The independence of syntactic processing in Mandarin

Citation for published version:

Digital Object Identifier (DOI):
10.1016/j.jml.2016.02.005

Link:
Link to publication record in Edinburgh Research Explorer

Document Version:
Peer reviewed version

Published in:
Journal of Memory and Language

General rights
Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy
The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact openaccess@ed.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.
The independence of syntactic processing in Mandarin: Evidence from structural priming

Jian Huang¹, Martin J. Pickering², Juanhua Yang¹, Suiping Wang¹,³*, Holly P. Branigan²*

¹Center for the Study of Applied Psychology and School of Psychology, South China Normal University

²Department of Psychology, University of Edinburgh

³Guangdong Provincial Key Laboratory of Mental Health and Cognitive Science, South China Normal University

*Corresponding authors

Suiping Wang
School of Psychology, South China Normal University, Shipai, Guangzhou 510631, P.R. China.
email: wangsuiping@m.scnu.edu.cn

Holly P. Branigan
Department of Psychology, University of Edinburgh
email: holly.branigan@ed.ac.uk

Keywords: Mandarin, Chinese, Animacy, Syntax, Structural Priming
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, Pearlmuter, & 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
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,

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 boys 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 boats 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\_AN \_IN AN PP\_AN IM \_AN], 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\_AN \_IN AN PP\_AN IM \_AN] in one
case vs. VP[V NPI\_AN IM \_AN PP\_AN IM \_AN] 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\_AN IM, Theme\_IN AN, Recipient\_AN IM). 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 with 90 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 Table 1. 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).

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

<table>
<thead>
<tr>
<th>Prime Condition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a. PO-An</td>
<td><em>Mingxing song le changpian gei nage zhuli.</em></td>
</tr>
<tr>
<td></td>
<td>The superstar give LE record to that assistant. (“The superstar gave the record to that assistant.”)</td>
</tr>
<tr>
<td>1b. DO-An</td>
<td><em>Mingxing song-gei zhuli yizhang changpian.</em></td>
</tr>
<tr>
<td></td>
<td>The superstar give-to assistant one record.</td>
</tr>
</tbody>
</table>
The superstar give LE record to that company. ("The superstar gave the record to that company.")

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 200 ms, 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: \( \chi^2 = 67.99, p < .001 \)). 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

<table>
<thead>
<tr>
<th>Prime</th>
<th>PO-An</th>
<th>DO-An</th>
<th>Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO</td>
<td>51</td>
<td>130</td>
<td>86</td>
</tr>
<tr>
<td>PO</td>
<td>188</td>
<td>108</td>
<td>152</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Proportion DO</td>
<td>.21</td>
<td>.54</td>
<td>.36</td>
</tr>
</tbody>
</table>
Experiment 1: Results of pair-wise comparisons on DO responses

<table>
<thead>
<tr>
<th>Prime pairs</th>
<th>Estimate</th>
<th>SE</th>
<th>Z</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO-An vs. PO-An</td>
<td>1.79</td>
<td>.23</td>
<td>7.77</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>DO-An vs. baseline</td>
<td>.93</td>
<td>.21</td>
<td>4.43</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>baseline vs. PO-An</td>
<td>.86</td>
<td>.23</td>
<td>3.80</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

**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: χ² = 141.47, p < .001). Pair-wise comparisons (Table 5) indicated that as in Experiment 1, 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

<table>
<thead>
<tr>
<th>prime</th>
<th>PO-An</th>
<th>DO-An</th>
<th>PO-In</th>
<th>DO-In</th>
<th>baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO</td>
<td>47</td>
<td>135</td>
<td>57</td>
<td>127</td>
<td>106</td>
</tr>
<tr>
<td>PO</td>
<td>163</td>
<td>75</td>
<td>153</td>
<td>82</td>
<td>101</td>
</tr>
<tr>
<td>Others</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Proportion DO</td>
<td>.22</td>
<td>.64</td>
<td>.27</td>
<td>.60</td>
<td>.50</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Prime pairs</th>
<th>Estimate</th>
<th>SE</th>
<th>Z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO-An vs. Baseline</td>
<td>.64</td>
<td>.21</td>
<td>3.01</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>DO-In vs. Baseline</td>
<td>.46</td>
<td>.21</td>
<td>2.19</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Baseline vs. PO-An</td>
<td>1.39</td>
<td>.23</td>
<td>6.12</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Baseline vs. PO-In</td>
<td>1.12</td>
<td>.22</td>
<td>5.08</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>
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)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>2a. PO-An</td>
<td><em>Huanbaozhe song le yixie zhibei gei shiming.</em> The environmentalist give LE some plant to citizens. (“The environmentalist gave some plant to the citizens.”)</td>
</tr>
<tr>
<td>2b. DO-An</td>
<td><em>Huanbaozhe song-gei shiming yixie zhibei.</em> The environmentalist give-to citizens some plant. (“The environmentalist gave the citizens some plant.”)</td>
</tr>
<tr>
<td>2c. PO-In</td>
<td><em>Huanbaozhe song le yixie zhibei gei shamo.</em> The environmentalist give LE some plant to desert. (“The environmentalist gave some plant to the desert.”)</td>
</tr>
<tr>
<td>2d. DO-In</td>
<td><em>Huanbaozhe song-gei shamo yixie zhibei.</em> The environmentalist give-to desert some plant. (“The environmentalist gave the desert some plant.”)</td>
</tr>
<tr>
<td>2e. Baseline</td>
<td><em>Wypo zou le.</em> The witch go LE. (“The witch has gone.”)</td>
</tr>
</tbody>
</table>

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
A 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: $\chi^2 = 90.58$, p < .001). Pair-wise comparisons (Table 8) indicated that, as in Experiments 1 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

<table>
<thead>
<tr>
<th>prime</th>
<th>PO-An</th>
<th>DO-An</th>
<th>PO-In</th>
<th>DO-In</th>
<th>Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO</td>
<td>54</td>
<td>124</td>
<td>60</td>
<td>116</td>
<td>91</td>
</tr>
<tr>
<td>PO</td>
<td>156</td>
<td>86</td>
<td>150</td>
<td>94</td>
<td>119</td>
</tr>
<tr>
<td>Others</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Proportion DO</td>
<td>.26</td>
<td>.59</td>
<td>.29</td>
<td>.55</td>
<td>.43</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Prime pairs</th>
<th>estimate</th>
<th>SE</th>
<th>Z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO-An vs Baseline</td>
<td>.73</td>
<td>.21</td>
<td>3.43</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>DO-In vs Baseline</td>
<td>.55</td>
<td>.21</td>
<td>2.61</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Baseline vs PO-An</td>
<td>.91</td>
<td>.23</td>
<td>4.02</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Baseline vs PO-In</td>
<td>.74</td>
<td>.22</td>
<td>3.36</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

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.
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

<table>
<thead>
<tr>
<th>Condition</th>
<th>Examples</th>
</tr>
</thead>
</table>
| 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: $\chi^2 = 7.83$, $p < .05$). 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**

<table>
<thead>
<tr>
<th>Prime</th>
<th>PO-An</th>
<th>DO-An</th>
<th>Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO</td>
<td>87</td>
<td>128</td>
<td>109</td>
</tr>
<tr>
<td>PO</td>
<td>151</td>
<td>110</td>
<td>130</td>
</tr>
<tr>
<td>Others</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Proportion DO</td>
<td>.36</td>
<td>.53</td>
<td>.45</td>
</tr>
</tbody>
</table>
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).

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

<table>
<thead>
<tr>
<th>Prime pairs</th>
<th>estimate</th>
<th>SE</th>
<th>Z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO-An vs PO-An</td>
<td>.84</td>
<td>.28</td>
<td>2.98</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>DO-An vs baseline</td>
<td>.35</td>
<td>.20</td>
<td>1.72</td>
<td>=.09</td>
</tr>
<tr>
<td>baseline vs PO-An</td>
<td>.49</td>
<td>.25</td>
<td>1.99</td>
<td>&lt;.05</td>
</tr>
</tbody>
</table>
**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: $\chi^2$=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

<table>
<thead>
<tr>
<th>Prime</th>
<th>PO-An</th>
<th>DO-An</th>
<th>PO-In</th>
<th>DO-In</th>
<th>Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO</td>
<td>81</td>
<td>111</td>
<td>82</td>
<td>103</td>
<td>108</td>
</tr>
<tr>
<td>PO</td>
<td>128</td>
<td>99</td>
<td>128</td>
<td>107</td>
<td>102</td>
</tr>
<tr>
<td>Others</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Proportion DO</td>
<td>.39</td>
<td>.53</td>
<td>.39</td>
<td>.49</td>
<td>.51</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Prime pairs</th>
<th>estimate</th>
<th>SE</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO-An vs baseline</td>
<td>.06</td>
<td>.20</td>
<td>.31</td>
<td>.75</td>
</tr>
<tr>
<td>DO-In vs baseline</td>
<td>-.10</td>
<td>.20</td>
<td>-.50</td>
<td>.62</td>
</tr>
<tr>
<td>baseline vs PO-An</td>
<td>.57</td>
<td>.21</td>
<td>2.74</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>baseline vs PO-In</td>
<td>.55</td>
<td>.21</td>
<td>2.65</td>
<td>&lt;.01</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Prime pairs</th>
<th>Estimate</th>
<th>SE</th>
<th>z</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO-An(Exp2) vs. PO-An(Exp5)</td>
<td>-.85</td>
<td>.28</td>
<td>-3.02</td>
<td>&lt; .01</td>
</tr>
<tr>
<td>PO-In (Exp2) vs. PO-In(Exp5)</td>
<td>-.60</td>
<td>.28</td>
<td>-2.15</td>
<td>&lt; .05</td>
</tr>
<tr>
<td>DO-An (Exp2) vs. DO-An(Exp5)</td>
<td>.53</td>
<td>.27</td>
<td>1.96</td>
<td>&lt; .05</td>
</tr>
<tr>
<td>DO-In (Exp2) vs. DO-In(Exp5)</td>
<td>.52</td>
<td>.27</td>
<td>1.94</td>
<td>= .05</td>
</tr>
</tbody>
</table>

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 $V \text{NP}_{\text{ANIM}} \text{PP}_{\text{INAN}}$ but the locus of priming would be $V \text{NP} \text{PP}$. But this account would imply that the syntactic (e.g., $V \text{NP} \text{PP}$) 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.
Acknowledgements

This research was supported by a Royal Society of Edinburgh/National Science Foundation of China research grant awarded to SW and HB. HB was supported by a British Academy/Leverhulme Trust Senior Research Fellowship. SW was supported by the Guangdong Province Universities and Colleges Pearl River Scholar Funded Scheme (GDUPS 2011) in China. JH was supported by the Guangzhou Philosophy and Social Science Foundation (14Q15).
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.
References


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.

<table>
<thead>
<tr>
<th>Experiments 1 and 2</th>
<th>Experiments 4 and 5</th>
<th>Experiment 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>妈妈抱(了西瓜给那个阿姨/商店)(给阿姨/商店一个西瓜)</td>
<td>妈妈送(了西瓜给那个阿姨/商店)(给阿姨/商店一个西瓜)</td>
<td>专家还(了一片绿洲给牧民/沙漠)(给牧民/沙漠一片绿洲)</td>
</tr>
<tr>
<td>Mother handed {the watermelon to that aunt/store}{the aunt/store a watermelon}</td>
<td>Mother gave {the watermelon to that aunt/store}{the aunt/store a watermelon}</td>
<td>The expert returned{an oasis to the herdsman/desert}{the herdsman/desert an oasis}</td>
</tr>
<tr>
<td>领导到了 The leader arrived</td>
<td>领导到了 The leader arrived</td>
<td>领导到了 The leader arrived</td>
</tr>
<tr>
<td>医生抱给女孩一个花盆 The doctor handed the girl a flowerpot</td>
<td>医生抱给女孩一个花盆 The doctor handed the girl a flowerpot</td>
<td>女孩还给歌手一份歌谱 The girl returned the singer a musical score</td>
</tr>
<tr>
<td>皇上赐(了珠宝/佛经给那个官/祠庙)(给官员/祠庙一箱珠宝/佛经)</td>
<td>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)</td>
<td>牧民赠(了一些肥料给邻居/草原)(给邻居/草原一些肥料)</td>
</tr>
<tr>
<td>The emperor granted {the jewelry/Buddhist texts to that pirate/factory}{the officials/temple a case of jewelry/a roll}</td>
<td>The rich man returned{the steamer/car to that pirate/factory}{the officials/temple a steamer/car}</td>
<td>The herdsman bestowed-upon {some manure to the neighbor/prairie}{the neighbor/prairie some manure}</td>
</tr>
</tbody>
</table>
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 bestowed upon the princess a crown
书记还(了桌子给那个大叔/商店)(给了大叔/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/一卷佛经)The emperor awarded {the jewelry/Buddhist texts to that officials/temple}{the officials/temple a case of jewelry/a roll of Buddhist texts}
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 pirate/ factory}{the pirate/ factory a steamer/car}
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 that guide/mountain}{the guide/mountain a string of footprints}
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
道士抛给女巫一串炮竹 The taoist priest threw the witch a string of firecrackers
pirate/ factory}{the painting to that secretary/ the leader/ snowy mountain
pirate/factory a steamer/car} shop}{the secretary/ shop a house/a famous painting} \{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 painter left the drummer an air condition

经理/富翁买(了房子/名画给)给土豪/工厂 The clerk compensated {the timber to that local tyrant/factory} to the beggar/lake\{the coins to the beggar/lake\}

一套房子/一幅名画)The manager/The rich man bought {the house /famous painting to that secretary/the shop}

爸爸累了 Father was tired

护士买给男孩一束鲜花 The nurse bought the boy a flower princess tossed the farmer a gem

记者卖(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} to the god/hell\{the soul to the god/hell\}

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}
local tyrant/factory some timber} customer/army}{the customer/army a refrigerator/some grain}

The enemy die 敌人阵亡了

nun sold the doctor a sofa

The nun sold the doctor a sofa

racing driver submitted the chauffeur a license plate

customer/army}{the

customer/army a

manufacturer compensated {the refrigerator/grain to that customer/army}{the
customer/army a

refrigerator/some grain}

The enemy die 敌人阵亡了

The nun sold the doctor a sofa

racing driver submitted the chauffeur a license plate

The enemy die 敌人阵亡了

7 厂商配(了冰箱/粮食给那个顾客/军队)The employer rent {the car to that manager/factory}{the

manager/factory a car}

customer/army}{the

customer/army a

refrigerator/some grain}

The enemy die 敌人阵亡了

The nun sold the doctor a sofa

racing driver submitted the chauffeur a license plate

The enemy die 敌人阵亡了

8 老板配(了汽车给那个经理/工厂)The The official gave the fisher the

airline stewardess compensated the traffic police a trumpet

The airline stewardess compensated the traffic police a trumpet

The nun sold the doctor a sofa

racing driver submitted the chauffeur a license plate

The enemy die 敌人阵亡了

The nun sold the doctor a sofa

racing driver submitted the chauffeur a license plate

The enemy die 敌人阵亡了

The nun sold the doctor a sofa

racing driver submitted the chauffeur a license plate

The enemy die 敌人阵亡了
The employer distributed the car to that manager/department. The manager/department bought the record to that assistant/company. The expedition distributed some materials to the residents/the north pole.

The little baby woke up. The king distributed the general a cannon.

The star gave the record to the assistant/company. The milord distributed the bride-price/the full dress to that landlord/band.

The witch went out. The girl gave the painter a flower.

The royal family gave the general a cannon. The scientist brought a satellite to the chieftain/universe.

The ladies gave the painter a flower. The nurse brought the boy the flower.

The slow sacrificed the horse to the girl. The manager/department bought the record to the assistant/company.
The milord restored {the bride-price/the full dress to that landlord/market} to the landlord/market.a bride-price/a full dress.

The clerk lent {the desk to that uncle/store} to the uncle/store.a desk.

The employer returned {the contract to that lawyer/company} to the lawyer/company.a contract.

The chieftain bestowed- upon {some flocks and herds to the herdsmen/prairie} to the herdsmen/prairie some flocks and herds.

The general submitted {the letter to that subordinate/army} to the subordinate/army.a letter.

The angel bestowed- upon the girl a candy.

The sister cried.

The racing driver submitted the racing driver a license plate to the chauffeur a license plate.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.

The staff got promoted.
The emperor awarded {the silver to that general/palace of a prince}{the general/palace of a prince a box of silver}

The employer lent {the site to that manufacturer/market}{the manufacturer/market a site}

The god left {a heap of ashes to the villagers/volcano}{the villagers/volcano a heap of ashes}

The employer rented {the site to that manufacturer/market}{the manufacturer/market a site}

The scientist tossed {a problem to the human/universe}{the human/universe a problem}

XiaoMing was ill

The dressmaker rented the model a piece of clothing

The god of wealth tossed the footballer some bills
The minister bestowed a gift to the princess/church.
The minister bought the princess/church a gift.
The human submitted a paper to the god/universe.
The minister bought the princess/church a gift.
The human submitted the god/universe a paper.
The young brother woke up.
The young brother woke up.
The young brother woke up.
The angel bestowed upon the girl a candy.
The dressmaker submitted the model a piece of clothing.
The blacksmith submitted the apprentice/community a store.
The environmentalists gave some vegetation to the citizens/desert.
The younger sister fell down.
The younger sister fell down.
The younger sister fell down.
The painter left the drummer an air condition.
The girl gave the painter a flower.
The environmentalists gave some vegetation to the citizen/desert.
The painter left the drummer an air condition.
The girl gave the painter a flower.

The minister bestowed a gift to the princess/church.
The minister bought the princess/church a gift.
The human submitted a paper to the god/universe.
The minister bought the princess/church a gift.
The human submitted the god/universe a paper.
The young brother woke up.
The young brother woke up.
The young brother woke up.
The angel bestowed upon the girl a candy.
The dressmaker submitted the model a piece of clothing.
The blacksmith submitted the apprentice/community a store.
The environmentalists gave some vegetation to the citizens/desert.
The younger sister fell down.
The younger sister fell down.
The younger sister fell down.
The painter left the drummer an air condition.
The girl gave the painter a flower.

The minister bestowed a gift to the princess/church.
The minister bought the princess/church a gift.
The human submitted a paper to the god/universe.
The minister bought the princess/church a gift.
The human submitted the god/universe a paper.
The young brother woke up.
The young brother woke up.
The young brother woke up.
The angel bestowed upon the girl a candy.
The dressmaker submitted the model a piece of clothing.
The blacksmith submitted the apprentice/community a store.
The environmentalists gave some vegetation to the citizens/desert.
The younger sister fell down.
The younger sister fell down.
The younger sister fell down.
The painter left the drummer an air condition.
The girl gave the painter a flower.

The minister bestowed a gift to the princess/church.
The minister bought the princess/church a gift.
The human submitted a paper to the god/universe.
The minister bought the princess/church a gift.
The human submitted the god/universe a paper.
The young brother woke up.
The young brother woke up.
The young brother woke up.
The angel bestowed upon the girl a candy.
The dressmaker submitted the model a piece of clothing.
The blacksmith submitted the apprentice/community a store.
The environmentalists gave some vegetation to the citizens/desert.
The younger sister fell down.
The younger sister fell down.
The younger sister fell down.
The painter left the drummer an air condition.
The girl gave the painter a flower.

The minister bestowed a gift to the princess/church.
The minister bought the princess/church a gift.
The human submitted a paper to the god/universe.
The minister bought the princess/church a gift.
The human submitted the god/universe a paper.
The young brother woke up.
The young brother woke up.
The young brother woke up.
The angel bestowed upon the girl a candy.
The dressmaker submitted the model a piece of clothing.
The blacksmith submitted the apprentice/community a store.
The environmentalists gave some vegetation to the citizens/desert.
The younger sister fell down.
The younger sister fell down.
The younger sister fell down.
The painter left the drummer an air condition.
The girl gave the painter a flower.

The minister bestowed a gift to the princess/church.
The minister bought the princess/church a gift.
The human submitted a paper to the god/universe.
The minister bought the princess/church a gift.
The human submitted the god/universe a paper.
The young brother woke up.
The young brother woke up.
The young brother woke up.
The angel bestowed upon the girl a candy.
The dressmaker submitted the model a piece of clothing.
The blacksmith submitted the apprentice/community a store.
The environmentalists gave some vegetation to the citizens/desert.
The younger sister fell down.
The younger sister fell down.
The younger sister fell down.
The painter left the drummer an air condition.
The girl gave the painter a flower.

The minister bestowed a gift to the princess/church.
The minister bought the princess/church a gift.
The human submitted a paper to the god/universe.
The minister bought the princess/church a gift.
The human submitted the god/universe a paper.
The young brother woke up.
The young brother woke up.
The young brother woke up.
The angel bestowed upon the girl a candy.
The dressmaker submitted the model a piece of clothing.
The blacksmith submitted the apprentice/community a store.
The environmentalists gave some vegetation to the citizens/desert.
The younger sister fell down.
The younger sister fell down.
The younger sister fell down.
The painter left the drummer an air condition.
The girl gave the painter a flower.

The minister bestowed a gift to the princess/church.
The minister bought the princess/church a gift.
The human submitted a paper to the god/universe.
The minister bought the princess/church a gift.
The human submitted the god/universe a paper.
The young brother woke up.
The young brother woke up.
The young brother woke up.
The angel bestowed upon the girl a candy.
The dressmaker submitted the model a piece of clothing.
The blacksmith submitted the apprentice/community a store.
The environmentalists gave some vegetation to the citizens/desert.
The younger sister fell down.
The younger sister fell down.
The younger sister fell down.
The painter left the drummer an air condition.
The girl gave the painter a flower.

The minister bestowed a gift to the princess/church.
The minister bought the princess/church a gift.
The human submitted a paper to the god/universe.
The minister bought the princess/church a gift.
The human submitted the god/universe a paper.
The young brother woke up.
The young brother woke up.
The young brother woke up.
The angel bestowed upon the girl a candy.
The dressmaker submitted the model a piece of clothing.
The blacksmith submitted the apprentice/community a store.
The environmentalists gave some vegetation to the citizens/desert.
The younger sister fell down.
The younger sister fell down.
The younger sister fell down.
The painter left the drummer an air condition.
The girl gave the painter a flower.

The minister bestowed a gift to the princess/church.
The minister bought the princess/church a gift.
The human submitted a paper to the god/universe.
The minister bought the princess/church a gift.
The human submitted the god/universe a paper.
The young brother woke up.
The young brother woke up.
The young brother woke up.
The angel bestowed upon the girl a candy.
The dressmaker submitted the model a piece of clothing.
The blacksmith submitted the apprentice/community a store.
The environmentalists gave some vegetation to the citizens/desert.
The younger sister fell down.
The younger sister fell down.
The younger sister fell down.
The painter left the drummer an air condition.
The girl gave the painter a flower.

The minister bestowed a gift to the princess/church.
The minister bought the princess/church a gift.
The human submitted a paper to the god/universe.
The minister bought the princess/church a gift.
The human submitted the god/universe a paper.
The young brother woke up.
The young brother woke up.
The young brother woke up.
The angel bestowed upon the girl a candy.
The dressmaker submitted the model a piece of clothing.
The blacksmith submitted the apprentice/community a store.
The environmentalists gave some vegetation to the citizens/desert.
The younger sister fell down.
The younger sister fell down.
The younger sister fell down.
The painter left the drummer an air condition.
The girl gave the painter a flower.

The minister bestowed a gift to the princess/church.
The minister bought the princess/church a gift.
The human submitted a paper to the god/universe.
The minister bought the princess/church a gift.
The human submitted the god/universe a paper.
The young brother woke up.
The young brother woke up.
The young brother woke up.
The angel bestowed upon the girl a candy.
The dressmaker submitted the model a piece of clothing.
The blacksmith submitted the apprentice/community a store.
The environmentalists gave some vegetation to the citizens/desert.
The younger sister fell down.
The younger sister fell down.
The younger sister fell down.
The painter left the drummer an air condition.
The girl gave the painter a flower.

The minister bestowed a gift to the princess/church.
The minister bought the princess/church a gift.
The human submitted a paper to the god/universe.
The minister bought the princess/church a gift.
The human submitted the god/universe a paper.
The young brother woke up.
The young brother woke up.
The young brother woke up.
The angel bestowed upon the girl a candy.
The dressmaker submitted the model a piece of clothing.
The blacksmith submitted the apprentice/community a store.
The environmentalists gave some vegetation to the citizens/desert.
The younger sister fell down.
The younger sister fell down.
The younger sister fell down.
The painter left the drummer an air condition.
The girl gave the painter a flower.

The minister bestowed a gift to the princess/church.
The minister bought the princess/church a gift.
The human submitted a paper to the god/universe.
The minister bought the princess/church a gift.
The human submitted the god/universe a paper.
The young brother woke up.
The young brother woke up.
The young brother woke up.
The angel bestowed upon the girl a candy.
The dressmaker submitted the model a piece of clothing.
The blacksmith submitted the apprentice/community a store.
The environmentalists gave some vegetation to the citizens/desert.
The younger sister fell down.
The younger sister fell down.
The younger sister fell down.
The painter left the drummer an air condition.
The girl gave the painter a flower.

The minister bestowed a gift to the princess/church.
The minister bought the princess/church a gift.
The human submitted a paper to the god/universe.
The minister bought the princess/church a gift.
The human submitted the god/universe a paper.
The young brother woke up.
The young brother woke up.
The young brother woke up.
The angel bestowed upon the girl a candy.
The dressmaker submitted the model a piece of clothing.
The blacksmith submitted the apprentice/community a store.
The environmentalists gave some vegetation to the citizens/desert.
The younger sister fell down.
The younger sister fell down.
The younger sister fell down.
The painter left the drummer an air condition.
The girl gave the painter a flower.

The minister bestowed a gift to the princess/church.
The minister bought the princess/church a gift.
The human submitted a paper to the god/universe.
The minister bought the princess/church a gift.
The human submitted the god/universe a paper.
The young brother woke up.
The young brother woke up.
The young brother woke up.
The angel bestowed upon the girl a candy.
The dressmaker submitted the model a piece of clothing.
The blacksmith submitted the apprentice/community a store.
The environmentalists gave some vegetation to the citizens/desert.
The younger sister fell down.
The younger sister fell down.
The younger sister fell down.
The painter left the drummer an air condition.
The girl gave the painter a flower.

The minister bestowed a gift to the princess/church.
The minister bought the princess/church a gift.
The human submitted a paper to the god/universe.
The minister bought the princess/church a gift.
The human submitted the god/universe a paper.
The young brother woke up.
The young brother woke up.
The young brother woke up.
The angel bestowed upon the girl a candy.
The dressmaker submitted the model a piece of clothing.
The blacksmith submitted the apprentice/community a store.
The environmentalists gave some vegetation to the citizens/desert.
The younger sister fell down.
The younger sister fell down.
The younger sister fell down.
The painter left the drummer an air condition.
The girl gave the painter a flower.

The minister bestowed a gift to the princess/church.
The minister bought the princess/church a gift.
The human submitted a paper to the god/universe.
The minister bought the princess/church a gift.
The human submitted the god/universe a paper.
The young brother woke up.
The young brother woke up.
The young brother woke up.
The angel bestowed upon the girl a candy.
The dressmaker submitted the model a piece of clothing.
The blacksmith submitted the apprentice/community a store.
The environmentalists gave some vegetation to the citizens/desert.
The younger sister fell down.
The younger sister fell down.
The younger sister fell down.
The painter left the drummer an air condition.
The girl gave the painter a flower.
The uncle handed {the basketball to that boy/school}{the boy/school a basketball}

The scientific expedition team distributed {a base station to the experts/the north pole}{the experts/the north pole a base station}

The witch was cheated

Grandmother handed the racing driver a coconut

The director distributed the driver a taxi

The general granted {the sword/Buddha to that bodyguards/temple}{the bodyguards/temple a sword/a figure of Buddha}

The sailor brought {some pollution to the fishermen/sea}{the fishermen/sea some pollution}

The child was asleep

The queen granted the knight a

Grandfather brought the chef...
18 The security returned the key to that head of a household/company. The general awarded the sword/Buddha figure to that head of a household/company a key.

19 The employer lent the contract to that lawyer/company. The general left the letter to that subordinate/army a letter. The child threw a stone to the villagers/pond a stone.

Xiao Ming fell down.

The policeman returned the pregnant woman a passport. The singer bestowed upon the airline stewardess a piano.

The president bestowed upon a gift to the citizens/Mars the sword/Buddha figure of Buddha.

The fireman was sacrificed.

The policeman returned the pregnant woman a passport. The singer bestowed upon the airline stewardess a piano.

The general left the letter to that subordinate/army a letter.

The general left the letter to that subordinate/army a letter. The child threw a stone to the villagers/pond a stone.

The president bestowed upon a gift to the citizens/Mars the sword/Buddha figure of Buddha.

The fireman was sacrificed.

The policeman returned the pregnant woman a passport. The singer bestowed upon the airline stewardess a piano.

The general left the letter to that subordinate/army a letter.

The child threw a stone to the villagers/pond a stone.
god of wealth lent the footballer some bills

Grandmother threw the racing driver a coconut

经理买了名画/电脑给那个贵妇/部门

祖先留下了一些宝藏给子孙/峡谷

经理抱给了名画/电脑给那个贵妇/部门

The manager threw a coconut to the racing driver

bought {the famous painting/computer} to that lady

handed {the famous painting/computer} to that lady

The manager bought the famous painting/computer to that lady

bought {the famous painting/computer} to that lady boutique/department

handed {the famous painting/computer} to that lady boutique/department

The manager handed the famous painting/computer to that lady boutique/department

姨妈退休了

The maternal aunt retired

歌手买了给空姐一台空调

The singer bought an air conditioner to the airline stewardess

修女留下给医生一套沙发

The nun left the doctor a sofa

贩子卖给了药材给那个商人/商店

The dealer sold the medicinal materials to that merchant/store

敌人丢给了一个导弹给红军/荒岛

The enemy tossed a bomb to the Red Army/uninhabited island

贩子赔给了药材给那个商人/商店

The dealer compensated the medicinal materials to that merchant/store

药材卖给那个商人/商店

The medicinal materials sold to the merchant/store

}
爸爸来了 Father came
爷爷卖给渔夫一张渔网 Grandfather sold the fisher a fishing net 超人丢给小新一个球拍 The superman tossed Xiaoxing a racket
爷爷卖给渔夫一张渔网 Grandfather sold the fisher a fishing net 工程师交给主管一份报告给主管/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}
班长赔了字典给那个同学/班级班长赠了字典给那个同学/班级 The monitor compensated {the dictionary to that classmate/class}{the classmate/class a dictionary} The monitor bestowed {the dictionary to that classmate/class}{the classmate/class a dictionary}
22 班长赔了字典给那个同学/班级班长赠了字典给那个同学/班级 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 小明跑了 Xiao Ming ran away 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 导演赔给模特一枚戒指 The director compensated the model a ring 司机交给邮差一辆货车 The driver submitted the postman a truck
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 皇上配了轿子给那个大臣/王府 群众送了一些物资给灾民/草原 The emperor distributed {the sedan chair to that minister/palace of a prince}{the minister/palace of a prince a sedan chair} The masses gave {some materials to the victims/prairie}{the victims/prairie some materials}
The witch was tricked.

The director distributed the driver a key.

The fairy gave the shepherd boy a conch.

The judge granted the money to that witness/team.

The experts distributed a detecting instrument to that team member/volcano.

The Red Army gave the grain to that aunt/war zone.

The director restored the cargo to that general.

The director distributed the cargo to that general.

The director distributed the nanny a key.

The director distributed the manager/ factory a batch of a conch.

The director distributed the manager/ factory a batch of a conch.

The director distributed the manager/ factory a batch of a conch.
The worker was laid-off.

The pregnant woman restored the doctor some capsules.

The girl brought the singer a musical score.

The parents submitted the tuition to that teacher/school.

The prisoner submitted the policeman a gun.

The sower threw some seeds to the gardener/lawn.

The star was late.

The prisoner submitted the policeman a gun.

Grandfather threw the fisherman a fishing net.

The tourists left a heap of coins to the guide/snowy mountain.

The tenant returned some medicine to the doctor.

The worker was laid-off.

The pregnant woman restored the doctor some capsules.

The girl brought the singer a musical score.

The parents submitted the tuition to that teacher/school.

The prisoner submitted the policeman a gun.

Grandfather threw the fisherman a fishing net.

The tourists left a heap of coins to the guide/snowy mountain.

The worker was laid-off.

The pregnant woman restored the doctor some capsules.

The girl brought the singer a musical score.

The parents submitted the tuition to that teacher/school.

The prisoner submitted the policeman a gun.

Grandfather threw the fisherman a fishing net.

The tourists left a heap of coins to the guide/snowy mountain.

The worker was laid-off.

The pregnant woman restored the doctor some capsules.

The girl brought the singer a musical score.

The parents submitted the tuition to that teacher/school.

The prisoner submitted the policeman a gun.

Grandfather threw the fisherman a fishing net.

The tourists left a heap of coins to the guide/snowy mountain.

The worker was laid-off.

The pregnant woman restored the doctor some capsules.

The girl brought the singer a musical score.

The parents submitted the tuition to that teacher/school.

The prisoner submitted the policeman a gun.

Grandfather threw the fisherman a fishing net.

The tourists left a heap of coins to the guide/snowy mountain.

The worker was laid-off.
resigned

国王赏给士兵一座城堡 The king awarded the soldier a castle

king awarded the soldier a castle

Grandmother left the worker a pair of gloves

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}

director sold {the property to that scriptwriter/crew}{the scriptwriter/crew a property}

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}

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}

emperor restored {the grain to that chieftain/village}{the chieftain/village some grain}

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

小孩哭了 The child cried

小孩哭了 The child cried
The teacher bestowed upon the boy a racket.
The prince distributed the general a dagger.
The writer left the posthumous paper to that nanny/newspaper office.
The tour guide brought some flowers to the merchant/desert.
The witch fainted.
Grandmother left the worker a pair of gloves.
Grandmother brought the nanny some mushrooms.
Figures

Figure 1. Example target picture

Figure 2. Example filler picture
Figure 1.
Figure 2.