}	cargo}	specimens}
	工人下岗了 The worker was laid-off	工人下岗了 The worker was laid-off	工人下岗了 The worker was laid-off
	孕妇退给医生一些胶囊 The pregnant woman restored the doctor some capsules	孕妇退给医生一些胶囊 The pregnant woman restored the doctor some capsules	女孩带给歌手一份歌谱 The girl brought the singer a musical score
26	家长交(了学费给那个老师/学校)(给老师/学校一些学费)The parents submitted {the tuition to that teacher/school}{the teacher/school some tuition}	家长留(了学费给那个老师/学校)(给老师/学校一些学费)The parents left {the tuition to that teacher/school}{the teacher/school some tuition}	播种者抛(了一些种子给园丁/草坪)(给园丁/草坪一些种子)The sower threw {some seeds to the gardener/lawn}{the gardener/lawn some seeds}
	明星迟到了 The star was late	明星迟到了 The star was late	明星迟到了 The star was late
	囚犯交给警察一把手枪 The prisoner submitted the policeman a gun	囚犯交给警察一把手枪 The prisoner submitted the policeman a gun	爷爷抛给渔夫一张渔网 Grandfather threw the fisher a fishing net
27	法官赏(了金钱给那个证人/团队)(给证人/团队一些金钱)The judge awarded {the money to that witness/team}{the witness/team some money}	红军买(了粮食给那个大娘/战区)(给大娘/战区一些粮食)The Red Army bought {the grain to that aunt/war zone}{the aunt/war zone some grain}	游客留(了一堆废物给向导/雪山)(给向导/雪山一堆废物)The tourists left {a heap of coins to the guide/snowy mountain}{the guide/snowy mountain {a heap of coins}
	工人辞职了 The worker	工人辞职了 The worker	工人辞职了 The worker

	resigned 国王赏给士兵一座城堡 The king awarded the soldier a castle	resigned 国王赏给士兵一座城堡 The king awarded the soldier a castle	resigned 奶奶留给工人一副手套 Grandmother left the worker a pair of gloves
28	导演租(了道具给那个编剧/剧组)(给编剧/剧组一些道具)The director rent {the property to that scriptwriter/crew}{the scriptwriter/crew a property} 士兵阵亡了 The soldiers die 司机租给邮差一辆货车 The driver rent the postman a truck	导演卖(了道具给那个编剧/剧组)(给编剧/剧组一些道具)The director sold {the property to that scriptwriter/crew}{the scriptwriter/crew a property} 士兵阵亡了 The soldiers die 司机租给邮差一辆货车 The driver rent the postman a truck	宇航员送(了一面红旗给战友/太空)(给战友/太空一面红旗)The astronaut gave {a flag to the comrade in arms/space}{the comrade in arms/space a flag} 士兵阵亡了 The soldiers die 导演送给模特一枚戒指 The director gave the model a ring
29	皇上赠(了粮食给那个首领/村子)(给首领/村子一些粮食)The emperor bestowed-upon {the grain to that chieftain/village}{the chieftain/village some grain} 小孩哭了 The child cried	皇上退(了粮食给那个首领/村子)(给首领/村子一些粮食)The emperor restored {the grain to that chieftain/village}{the chieftain/village some grain} 小孩哭了 The child cried	消防员配(了一些灭火器给居民/森林)(给居民/森林一些灭火器)The firemen distributed {some extinguishers to the residents/forest}{the residents/forest some extinguishers} 小孩哭了 The child cried

	老师赠给男孩一副球拍 The teacher bestowed-upon the boy a racket	老师赠给男孩一副球拍 The teacher bestowed-upon the boy a racket	王子配给将军一把匕首 The prince distributed the general a dagger
30	作家留(了遗书给那个保姆/报社)(给保姆/报社一封遗书)The writer left {the posthumous paper to that nanny/newspaper office}{the nanny/newspaper office a posthumous paper} 巫婆晕了 The witch fainted 奶奶留给工人一副手套 Grandmother left the worker a pair of gloves	作家交(了遗书给那个保姆/报社)(给保姆/报社一封遗书)The writer submitted {the posthumous paper to that nanny/newspaper office}{the nanny/newspaper office a posthumous paper} 巫婆晕了 The witch fainted 奶奶留给工人一副手套 Grandmother left the worker a pair of gloves	导游带(了一些鲜花给商人/沙漠)(给商人/沙漠一些鲜花)The tour guide brought {some flowers to the merchant/desert}{the merchant/desert some flowers} 巫婆晕了 The witch fainted 奶奶带给保姆一些蘑菇 Grandmother brought the nanny some mushrooms
	1		
	2		

Figures

Figure 1. Example target picture

Figure 2. Example filler picture

1

2 Figure 1.

女孩送_____。

3

4

Figure 2.