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# Animacy effects in Chinese relative clause processing

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Prior research on relative clauses (RCs) in Mandarin Chinese has led to conflicting results regarding ease of processing subject-extracted RCs (SRCs) versus object-extracted RCs (ORCs) and has often used animacy configurations that are rare in corpora. Building on animacy patterns observed in a corpus, we used self-paced reading to explore how animacy influences real-time processing of Chinese RCs. Experiment 1 tested SRCs, and found marginal facilitation effects with animate heads (subjects) and inanimate objects. Experiment 2 tested ORCs and found significant facilitation effects with inanimate head (objects). Experiment 3 showed that when the subject is animate and the object inanimate, ORCs are as easy to process as SRCs, but when the subject is inanimate and the object is animate, SRCs are processed faster. Thus, the animacy of the head and the embedded noun must be taken into account when evaluating processing ease.

***Keywords:*** Animacy; Relative clause (RC); Mandarin Chinese; Processing.

The processing of relative clauses (RCs) has been an important topic of inquiry among psycholinguists for almost half a century because of the complexity of the RC structure (e.g., Gibson, 1998, 2000; MacWhinney & Pléh, 1988) and the potential ambiguity involved in comprehending reduced RCs (e.g., MacDonald, Pearlmutter, & Seidenberg, 1994; Trueswell, Tanenhaus, & Garnsey, 1994). In recent years, there has

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been a growing interest in uncovering what type of information is used during real-time RC processing. Factors that have been proposed to influence RC processing ease include the extraction site (subject- or object-extracted relatives) (e.g., Gibson, 1998), assignment of thematic roles (e.g., Dahan & Tanenhaus, 2004; Kamide, Altmann, & Haywood, 2003), animacy relations (e.g., Gennari & MacDonald, 2008; Traxler, Morris, & Seely, 2002; Traxler, Williams, Blozis, & Morris, 2005), relative frequency of occurrence (e.g., Gibson & Schütze, 1999; Gibson, Schütze, & Salomon, 1996; MacDonald et al., 1994), the referential status of the nouns in the RC (Reali & Christiansen, 2007; Warren & Gibson, 2002), and the discourse context of the RC (e.g., Altmann & Steedman, 1988; Crain & Steedman, 1985).

This paper focuses on two of these factors, namely extraction site and animacy, in order to investigate how they guide processing of RCs in Mandarin Chinese. The RC structure in Chinese is typologically interesting because Mandarin Chinese has an unusual combination of verb-object order and head-final (or prenominal) RCs (Dryer, 1992). Examples of a subject-extracted RC (SRC) and an object-extracted RC (ORC) are given in (1) and (2), respectively.

(1) [$t_i$ raokai baoan de] **jizhe$_i$** henkuaide bujian le.
bypass guard DE reporter immediately disappear ASP
'The **reporter** [that __ bypassed the guard] disappeared immediately.'

(2) [baoan raokai $t_i$ de ] **jizhe$_i$** henkuaide bujian le.
guard bypass DE reporter immediately disappear ASP
'The **reporter** [that the guard bypassed __] disappeared immediately.'

Within the Mandarin RCs in (1) and (2), the basic word order is subject-verb-object, just as in English. However, the head noun *jizhe* "reporter" occurs in RC-final position immediately after the relativizer DE, unlike in head-initial languages such as English where the head noun "the reporter" precedes the RC.

## Previous work on head-initial RCs

Previous work on languages with head-initial RCs has found that ORCs are more difficult to process than SRCs (e.g., in English: Fodor, 1983; King & Just, 1991; King & Kutas, 1995; in German: Schriefers, Friederici, & Kuhn, 1995; in French: Frauenfelder, Segui, & Mehler, 1980; Holmes & O'Regan, 1981). Furthermore, recent processing studies have found that the processing load induced by ORCs is modulated by animacy. ORCs with animate heads are harder to process than ORCs with inanimate heads (Gennari & MacDonald, 2008; Mak, Vonk, & Schriefers, 2002, 2006; Traxler et al., 2002, 2005). In fact, Mak et al. (2002, 2006) and Traxler et al. (2002) found that while ORCs with animate heads are the most difficult structure, those with inanimate heads are processed as easily as SRCs with either animate or inanimate heads. Mak et al. (2002) and Traxler et al. (2002) also mentioned the difference in animacy as being relevant to explaining the head animacy effects. These findings suggest an interaction between syntactic complexity and head animacy in head-initial RCs.

Interestingly, an increasing number of corpus studies have found that RCs with two animate nouns are not frequently found in statistical profiles of natural language usage (e.g., Roland, Dick, & Elman, 2007 for English; Mak et al., 2002 for Dutch and German), although this type of RC has been widely used for experimental stimuli in RC processing studies. Both corpus studies and sentence-completion studies (e.g.,

Gennari & MacDonald, 2008) found correlations between RC type and head noun animacy. Specifically, ORCs typically occur with inanimate head nouns, whereas there is at least a weak tendency for SRCs to occur with animate head nouns.[1]

In sum, similar patterns arise in corpus analyses and in sentence-completion tasks in languages with head-initial RCs, revealing a clear connection between RC type and head animacy. The observed correlation fits with the processing difficulty associated with ORCs with animate heads (Gennari & MacDonald, 2008; Mak et al., 2002, 2006; Traxler et al., 2002, 2005), suggesting that frequency of occurrence is related to processing ease. We believe this correspondence between frequency and processing ease has important implications, and needs to be taken into consideration in models of language processing.

## Theoretical accounts of animacy effects in RC processing

Different theories have been proposed to account for the effects of head animacy on ease of RC processing. While acknowledging that syntactic complexity cannot be the sole reason why ORCs are harder to process than SRCs, existing theories differ in when, where, and how animacy is assumed to guide on-line processing. Below we brief discuss the syntax-driven reanalysis account (Traxler et al., 2002), the memory-based Dependency Locality Theory (henceforth, DLT) (Gibson, 1998, 2000), and the constraint-based semantic indeterminacy account (Gennari & MacDonald, 2008).

According to the syntax-driven parsing model of Traxler et al. (2002), SRCs are easier to process than ORCs because of a default preference to interpret the subject of the sentence as the subject of the RC. Furthermore, Traxler et al. argue that the effects of animacy affect the difficulty of reanalysis, but do not determine initial parsing decisions.

Gibson's DLT (1998, 2000) posits that compared with SRCs, ORCs have a greater number of temporarily incomplete dependencies and a longer linear distance between the head noun and the gap. Recent developments in this memory-based account also acknowledge the effects of semantic factors, including animacy (e.g. Fedorenko & Gibson, 2008). Building on existing research on similarity-based interference (Gordon, Hendrick, & Johnson, 2001, 2004; Vasishth & Lewis, 2006), Fedorenko and Gibson (2008) note that the presence of two semantically similar referents (e.g., two animate nouns) can result in interference and increased working memory cost. In addition, they note that poor agents such as an inanimate subject ("movie") in ORCs ("The director that the movie pleased...") can also increase working memory cost. It is worth noting that, according to memory-based accounts, frequency information cannot explain processing difficulty in object-extracted RCs (Grodner & Gibson, 2005).

According to Gennari and MacDonald's (2008) probability-based indeterminacy account, the relative ease of SRCs versus ORCs and the effects of animacy are best

[1] As a reviewer pointed out, the relation between head animacy and RC-type is clear with object RCs (which tend to occur with inanimate heads), but less so with subject RCs. Indeed, in Mak et al.'s (2002, pp. 54–55) German corpus, the 144 subject-extracted RCs have inanimate heads almost as frequently as animate heads: 57% animate heads and 43% inanimate heads. Also, in Roland et al.'s (2007, p. 357) analysis of the English-language Brown corpus, 47% of 100 randomly-selected subject-extracted RCs have inanimate heads. However, existing corpus data from Chinese suggest that subject RCs' head animacy patterns (at least in Chinese) may vary depending on the grammatical role of the RC's head noun. For Chinese, Pu (2007, p. 45) and Wu (2009) found that (1) when SRCs modify sentential subjects, animate heads significantly outnumber inanimate heads, but (2) when SRCs modify sentential objects, there is no particular bias toward animate or inanimate heads.

regarded as frequency-related effects. Because SRCs are consistent with the most frequent, canonical Subject-Verb-Object word order in English, they are easier to process than ORCs (MacDonald & Christiansen, 2002). Regarding animacy effects, Gennari and MacDonald (2008) suggest that noun animacy plays a role in modulating the likelihood of the alternative structures available to a parallel parser. Inanimate nouns frequently fulfill the semantic role of patient or theme and occupy the syntactic object position. In contrast, animate nouns are preferentially associated with either agentive or experiencer roles.[2] The agentive-like experiencer often occurs in passive structures ("John is pleased by the movie"), and this experiencer-causer interpretation rarely occurs with inanimate nouns. In the case of ORCs with animate heads ("The director that the movie pleased . . ."), a comprehender is more likely to interpret the sentence-initial animate head "director" as agentive, yet the next inanimate noun ("movie") conflicts with this initial analysis. Furthermore, given that in a causative event the agentive-like causer interpretation rarely occurs with an inanimate noun, the inanimate noun ("movie") makes the least frequent experiencer-causer interpretation for the animate-inanimate configuration more difficult to obtain, although it is ultimately the correct analysis.

The three accounts summarised above offer different explanations for the subject-object processing asymmetry and for the animacy effects found in languages with head-initial RCs. This paper aims to investigate how well these accounts extend to head-final RC processing in Mandarin Chinese, whose typological properties render it an interesting test case for distinguishing the adequacy of different processing models. In the next section, we present an overview of existing research on Mandarin RC processing.

## Controversies in Chinese head-final RCs

Existing work on RCs in Mandarin Chinese has led to mixed results regarding the issue of processing difficulty associated with RCs of different extraction types. Some experimental studies (e.g., Chen, Ning, Bi, & Dunlap, 2008; Gibson & Wu, 2011; Hsiao & Gibson, 2003; Lin & Garnsey, 2010) suggest that ORCs are easier to process than SRCs, while others (e.g., Kuo & Vasishth, 2006; Lin, 2006; Lin & Bever, 2006) have found the reverse. In addition, corpus studies (e.g., Hsiao, 2003; Kuo & Vasishth, 2006; Pu, 2007; Wu, 2009) suggest that SRCs are more frequent than ORCs. Clearly more research is needed to clarify this issue.

It is worth noting that almost all of the experiments conducted on Mandarin RCs to date used RCs with two animate referents.[3] As noted above, this kind of configuration may induce similarity-based interference (e.g., Gordon et al., 2001, 2004; Lewis, Vasishth, & Van Dyke, 2006). There is also the question of whether this configuration might be unusual or infrequent in natural usage of Mandarin Chinese, especially in light of corpus findings showing that ORCs with two animate arguments are rare in English (e.g., Roland et al., 2007), and in Dutch and German (Mak et al., 2002).

[2] The term "experiencer" refers to a change of psychological state on a human participant caused by someone or something in the context of certain intransitive verbs (e.g., *win*, *die*); experience-theme verbs (e.g., *love*, *discover*, *like*); or causer-experiencer verbs (e.g., *please*, *amuse*, *amaze*, and *annoy*).

[3] Lin and Garnsey (2010) manipulated animacy in their stimuli, but they also topicalised their RCs to a sentence-initial position and used null head nouns. Headless RCs and topicalisation in Mandarin normally occur only when supportive discourse contexts are given, but their stimuli were presented in isolation. Thus their stimuli had a marked structure, which may have complicated their results.

In fact, the few existing corpus studies in Mandarin suggest that RCs with two animate nouns are indeed rare. Hsiao's examination of 882 RCs in the Chinese Treebank 3.0 corpus yielded only 6 RCs that had transitive verbs and two animate nouns (Hsiao, 2003, p. 105). Kuo and Vasishth's (2006) examination of the Sinica Corpus 3.0 found that out of 164 *bona fide* RCs, only 13 (out of 119) SRCs and only 3 (out of 45) ORCs contained two animate nouns.

At least two corpus studies in Chinese, one by Pu (2007) and other by Wu (2009) (see also Wu, Kaiser, & Andersen, 2010) indicate a correlation between type of RC and head animacy, similar to what has been found in languages with head-initial RCs. In Pu's (2007, p. 43) spoken/written corpus containing 271 RCs with transitive verbs, 94.4% of 71 ORCs had nonhuman (inanimate) heads, whereas 70% of 200 SRCs had human heads. Similarly in Wu's (2009) analysis of the 331 RCs with transitive action verbs contained in the Chinese Treebank Corpus 5.0 (CTB, Palmer, Chiou, Xue, & Xia, 2005), 86.7% of 128 ORCs had inanimate heads, whereas 64.5% of 203 SRCs had animate heads. Both corpus studies demonstrate a strong bias for ORCs to occur with inanimate heads. In addition, the corpus studies also show that SRCs can have both animate and inanimate heads when they modify sentential objects [51% animate heads vs. 49% inanimate heads out of 76 OS RCs in Pu's (2007) corpus, and 47% animate heads vs. 53% inanimate heads out of 66 OS RCs in Wu (2009)]. However, in the case of subject-modifying, subject-extracted (SS) RCs, subject heads are predominately animate, accounting for 81% out of 124 SS RCs in Pu (2007), and 73% out of 137 SS RCs in Wu (2009).

In addition, Wu's (2009) corpus investigation of the animacy status of both the head and the embedded noun revealed an interesting distribution of animacy configurations, as summarised in Table 1. Here and elsewhere, the abbreviation "SS" refers to an RC that modifies the subject of the sentence and is also subject-extracted (i.e., with a gap in subject position); "OS" refers to an object-modifying, subject-extracted/gapped RC; "SO" refers to a subject-modifying, object-extracted/gapped RC; and finally, "OO" means an object-modifying, object-extracted/gapped RC.

The data presented in Table 1 demonstrate that RCs with *two animate nouns* (that is, where both the head and the embedded nouns are animate) were relatively rare, accounting for 15.76% of 203 SRCs and 13.28% of 128 ORCs. The low frequency of this animacy configuration recurs in other corpus studies (Hsiao, 2003; Kuo & Vasishth, 2006). Similarly, RCs with *two inanimates* were also infrequent, accounting for 18.72% of 203 SRCs and 7.81% of 128 ORCs. Thus, RCs in general tend not to have two noun phrases (NPs) of identical animacy type.[4]

Moreover, for both types of RCs, it is those with *two arguments that contrast in animacy* that occur most frequently: 78.91% of 128 ORCs had an inanimate head noun combined with an animate embedded noun, 48.77% of 203 SRCs had an animate head noun and an inanimate embedded noun. While the preference for contrastive animacy configuration was less dramatic for SRCs, this preference is very clear for

[4] One reviewer pointed out that the percentage of RCs where both nouns have the same animacy is 28% in Mak et al.'s (2002) Dutch corpus and 40% in their German corpus. However, viewed from another perspective, this means that the percentage of RCs with contrastive animacy configuration is 72% in Dutch and 60% in German, a pattern similar to Wu's (2009) corpus analysis. Furthermore, at least in Wu's (2009) analyses of Chinese Treebank Corpus, RCs with matched animacy (double-animates or double-inanimates) occurred significantly less frequently than RCs with nonmatched animacy ($p' < .05$).

TABLE 1
Animacy of head noun and embedded noun in different RC types

| | | *Animate head NP* | | | | *Inanimate head NP* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Animate embedded NP* | | *Inanimate embedded NP* | | *Animate embedded NP* | | *Inanimate embedded NP* | | *Total* | |
| | | *Token* | *%* | *Token* | *%* | *Token* | *%* | *Token* | *%* | *Token* | *%* |
| Subject-gapped | SS | 22 | 16.06 | 78 | 56.93 | 25 | 19.25 | 12 | 8.76 | 137 | 100 |
| | OS | 10 | 15.15 | 21 | 31.82 | 9 | 13.64 | 26 | 39.39 | 66 | 100 |
| | sum | 32 | 15.76 | 99 | 48.77 | 34 | 16.75 | 38 | 18.72 | 203 | |
| Object-gapped | SO | 11 | 13.1 | 0 | 0 | 70 | 83.33 | 3 | 3.57 | 84 | 100 |
| | OO | 6 | 13.64 | 0 | 0 | 31 | 70.45 | 7 | 15.91 | 44 | 100 |
| | sum | 17 | 13.28 | 0 | 0 | 101 | 78.91 | 10 | 7.81 | 128 | |
| Total | | 49 | | 99 | | 135 | | 48 | | 331 | 100 |

Note: A noun was coded as animate when it denoted humans or humanised nouns. See Wu (2009) for the details of the corpus analyses and how the coding was done.

ORCs, bearing a striking similarity to the contrastive animacy pattern in German and Dutch ORCs (87.5% and 92.7%, respectively) observed by Mak et al. (2002).

## ANIMACY PREFERENCE CONSTRAINTS

One question that comes up is why these particular preferences exist. In this paper, we will not offer a detailed account of precisely why these patterns exist for Chinese, but we will offer some suggestions based on earlier work.

There has been a long-standing observation in functional/typological linguistics (e.g., Croft, 1990; Givón, 1983) and in cognitive psychology (Clifton et al., 2003; Gennari & MacDonald, 2008; Just & Carpenter, 1992; Traxler et al., 2002) that human referents tend to be realised in subject position. Animate entities are prototypical actors or agents by nature, thus more likely to move and cause changes in the world than inanimate entities, and more likely to take the syntactically prominent subject position as we organise information flow linearly. Standardly dubbed as the Animate First Principle, this tendency for animates to occur in sentence-initial position appears to hold true cross-linguistically (e.g., Bock & Warren, 1985; Shridhar, 1988; Tomlin, 1986; Van Nice & Dietrich, 2003). This [subject = animate] preference reflects the characteristics of the way we interact with the world as agents, and the way we map the world into language (see also Gennari & MacDonald, 2008 for related discussion).

The preponderance of inanimate heads in ORCs is commonly attributed to topicality and the need to ground new entities in the discourse by linking them to animate participants (Fox & Thompson, 1990; Reali & Christiansen, 2007). We suggest that the same discourse-based explanation may be applied to Chinese ORCs. This preference may be conceptually construed as a corollary of the preference for animate subjects and discourse-driven pragmatic considerations.

Thus, the preference for animate subjects and the preference for object heads to be inanimate work jointly to produce a strong preference for ORCs to occur with a contrastive animacy configuration.

What about SRCs, whose heads tend to be animate when the RC is subject-modifying (SS RC) and whose heads have no clear animacy patterns when the RC is object-modifying (OS RC)? In SRCs, the head is the RC-subject, and the embedded noun is the RC-object. When an RC is in subject position and has a gap in subject position (i.e., SS RCs), the constraint for subjects to be animate is expected to be satisfied twice, reinforcing the likelihood of a prototypical agent to take this position. Subject heads introduce a topic that conveys new information and are made relevant or grounded in the discourse by inanimate referents that they own, use, and manipulate (Givón, 1993; Pu, 2007), resulting in a contrastive animacy configuration.

However, when an RC is in object position with a gap in subject position (i.e., OS RCs), however, the picture is a bit more complicated. Although the RC-subject presumably prefers to be animate, this animacy preference is in conflict with the other preference against putting a human referent in the object position in the main clause. In addition, unlike the strong bias for subjects to be animate agents, objects are known to have more variation in their animacy patterns (Bresnan, Cueni, Nikitina, & Baayen, 2007; Dahl, 2008; Dahl & Fraurud, 1996; Kempen & Harbusch, 2004; Van Valin & LaPolla, 1997). Given that we as human beings like to talk about our interactions with other people as well as with things that we use, manipulate and cause changes to, subject heads in sentential object positions are probably equally likely to be either animate or inanimate in OS RCs. In fact, this fits with what has been observed in the corpus analyses, which showed a split between animate and inanimate heads in OS RCs.

Taken together, the corpus analysis of animate arguments in SRCs and ORCs summarised above suggests that there may be a set of Animacy Preference Constraints that are important for understanding the patterns of RC structure and processing that have been observed not only for Chinese but also for cross-linguistically. These constraints are presented below:

(3) *Animacy Preference Constraints*

i. Subjects tend to be animate;
ii. Head nouns in object-extracted RCs tend to be inanimate;
iii. As a joint consequence of (i) and (ii), a contrastive animacy configuration tends to occur in object-extracted RCs with inanimate heads and in subject-modifying, subject-extracted RCs with animate heads.

These Animacy Preference Constraints highlight two features. First, animacy preferences are connected to particular syntactic roles. As an extension of the strong connection between subjects and [+animate], ORCs tend to have inanimate heads due to discourse considerations. Second, there is a preference for the two NPs to be distinct in terms of their semantic animacy features, which presumably results in decreased similarity-induced interference during retrieval (Gordon et al., 2001; Vasishth & Lewis, 2006), or lower memory cost (Fedorenko & Gibson, 2008).

To explore whether the animacy preference constraints that we formulated on the basis of corpus frequency patterns influence ease of real-time processing, we conducted three self-paced reading experiments, all using subject-modifying RCs (i.e., SS RCs and SO RCs). We focused solely on subject-modifying RCs to avoid complications associated with object-modifying RCs (i.e., the absence of clear animacy preferences with object-modifying, subject-extracted RCs and potential garden-path effects caused by the ambiguous status of the RC-internal subject in object-modifying, object-extracted RCs).

Experiment 1 tested whether animate heads and inanimate RC-internal nouns facilitate the processing of SRCs. Experiment 2 tested whether inanimate heads and animate RC-internal nouns facilitate the processing of ORCs. The results of the first two experiments provide the foundation for Experiment 3, which looked at both SRCs and ORCs with contrastive animacy patterns, to test whether a distinct animacy alternation mapped onto the appropriate syntactic position facilitates the online processing of RCs. Experiment 3 aims to shed light on the controversy regarding the ease of processing SRCs versus ORCs in Chinese, and to evaluate the predictions made by the three major sentence processing models.



## EXPERIMENT 1: HEAD ANIMACY IN SRCS

In this experiment, we examined the real-time processing of SRCs with different animacy configurations, in order to test whether the Animacy Preference Constraints that emerged from the corpus analysis influence ease of processing. Because the syntactic structure is the same and the sentence-initial word is a verb, if readers do not use animacy information, reading times within the RC should not differ. However, if readers do use the [subject = animate] constraint in anticipating an upcoming syntactic structure, then the difference across conditions may show up early, probably before the head of the SRC actually occurs.

### Method

#### *Participants*

Forty-eight native speakers of Mandarin Chinese who were undergraduate students at Shanghai International Studies University (SISU) in China, participated in this experiment. Their mean age was 21.5. They received Chinese RMB 15 yuan for participating in the experiment.

#### *Materials and design*

We manipulated the animacy of the RC-internal object (animate, inanimate) and the animacy of the head of the SRC (animate, inanimate). This yielded four conditions as exemplified in (4). Note that in this design, when two conditions have the same head noun ("reporter" in Animate-head [*Oi-**Sa*** and *Oa-**Sa***] vs. "egg" in Inanimate-head [*Oa-**Si*** and *Oi-**Si***]), they also have the same RC-internal verb ("bypass" in Animate-head vs. "smash into" in Inanimate-head) and all the same words in the main clause (i.e., adverbs, main verbs, and main objects). The experiment contained 24 target items (see Appendix 1).

(4) a. ***Preferred* Oi-Sa (Inanimate RC-Object/Animate Head)**
$t_i$ raokai damen de jizhe$_i$ qiaoqiaode liule jinqu
bypass gate DE **reporter** quietly slip-ASP inside
'The **reporter** that __ bypassed the gate slipped in quietly.'

b. ***Matched* Oa-Sa (Animate RC-Object/Animate Head)**
$t_i$ raokai baoan de jizhe$_i$ qiaoqiaode liule jinqu
bypass guard DE **reporter** quietly slip-ASP inside
'The **reporter** that __ bypassed the guard slipped in quietly.'

c. ***Reversed*** **Oa-Si (Animate RC-Object/Inanimate Head)**
$t_i$ zazhong baoan de jidan$_i$ nianhude liule yidi
smash-into guard DE **egg** stickily splash-ASP ground
'The **egg** that __ smashed into the guard splashed the ground stickily.'

d. ***Matched*** **Oi-Si (Inanimate RC-Object/Inanimate Head)**
$t_i$ zazhong damen de jidan$_i$ nianhude liule yidi
smash-into gate DE **egg** stickily splash-ASP ground
'The **egg** that __ smashed into the gate splashed the ground stickily.'

Within the RCs, word length (number of characters) was matched across the four conditions for RC-internal object nouns (mean lengths: 2.21 characters in the Oi-Sa condition, 2.25 in the Oa-Sa condition, 2.25 in the Oa-Si condition, and 2.21 in the Oi-Si condition). These lengths do not differ significantly across conditions, $F(3, 92) = 0.15$, $p = .93$. We also matched the number of characters across the four conditions for the head nouns (subjects) (mean lengths: 2.38 characters in the Oi-Sa condition, 2.38 in the Oa-Sa condition, 2.21 in the Oa-Si condition, and 2.21 in the Oi-Si condition). These lengths also do not differ significantly across conditions, $F(3, 92) = 0.88$, $p = .45$. The verbs in the main clause and the verbs inside the RCs were always two characters long, although sometimes an aspect marker (e.g., "le") was added to make the sentence sound more natural.

The frequencies of the RC nouns, as well as the verbs in the RCs and in the matrix clauses, were matched as closely as possible,[5] using both the SUBTLEX-CH, a frequency database of Chinese words and characters based on film subtitles (Cai & Brysbaert, 2010) and the Lexicon of Common Words in Contemporary Chinese (2008). Because a number of verbs (e.g., 溅脏 *jian-zang* "splash to make something/someone dirty") and nouns (e.g., 女主持 *nue-zhuchi* "female-anchor/anchorwoman") are morpheme-based compounds rather than "words" in the Western sense that consist of a string of letters, frequency information was not available for some of our experimental stimuli in either of the frequency resources, despite the fact that their meaning is transparent, particularly to well-educated Chinese college students, as in our experiments.

In addition to the 24 target items, 46 filler items were constructed. Ten of them were simple or complex sentences that did not contain RCs. Twenty fillers were reason-, manner-, time-, place-, or instrument-adjunct clauses (i.e., without gaps). The

[5] In Experiment 1, the log frequencies for the different verbs and for the embedded nouns were matched. The mean log frequencies for the *verbs* from the SUBTLEX-CH are as follows: 3.14 for Oi-Sa and Oa-Sa, 3.32 for Oa-Si and Oi-Si. The frequencies do not differ significantly, $F(3, 76) = 0.1069$, $p = .9558$. The mean log frequencies for the *verbs* from the 2008 frequency dictionary are as follows: 9.46 for Oi-Sa and Oa-Sa, 9.04 for Oa-Si and Oi-Si. These frequencies also do not differ significantly, $F(3, 78) = 0.6015$, $p = .616$. The mean log frequencies for the *embedded nouns* from the SUBTLEX-CH are as follows: 3.07 for Oi-Sa and Oi-Si, 3.28 for Oa-Sa and Oa-Si. The frequencies do not differ significantly, $F(3, 78) = 0.1726$, $p = .9146$. The log frequencies for the *embedded nouns* from the 2008 frequency dictionary are as follows: 9.38 for Oi-Sa and Oi-Si, 9.36 for Oa-Sa and Oa-Si. The frequencies also do not differ significantly, $F(3, 82) = 0.0087$, $p = .9989$. Log frequencies for the *head nouns* were matched for the 2008 dictionary (means: 8.5 for Oi-Sa and Oa-Sa, 9.05 for Oa-Si and Oi-Si). According to this corpus, the frequencies of the different head nouns do not differ significantly, $F(3, 72) = 1.7263$, $p = .1692$. However, according to the SUBTLEX-CH corpus, the log frequencies for the *head nouns* are not matched [means: 4.32 for Oi-Sa and Oa-Sa, 2.88 for Oa-Si and Oi-Si; $F(3, 74) = 4.8757$, $p = .0038$]. As said, the frequency check reported above are based on an *incomplete* list of words that have their frequencies listed in either resource.

remaining 16 fillers were structurally gapless clauses, or modifying attributive clauses, or pro-dropped possessives, all superficially resembling either ORCs or SRCs.

### *Plausibility and likelihood/expectation norming*

Two norming studies, one on plausibility and other on likelihood-of-occurrence, were conducted in order to control for potential verb-argument preference differences across conditions. The items consisted of the simple transitive clauses that map onto the meaning of the RCs in the four different conditions in (4). The transitive clauses corresponding to the sample item in (4) are shown in (5a–d). Twenty-four sets in four versions were randomised with an additional 24 filler items of equal length. In the *plausibility rating test*, 44 native speakers of Mandarin from Shanghai University of Finance and Economics (SUFE) were asked to rate on a 7-point scale how plausible (i.e., whether it makes sense) it was for the event described in the sentence to occur in the real world. In the *likelihood rating test*, another 36 native speakers of Mandarin from SUFE were asked to rate on a 7-point scale how likely the described event is to happen in the real world.

(5) a. Animate subject, inanimate object
记者绕开大门 (The reporter bypassed the gate.) 1 2 3 4 5 6 7
b. Animate subject, animate object
记者绕开保安 (The reporter bypassed the guard.) 1 2 3 4 5 6 7
c. Inanimate subject, animate object
鸡蛋砸中保安 (The egg smashed into the guard.) 1 2 3 4 5 6 7
d. Inanimate subject, inanimate object
鸡蛋砸中大门 (The egg smashed into the gate.) 1 2 3 4 5 6 7

Repeated-measures ANOVAs show that items were matched for likelihood/expectancy across the four conditions (mean ratings: 6.23 when the subject is animate and the object is inanimate, 6.29 when both are animate, 6.15 when the subject is inanimate and the object is animate, and 5.99 when both are inanimate). The likelihood/expectancy ratings for the four conditions do not differ significantly, $F(3, 21) = 1.03$, $p = .38$. The items are also matched for plausibility (mean ratings: 6.11 when the subject is animate and the object is inanimate, 6.25 when both are animate, 6.02 when the subject is inanimate and the object is animate, and 5.95 when both are inanimate). The plausibility ratings for the four conditions do not differ significantly, $F(3, 21) = 1.2$, $p = .32$. For each item, the plausibility ratings and likelihood/expectation ratings are presented in Appendix 1.

After conducting the two norming studies, the likelihood ratings and plausibility ratings for all items were carefully scrutinised. Three items (i.e., 12, 22, and 24) had uneven ratings across conditions *on both norming tests*: their mean ratings were $< 4.5$ in the Inanimate-Animate condition (5c) or the Inanimate-Inanimate condition (5d), as confirmed by the results of one-way ANOVAs with condition as the independent variable ($F$s $> 4.5$, $p$s $< .01$). Thus, these three items were excluded from subsequent analyses.

### *Procedure*

A word-by-word moving-window self-paced reading experiment was run on a PC laptop using Linger software developed by Doug Rohde. Participants were instructed to read the sentences for comprehension. Reading times for each word were recorded.

For each trial, participants read the sentences at their own speed, and then answered a yes/no comprehension question. The experiment was preceded by six practice trials.

All items, targets and fillers, were followed by comprehension questions. The questions asked about different parts of the sentences in order to encourage the participants to focus equally on all parts of each sentence. Half of the comprehension questions had "yes" answers, and the other half had "no" answers. Participants answered the questions by pushing the F key for "yes" and the J key for "no." The computer flashed "You are wrong" in Chinese if the questions were incorrectly answered, but no feedback was provided if the answers were correct.

## Results

Overall, four items were excluded from reading time analyses either due to a script error (item 14) or low ratings in the likelihood/expectation- and plausibility-norming tests in one condition (items 12, 22, 24, as discussed above). Out of 48 participants, two participants' results were omitted from analyses because of relatively poor comprehension question performance ( $<85\%$). Thus, 46 participants were included in the final analyses.

### *Question-answering accuracy*

Averaging across all target and filler trials, all 46 participants answered 95.1% of the comprehension questions correctly. On critical trials, the overall accuracy rate across participants was 96.2%. On filler trials, the overall accuracy rate was 94.5%. The relatively high accuracy rate on the target items suggests that SRCs were understood without difficulty.

### *Word-by-word reading times*

All reading time analyses reported in this paper were conducted by linear mixed-effects modeling with the lme4 package for the statistical language R (R Core Development Team, 2008). Mixed-effects models take independent variables as fixed effects and incorporate both random effects of subjects and items within a single analysis (Baayen, Davidson, & Bates, 2008). Models were fitted using a restricted maximum likelihood technique. Probabilities were estimated by means of the function pvals.fnc using Markov Chain Monte Carlo simulation (Baayen et al., 2008).

The model-based trimming procedure recommended by Baayen (2008) was used to trim outliers. Reading times longer than 4,000 ms were excluded from further analysis. From the remaining reading times, individual RTs were first log-transformed to correct for the heavily skewed distribution. Then an initial model was fitted to the logarithmic RT data that included conditions and positions as fixed effects, and subjects and items as random effects. Observations more than 2.5 standard deviations from the value predicted by the model were excluded, resulting in the elimination of 183 data points (2.85%). After elimination of outliers, separate mixed-models of logRT were fitted to each word region (7 positions) with Embedded-noun Animacy and Head Animacy as fixed effects in each case, and with subjects and items as random effects. Figure 1 presents the mean reading times per region across the four conditions in SS RCs.

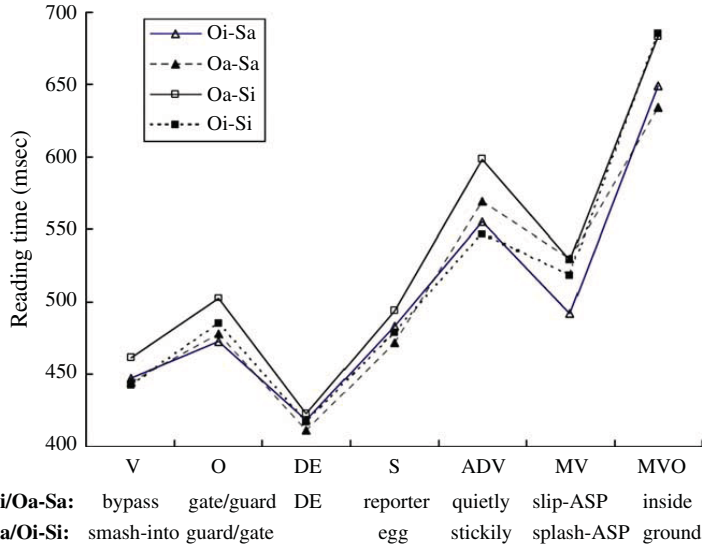


**Figure 1.** Mean reading times per word position in Experiment 1 on SRCs.

Analyses of reading times revealed no main effects or interactions at the sentence-initial RC-verb (position 1),[6] the relativizer DE (position 3) the RC head (position 4), and the post-head adverb (position 5). The subsequent discussion focuses on the remaining three regions that showed significant or marginal effects.

Within the RC, at the RC-object region (position 2), there was a marginal main effect of Head Animacy ($\beta = .058$, $SE = 0.031$, $t = 1.83$, $p = .067$). Conditions with animate heads (e.g., *bypass gate/guard DE* ***reporter*** in *Oi-**Sa*** and *Oa-**Sa***) were read numerically faster than conditions with inanimate heads (e.g., *smash-into guard/gate DE* ***egg*** in *Oa-**Si*** and *Oi-**Si***). There was no main effect of Animacy of Embedded-object, and there were no interactions.

In the main clause, at the **main verb (position 6)**, there was a marginal main effect of Animacy of RC-object ($\beta = -.065$, $SE = 0.034$, $t = -1.9$, $p = .057$). Conditions with inanimate objects (e.g., *bypass/smash-into* ***gate*** in **Oi**-Sa and **Oi**-Si) were read numerically faster than conditions with animate objects (e.g., *bypass/smash-into* ***guard*** in **Oa**-Sa and **Oa**-Si). There was no main effect of Head Animacy and no interactions.

At the main object (position 7), there was a marginal main effect of Head Animacy ($\beta = -.063$, $SE = 0.035$, $t = 1.82$, $p = .068$). Conditions with animate heads were read numerically faster than conditions with inanimate heads. There was no main effect of Embedded-noun Animacy and no interactions.

## Discussion of reading times for SRCs

The reading times hint at an effect of Head Animacy at the RC-internal object within the SRC and at the sentence-final matrix object, thus providing some support for the posited [subject = animate] constraint. However, the effect is only marginal, which may be due to the reading time paradigm adopted in this research.

[6] At the sentence-initial *RC-verb position* (pos 1, e.g., *raokai* "bypass"), there was a marginal main effect of Head Animacy ($t = 1.84$, $p = .0663$), and a marginal interaction between Head Animacy and Embedded-noun Animacy ($t = -1.8$, $p = .073$). However, given that this is the first word region, these weak effects are probably due to lexical differences.

Interestingly, in the RC-internal object region where the head of the SRC itself was yet to be seen, conditions with an upcoming animate subject (*bypass gate/guard DE* ***reporter***) were read marginally faster than conditions with an inanimate subject (*smash-into gate/guard DE* ***egg***). Given that the verb-argument preference was well-controlled, this pattern suggests that upon encountering the sentence-initial verb and the following object, the parser may already start to build expectations about what kind of thematic relationship an agent as the action-doer might bear with the verb, and may have a bias for an animate subject. This suggests that comprehenders process Chinese head-final RCs in a highly incremental fashion, using pieces of available information such as the verb as an early cue to predict the animacy of the RC-subject.

The fact that we found a marginal facilitatory effect of animate heads (compared to inanimate heads) at the matrix object fits with our prior corpus findings that subject heads in SS RCs prefer to be animate. The fact that head animacy influences readings times of the matrix object makes sense given that the sentence-final position is the region where the overall meaning of a sentence is integrated. Animate subjects (“reporter”) in the matrix clause are good agents or action-doers, and thus are relatively easier to integrate than are inanimate subjects (“egg”) into propositions embodied by the whole sentence.

At the main verb, we found a marginal effect of the Animacy of the RC-object. SRCs with inanimate RC-objects (“*[$t_i$ bypass/smash-into* ***gate*** *DE] reporter/egg successfully/stickily bypass/splash*”) were read numerically faster than SRCs with animate RC-objects (“*[$t_i$ bypass/smash-into* ***guard*** *DE] reporter/egg successfully/stickily bypass/splash*”). We should note that the adverbs and main verbs differ in the former and latter two conditions, respectively. Nevertheless, comprehenders seemed to have a bias for RCs that have inanimate objects, despite the fact that both animate (“guard”) and inanimate objects (“gates”) are equally plausible and probable as an argument of the preceding verb (“bypass/smash into”).

In sum, Experiment 1 presents indicative evidence for Head Animacy effects and Object (In)animacy effects in Mandarin SRCs, consistent with our corpus findings.

## EXPERIMENT 2: HEAD ANIMACY IN ORCS

Experiment 1 found hints of a Head Animacy effect in SRCs at the RC-internal object and at the sentence-final main object. In Experiment 2 we use ORCs to investigate whether Head Animacy influences ORC processing, specifically, whether *object heads* prefer to be inanimate.

In ORCs, the word order resembles canonical SV(O) word order. If any (subject) animacy information (i.e., subject = animate) is available to the parser at the very beginning of the sentence, we would expect reading time differences to occur early, possibly prior to the relativizer DE, the presence of which provides a clear indication that the structure is an RC. Furthermore, if the head of ORCs prefers to be inanimate, then we expect to see such effects early within the RC region, no later than the head noun.

### Method

#### *Participants*

Forty-eight students from SISU participated in this experiment in exchange of Chinese RMB 15 yuan. They were native speakers of Mandarin. None of them participated in the other experiments. Their average age was 21.5 years.

### Materials and design

We manipulated the Animacy of the RC-subject and the Animacy of the head noun. This resulted in four conditions as exemplified in (6). Note that in this design, when two conditions have the same head ("gate" in Inanimate-head [*Sa-**Oi*** and *Si-**Oi***] vs. "guard" in Animate-head [*Sa-**Oa*** and *Si-**Oa***]), they also have the same words within the main clause (all post-head regions), but have different RC-internal subjects and RC-verbs within the RC (e.g., *reporter bypass/egg smash-into DE gate* vs. *reporter bypass/egg smash-into DE guard*).

(6) a. *Preferred* **Sa-Oi (Animate RC-Subject/Inanimate Head)**
jizhe raokai $t_i$ de damen$_i$ lingluande tiezhe guanggao
reporter bypass DE **gate** messily post-ASP advertisement
'The **gate** that the reporter bypassed had flyers messily posted on it.' [Note: In Chinese, the sentence is not a passive construction.]

b. *Matched* **Sa-Oa (Animate RC-Subject/Animate Head)**
jizhe raokai $t_i$ de baoan$_i$ shengqide huangu sizhou
reporter bypass DE **guard** angrily look-about surroundings
'The **guard** that the reporter bypassed __ looked about his surroundings angrily.'

c. *Reversed* **Si-Oa (Inanimate RC-Subject/Animate Head)**
jidan zazhong $t_i$ de baoan$_i$ shengqide huangu sizhou
egg smash into DE **guard** angrily look-about surroundings
'The **guard** that the egg smashed into __ looked about his surroundings angrily.'

d. *Matched* **Si-Oi (Inanimate RC-Subject/Inanimate Head)**
jidan zazhong $t_i$ de damen$_i$ lingluande tiezhe guanggao
egg smash into DE **gate** messily post-ASP advertisement
'The **gate** that the egg smashed into __ had flyers messily posted on it.'

As in Experiment 1, the two nouns and the verbs (in RCs and in matrix clauses) were matched for word length and frequency (as much as possible). There were 24 critical items and 46 fillers. A full set of experimental stimuli is provided in Appendix 2. Self-paced reading was used and all items were followed by comprehension questions, as in Experiment 1.

## Results

As in Experiment 1, three items (item 12, 22, and 24) were eliminated due to relatively low ratings in one condition in both likelihood- and plausibility-norming tests. Four participants' results were omitted from analyses because of relatively poor comprehension question performance on the target items ( $<85\%$).

### Question-answering accuracy

On average, all 44 participants answered 94% of all comprehension questions (critical and filler trials) correctly, and all participants answered at least 89% of the questions correctly. On critical trials, the overall accuracy rate across participants was 93%, and all participants answered at least 87.5% of these questions correctly. On the fillers, the overall accuracy rate across participants was 94%.

### *Word-by-word reading times*

Using the same model-based trimming procedure as described in Experiment 1, we eliminated 2.7% of the data (174 data points). Figure 2 presents mean reading times for each of the seven word positions.

There were no effects or interactions at the sentence-initial RC-subject (position 1), DE (position 3), and the main object (position 6).

Within the RC, at the RC-internal verb (position 2), there was a main effect of Head Animacy ($\beta = -.063$, $SE = 0.031$, $t = -2.07$, $p = .0384$) and a marginal interaction ($\beta = .077$, $SE = 0.043$, $t = 1.76$, $p = .0784$). Conditions with inanimate heads (*reporter bypassed/egg smash-into DE gate*: Sa-Oi + Si-*Oi*) were processed faster than conditions with animate heads (*reporter bypassed/egg smash-into DE guard*: Si-Oa + Si-Oa). ORCs with inanimate head and animate RC-subject were read fastest. There was no main effect of Animacy of Embedded-noun.

At the head noun (position 4), there was a main effect of Head Animacy ($\beta = -.073$, $SE = 0.034$, $t = -2.13$, $p = .0335$), which interacted with the Animacy of RC-subject ($\beta = -.094$, $SE = 0.049$, $t = 1.93$, $p = .054$). Conditions with inanimate heads were read faster than conditions with animate heads, and the condition with inanimate head and animate RC-subject (Sa-Oi: "*reporter bypassed DE gate*") was read faster than the condition with animate head and animate RC-subject (Sa-Oa: "*reporter bypassed DE guard*") ($t = 2.13$, $p = .034$). That is, whereas we observed the head-animacy effect for ORCs with animate RC-subjects (e.g., "reporter"), we found no effect of head animacy in ORCs with inanimate RC-subjects (e.g., "egg"). There was no main effect of Animacy of RC-subject.

In the main clause, at the adverb (position 5), there was a marginal main effect of Head Animacy ($\beta = -.066$, $SE = 0.037$, $t = -1.78$, $p = .0784$). ORCs with inanimate heads (*reporter bypassed/egg smash-into DE gate*: Sa-Oi + Si-*Oi*) were read faster than

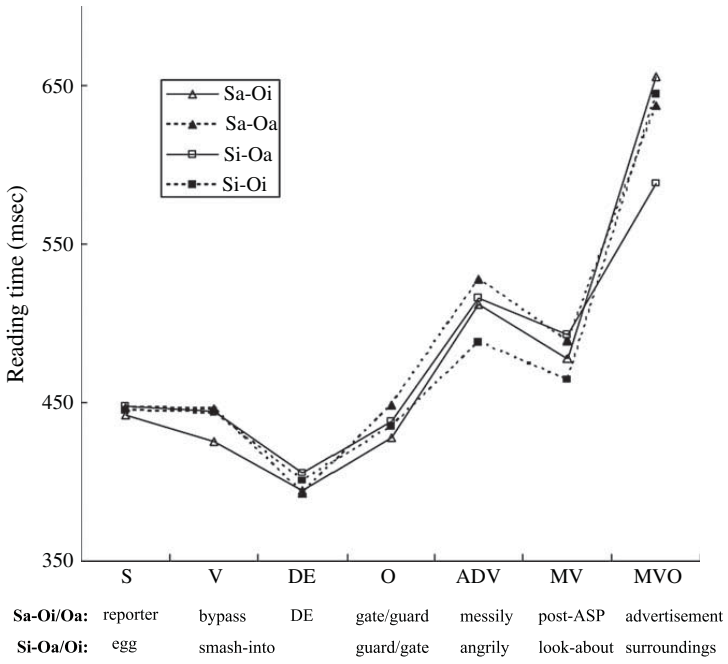


**Figure 2.** Mean reading times per word position in Experiment 2 on ORCs.

ORCs with animate heads (*reporter bypassed/egg smash-into DE guard*: Si-Oa + Si-Oa). There was no main effect of Animacy of RC-subject and no interactions.

At the main-clause object (position 7), there was a main effect of Animacy of RC-subject ($\beta = -.091$, $SE = 0.039$, $t = -2.33$, $p = .0198$), and a marginal interaction ($\beta = .094$, $SE = 0.055$, $t = 1.7$, $p = .0895$). Conditions with inanimate RC-subjects (Si-Oa + Si-Oi) were read faster than Conditions with animate RC-subjects (Sa-Oi + Sa-Oa). The inanimate-subject facilitation was carried by ORCs with animate head: ORCs with an inanimate RC-subject and an animate head (Si-Oa) were read faster than ORCs with an inanimate RC-subject and an inanimate head (Sa-Oa) ($t = -2.33$, $p = .019$). There was no main effect of Head Animacy.

## Discussion of ORCs

In Experiment 2, we found a reliable effect of Head Animacy at the RC-internal verb and at the head noun within the RC. ORCs with inanimate heads were processed faster than ORCs with animate heads. This was particularly so in the case of ORCs with animate RC-internal subjects. The strong preference for ORCs to have inanimate heads fits well with the cross-linguistic corpus findings.

The main effect of the animacy of the RC-subject at the sentence-final region (i.e., main object) may initially appear unexpected. ORCs with animate RC-subjects were processed much slower than ORCs with inanimate RC-subjects. Given that RTs to the last word usually involve prolonged processing times (presumably to integrate the meaning of the whole sentence), participants apparently took a significantly longer time to complete the syntactic and semantic integration process when ORCs began with an animate RC-subject. We do not have a good explanation for this, but would like to suggest that a sentence-initial human noun is more likely than an inanimate entity to be taken as a prototypical agent, which presumably will bias a comprehender to interpret it as the discourse-prominent subject, reinforcing the main clause analysis that was initially assumed based on the subject-verb word order. It may not take much effort for comprehenders to revise this initial analysis and adopt an ORC structure. But at the sentence-final position where an integral meaning of the whole sentence has to be established with all thematic roles initially assigned and then confirmed or rechecked before comprehenders proceed to push the button to prompt a comprehension question, differences did show up. We will discuss this further in the General Discussion.

# EXPERIMENT 3: COMPARING SRCS AND ORCS

The Head-animacy effects found in both Experiment 1 and Experiment 2 provide us with the empirical grounds for investigating animacy configuration effects in Experiment 3. Our third experiment was designed to further test whether mapping distinct animacy alternations onto the appropriate syntactic position facilitates online processing of RCs. In light of the existing controversy regarding the processing ease of SRCs and ORCs in Mandarin, this experiment investigates whether and to what extent animacy effects modulate the effects of extraction site, and whether a better understanding of animacy effects could help shed light on the mixed results obtained to date. It does so by comparing SRCs and ORCs, and only testing RCs with two nouns that contrast in animacy.

Experiment 3 combines a subset of the conditions from Experiments 1 and 2: we tested SRCs (e.g., 7a–b) and ORCs (e.g., 7c–d), in which the two nouns contrast in

animacy (animate vs. inanimate heads, paired with inanimate and animate embedded nouns respectively). As in Experiments 1 and 2, we focus on RCs in subject position (i.e., subject-modifying RCs). The lexical items were adjusted to maximise comparability across conditions. This facilitates direct comparisons between SRCs and ORCs, and also allows for direct within-participant comparisons of extraction site and animacy configuration.

(7) a. **SRC, Animate RC-Subject Head (*preferred* Oi-Sa)**
$t_i$ duokai shikuai de jizhe$_i$ chenggongde hunrule yingdi
dodge stone DE reporter successfully slip-into-ASP camp
'The reporter that __ dodged the stone successfully slipped into the camp.'

b. **SRC, Inanimate RC-Subject Head (*reversed* Oa-Si)**
$t_i$ zazhong jizhe de shikuai$_i$ zhongzhongde luozaile dishang
hit reporter DE stone heavily fall-to-ASP ground
'The stone that __ hit the reporter fell to the ground heavily.'

c. **ORC, Inanimate RC-Object Head (*preferred* Sa-Oi)**
jizhe duokai $t_i$ de shikuai$_i$ zhongzhongde luozaile dishang
reporter dodge DE stone heavily fall-to-ASP ground
'The stone that the reporter dodged fell to the ground heavily.'

d. **ORC, Animate RC-Object Head (*reversed* Si-Oa)**
shikuai zazhong $t_i$ de jizhe$_i$ chenggongde hunrule yingdi
stone hit DE reporter successfully slip-into-ASP camp
'The reporter that the stone hit __ successfully slipped into the camp.'

## Predictions made by the three models for SRCs and ORCs

In this section, we consider the predictions concerning effects of animacy and extraction site made by the three sentence processing models discussed in the Introduction. As these models were initially formulated on the basis of head-initial RCs, it will become clear that some auxiliary assumptions need to be made to adapt them for Chinese head-final RCs.

### *Syntax-driven reanalysis account*

To apply Traxler et al.'s (2002) syntax-driven reanalysis account to head-final RCs in Mandarin, we might assume an auxiliary parsing strategy comparable to the Active Filler Strategy (Frazier & d'Arcais, 1989; Stowe, 1989). We adopt Lin's (2006) Active Gap Strategy (see also Hsu & Bruening, 2003), which states that a parser "fills an identified gap as soon as possible, taking the closest lexical NP as a filler within the domain of an identified gap" (Lin, 2006, p. 80). Driven by the Active Gap Strategy, a Chinese comprehender, upon encountering a sentence-initial verb (e.g., *duoka*i "dodge") in character strings of the type *[V O] DE S...* (of SRCs; e.g., 7a), would posit a (subject) gap and assume an SRC interpretation.

In character strings of the type *[S V] DE O...* which occur in ORCs (e.g., 7c), there are two possibilities: (1) driven by the Active Gap Strategy, a comprehender might posit an object gap immediately upon encountering the verb (e.g., *duokai* "dodge"), assuming an ORC interpretation or (2) the comprehender might posit an object gap "retrospectively" (Hawkins, 2004) upon encountering a relativizer DE because the

first two words before DE are likely to be temporarily analyzed as the Subject-Verb of a matrix clause (see also Hsiao & Gibson, 2003, p. 7). Under the first possibility, in both SRCs (e.g., 7a–b) and ORCs (e.g., 7c–d), the initial analyses are confirmed by the occurrence of a relativizer DE, and therefore no reanalysis is needed. This leads to the prediction of a comparable filled-gap effect (i.e., a slowdown in reading times) at the head noun region (e.g., *jizhe* "reporter"/*shikuai* "stone"), regardless of extraction type. Under the second possibility, a reanalysis (from a matrix clause to an RC) is initiated upon the relativizer DE in ORCs, resulting in longer reading times for ORCs (7c–d) than SRCs (7a–b) at DE. Given the minimal attachment principle normally assumed by the syntax-driven model (Frazier, 1987), the second possibility is more probable.

Furthermore, this syntax-driven reanalysis account suggests that reanalysis or commitment to an initial analysis is affected by the goodness of the agent/patient role and the plausibility of the thematic roles assigned by the verb (Traxler et al., 2002, p. 84). In our experiment, the thematic roles of the two NPs are appropriately assigned by verbs in our stimuli (as confirmed by the likelihood/expectation- and plausibility-norming studies reported in the Method section), but goodness of fit between subject/object and the agent/patient role is satisfied only by preferred animacy configurations (e.g., 7a, c). Therefore, the preferred animacy configuration (e.g., 7c) should make reanalysis easier than the reversed animacy configuration (e.g., 7d) in ORCs.

As a whole, when applied to Chinese, the syntax-driven reanalysis account predicts: (1) a main effect of extraction type at the DE region or possibly at the head noun region due to "spillover;" (2) a late effect of animacy configuration (at around the head noun region); and (3) an interaction between the two after the DE region or at the head noun region.

### *DLT account*

Gibson's DLT (1998, 2000) as interpreted by Hsiao and Gibson (2003) predicts that SRCs in Mandarin Chinese involve a longer distance and more head-dependency relationships than ORCs. Hsiao and Gibson (2003, p. 6) suggest that in SRCs (e.g., 7a), upon encountering the sentence-initial verb (e.g., *duokai* "dodge"), a Chinese comprehender "realizes an RC is being processed," and hence needs to posit three syntactic heads: an object, a relativizer DE, and a matrix verb. At the next noun (e.g., *shikuai* "stone"), the comprehender needs to posit two syntactic heads: a relativizer DE and a matrix verb. In contrast, in ORCs (e.g., 7c) fewer syntactic heads need to be posited in each corresponding region. After processing the sentence-initial subject noun (e.g., *jizhe* "reporter"), the comprehender only needs to posit a verb, since the simplest structure is a matrix clause. At the next available verb (e.g., *duokai* "dodge"), only one syntactic head, namely an object, needs to be predicted.

In sum, Gibson's DLT predicts that the greater complexity of SRCs versus ORCs in Chinese will lead to more difficulty processing the former (7a–b) than the latter (7c–d), specifically at the first and the second word regions (Hsiao & Gibson, 2003). Given that the nouns in our stimuli contrast in animacy (e.g., "reporter" vs. "stone"), and given that the verb-argument preferences are controlled, we do not expect any extra processing load from similarity-based interference or from poor agents (see Fedorenko & Gibson 2008).

### *Constraint-based models*

The constraint-based approach does not assume one particular syntactic parsing preference, nor does it assume that only one structure is entertained throughout the parsing process. Rather, upon encountering the first verb in SRCs, a Chinese comprehender is predicted to simultaneously consider a ranked set of structural alternatives. For a sentence like (7a), this set could include an imperative (e.g., "dodge the stone!"), a serial verb (e.g., "(pro) dodged the stone and then slipped in"), a plain statement (e.g., "It's not so easy to dodge stones"), or a modifier phrase (e.g., "(pro) dodge stones' severe attack [that is] like a heavy rainfall") in addition to an RC (e.g. "The reporter who dodged the stone. . ."). It is probable, though, that an SRC analysis might be ranked much higher than other possible alternatives given a null discourse context (e.g., Zhang, Zhang, & Hua's, 2000 corpus data). We will come back to this point in the Discussion section.

Indeed this approach suggests that both SRCs and ORCs in Mandarin Chinese involve temporary structural *indeterminacy* (Gennari & MacDonald, 2008). However, because frequency or probabilistic information can play an important role in processing (e.g., MacDonald & Christiansen, 2002), the more frequent SRCs (Hsiao, 2003; Kuo & Vasishth, 2006; Pu, 2007; Wu, 2009; Wu et al., 2010) should be easier than the less frequent ORCs. Moreover, by this account, a comprehender may greatly benefit from semantic factors such as animacy and thematic roles assigned by verbs (e.g., MacDonald et al., 1994; Trueswell et al., 1994). In light of the rarity of ORCs with animate heads, the structural indeterminacy associated with ORCs and their overall low frequency, the constraint-based model would predict that RCs with preferred contrastive animacy configurations (7a, c) should be easier to process than RCs with reversed contrastive animacy configurations (7b, d).

## Method

### *Participants*

Forty-eight students, all from Tongji University in Shanghai except for four from SISU, participated in the experiment in exchange for Chinese RMB 15 yuan. They were native speakers of Mandarin with an average age of 22.6 years. None of them had participated in the other two experiments or in any norming studies.

### *Materials and design*

We manipulated RC-type (subject vs. object) and animacy of the head (animate vs. inanimate). This yielded four conditions, as exemplified in (7). Note that in this design, the animacy configurations in the four conditions are always contrastive. Two conditions are *preferably* contrastive: SRCs with animate heads (*SRC Oi-**Sa***; e.g., 7a) and ORC with inanimate heads (*ORC Sa-**Oi***; e.g., 7c). The other two conditions are *reversely* contrastive: SRCs with inanimate heads (*SRC Oa-**Si***; e.g., 7b) and ORCs with animate heads (*ORC Si-**Oa***; e.g., 7d). The experiment contained 24 critical items.

The word length for the two nouns within the RCs was matched (mean length = 2.25 characters for both embedded nouns and head nouns), though across conditions the mean length of embedded nouns (mean lengths: 2.08 for SRCs with animate heads and for ORCs with animate heads, 2.41 for SRCs with inanimate heads and for ORCs with inanimate heads), and that of head nouns (mean lengths: 2.41 for SRCs with animate heads and for ORCs with animate heads, 2.08 for SRCs with inanimate heads and for ORCs with inanimate heads) were not matched, $F(3,$

92) = 4.23, $p < .05$. As in Experiments 1 and 2, the frequencies of the two nouns as well as the verb were matched as closely as possible.[7] The experiment contained 46 fillers.

### *Plausibility and likelihood/expectation norming*

Similar to the first two experiments, a plausibility-norming survey and a likelihood/expectation-norming survey were given to 38 and 40 students from SISU and Donghua University (in Shanghai) respectively, in order to control for potential verb-argument preference differences. None of them participated in other studies. The items consisted of the simple transitive clauses that made up each RC. Twenty-four sets in two versions (e.g. 8a–b) were randomised with 24 filler items.

(8) a. Animate subject, inanimate object
记者躲开石块 (The reporter dodged the stone.) 1 2 3 4 5 6 7
b. Inanimate subject, animate object
石块砸中记者 (The stone hit the reporter.) 1 2 3 4 5 6 7

The paired-sample *t*-test showed that all items were matched for likelihood/expectancy [means: 5.78 for (8a), 5.61 for (8b), $t(23) = 1.717$, $p = .099$] and for plausibility [means: 6.17 for (8a), 5.9 for (8b), $t(23) = 1.737$, $p = .096$] between the two conditions. The ratings for sentences with animate subjects are marginally higher than the ratings for sentences with inanimate subjects, which is not surprising given the association between subjecthood and animacy. In light of this pattern, one might expect to see a main effect of subject animacy, such that RCs with animate subjects are read faster than RCs with inanimate subjects. However, as will become clear in the results section, as our main focus is on comparing SRCs and ORCs, this potential difference is not central for the claims we are making here. For each item, both the plausibility ratings and expectation ratings are presented in Appendix 3.

### *Procedure*

The same procedure was used as in Experiments 1 and 2.

## Results

### *Question-answering accuracy*

On average, participants answered 93.3% of all the comprehension questions correctly, and all participants answered at least 84.3% of the questions correctly. For the critical trials, the overall accuracy rate across participants was 89.4%, and all participants answered at least 79% of the questions correctly. For the fillers, the overall accuracy rate across participants was 95.4%.

### *Word-by-word reading times*

Following the same trimming procedure as described earlier, we eliminated 2.24% of the data (180 data points). Figure 3 presents the mean reading times for all word positions. The results of linear mixed-effects model at different regions are reported in Table 2.

At the *first word position* (e.g., RC-verb "dodge" for SRCs and RC-subject "reporter" for ORCs), we found no main effects and no interactions.

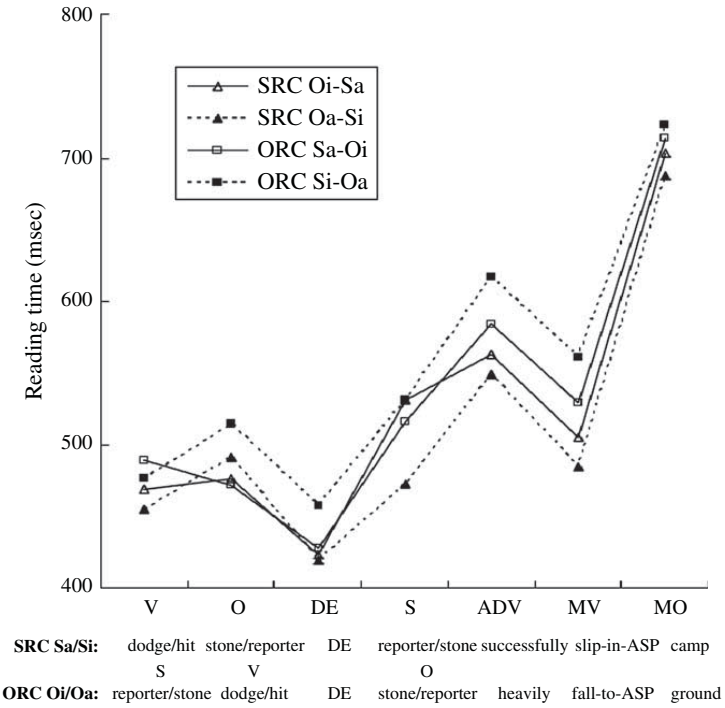


**Figure 3.** Mean reading times per word position in Experiment 3.

At the *second word position* (e.g., RC-object "stone" for SRCs and RC-verb "dodge" for ORCs), there was a main effect of RC-type (SRCs were read faster than ORCs), a main effect of Head Animacy (RCs with inanimate heads were read faster than RCs with animate heads), and an interaction between RC-type and Head Animacy. Planned comparisons showed that the speed-up for inanimate heads was carried by ORCs: ORCs with inanimate heads (*ORC Sa-**Oi***: "reporter dodge $t_i$ DE **stone**$_i$. . .") were read faster than ORCs with animate heads (*ORC Si-**Oa***: "stone hit $t_i$ DE **reporter**$_i$. . .") ($t = -2.73$, $p = .0064$), but there was no difference in SRCs regardless of whether the head was animate or inanimate.

At the *relativizer DE region* (word position 3), there was a main effect of RC-type: SRCs were read faster than ORCs. There was a main effect of Head Animacy: RCs with inanimate heads were read faster than RCs with inanimate heads. There was also a marginal interaction, as reflected by the slowest RTs in ORCs with animate heads (*ORC Si-**Oa***: "stone hit $t_i$ DE **reporter**$_i$. . .").

At the *head noun region* (word position 4), there was a marginal interaction of RC type and Head Animacy, but no other effects. Planned comparisons showed that SRCs with inanimate heads (Oa-**Si**: *$t_i$ hit reporter DE **stone**$_i$*) were read faster than SRCs with animate heads (Oi-**Sa**: *$t_i$ dodge stone DE **reporter**$_i$*), and were faster than ORCs with animate heads (ORC Si-**Oa**: *stone hit $t_i$ DE **reporter**$_i$*) ($t$s $< -2.4$, $p$s $< .015$).

At the *adverb region* (word position 5), there was a main effect of RC-type. SRCs were read faster than ORCs. No other effects were significant.

At the *main verb region* (word position 6), there was a main effect of RC-type (SRCs were faster than ORCs), and a marginal main effect of Head Animacy (RCs with inanimate heads were faster than RCs with animate heads). There was no interaction.

At the *main-clause object region* (word position 7), there was no significant effects.

TABLE 2
Final linear mixed-effects models for log-RTs by regions in Experiment 3

| *Region* | *Predictors in final model* | β | *SE* | *t* | *p* |
|---|---|---|---|---|---|
| RC-internal V/RC-internal O | Intercept (ORC/head-anim) | 6.166 | 0.0452 | 136.54 | <.0001 |
| | RCtype = SRC | −.0167 | 0.0250 | −0.67 | .5038 |
| | headAni = inanim | .0267 | 0.0250 | 1.07 | .2863 |
| | RCtype × headAni | −.0579 | 0.0354 | −1.64 | .1018 |
| RC-internal O/RC-internal V | Intercept (ORC/head-anim) | 6.241 | 0.0522 | 119.62 | <.0001 |
| | RCtype = SRC | −.0748 | 0.0294 | −2.54 | .0112 |
| | headAni = inanim | −.0846 | 0.0294 | −2.88 | .004 |
| | RCtype × headAni | .1157 | 0.0417 | 2.77 | .0056 |
| DE | Intercept (ORC/head-anim) | 6.1256 | 0.0407 | 150.55 | <.0001 |
| | RCtype = SRC | −.0776 | 0.0246 | −3.15 | .0017 |
| | headAni = inanim | −.0672 | 0.0246 | −2.73 | .0064 |
| | RCtype × headAni | .0599 | 0.0348 | 1.72 | .0854 |
| RC-S/RC-O | Intercept (ORC/head-anim) | 6.2819 | 0.0626 | 100.4 | <.0001 |
| | RCtype = SRC | −.0007 | 0.035 | −0.02 | .9834 |
| | headAni = inanim | −.0358 | 0.0348 | −1.03 | .3042 |
| | RCtype × headAni | −.0838 | 0.0492 | −1.7 | .0888 |
| Adverb | Intercept (ORC/head-anim) | 6.4213 | 0.0575 | 111.61 | <.0001 |
| | RCtype = SRC | −.0885 | 0.0345 | −2.57 | .0104 |
| | headAni = inanim | −.0462 | 0.0347 | −1.33 | .1833 |
| | RCtype × headAni | .0214 | 0.0489 | 0.44 | .6614 |
| Main verb | Intercept (ORC/head-anim) | 6.3278 | 0.04435 | 142.68 | <.0001 |
| | RCtype = SRC | −.10121 | 0.03086 | −3.28 | .0011 |
| | headAni = inanim | −.05677 | 0.03083 | −1.84 | 0.0658 |
| | RCtype × headAni | .01305 | 0.04354 | 0.30 | .7644 |
| Main object | Intercept (ORC/head-anim) | 6.6016 | 0.05912 | 111.67 | <.0001 |
| | RCtype = SRC | −.0381 | 0.03724 | −1.02 | .3071 |
| | headAni = inanim | −.0146 | 0.03788 | −0.39 | .6997 |
| | RCtype × headAni | −.0075 | 0.05275 | 0.14 | .8875 |

## Discussion of Experiment 3

In Experiment 3, the animacy of the head and the embedded nouns were contrastive in all conditions, and contrastive animacy configuration (preferred vs. reversed) was crossed with RC-type. The results showed that while SRCs were processed equally fast regardless of head animacy (except at the head noun region), ORCs with animate heads (i.e., reversed animacy configuration) were processed slowest, thus providing further support for the claim that the heads of ORCs prefer to be inanimate, whereas the heads of SRCs have no particular preference for animacy. Importantly, the results also indicate that SRCs are easier to process than ORCs when animacy configurations are controlled.

The primary contribution of Experiment 3 is that it allows us to compare directly the effects of animacy on the processing of SRCs and ORCs. Crucially, the results show an overall processing advantage for SRCs over ORCs, modulated by the animacy configuration. That is, SRCs were processed significantly faster than ORCs with the reversed animacy configuration (*ORC Si-**Oa***: "*stone hit* $t_i$ *DE* ***reporter***$_i$*...*") at the relativizer DE and the post-head main verb and main object regions. This supports the

prediction that the ORCs with animate heads have a marked (reversed) animacy structure, and are therefore processed the slowest.

When RCs of both extraction types *satisfied the preferred animacy configurations* (the *SRC Oi-Sa* condition "$t_i$ *dodge stone DE* ***reporter***$_i$. . ." and the *ORC Sa-Oi* condition "*reporter dodge* $t_i$ *DE* ***stone***$_i$"), the sentences were equally easy to process at nearly all regions (although they are numerically different). This conforms to what Mak et al. (2002, 2006) found in Dutch and Traxler et al. (2002) found in English. That is, the reported difficulties normally associated with ORCs disappear when head NPs are inanimate (i.e., *preferred* animacy configuration), and the subject-object processing asymmetry disappears.

When RCs of both extraction types had the *reversed animacy configurations* (the *SRC Oa-Si* condition "$t_i$ *hit reporter DE* ***stone***$_i$. . ." and the *ORC Si-Oa* condition "*stone hit* $t_i$ *DE* ***reporter***$_i$. . ."), a processing advantage emerged for SRCs: reading times in the *SRC Oa-Si* condition were faster than in the *ORC Si-Oa* condition in nearly all regions beginning from the relativizer DE. We take this as an evidence suggesting that SRCs and ORCs are processed differently because the indeterminacies are different at different word positions. As discussed in the predictions section for Experiment 3, character strings of both types [V O. . .] and [S V. . .] involve temporary ambiguities. In what follows, we discuss each of these structures in turn.

For the ambiguous [S V. . .] sequence (where the ambiguity is resolved as an ORC), a structurally simple matrix clause is the most probable analysis until the relativizer DE. We posit that switching from a preferred matrix-clause analysis to an RC analysis can be "cheap" if the animacy configuration is preferably contrastive—or perhaps even when two NP arguments are animate as suggested by prior studies that indicate a processing advantage for ORCs in Mandarin (e.g., Hsiao & Gibson, 2003). However, this reanalysis would be more costly when the animacy configuration is reversed. In (7d) (ORC *Si-Oa*; "*stone hit* $t_i$ *DE reporter*$_i$ . . ."), the hitting involves an inanimate subject ("stone") affecting an animate object ("reporter"). It is well-known that cross-linguistically, there is a strong bias for subjects to be animate. The subject NP "stone" as an inanimate entity is not a prototypical agent, even though it is a plausible and likely argument selected by the verb "hit." In such cases, a passive construction is usually necessary in Chinese, using the syntactic marker BEI before the subject NP to explicitly mark the inanimate subject as the agent (e.g., ***bei*** *shikuai zazhong de jizhe* "the reporter who was hit by the stone"). The absence of this passive marker would therefore make it hard for a comprehender to switch from a matrix clause to an RC analysis.

This argument is further supported by the results of an off-line survey on sentence naturalness (with similar stimuli as used in this study) conducted with 46 participants in China (see Wu, 2009 for details). Participants tended to judge ORCs with a reversed animacy configuration [i.e., similar to (7d)] as "unnatural," and often added a passive marker BEI at the sentence-initial position. This suggests that a sentence-initial inanimate NP in ORCs is generally dispreferred, particularly when an inanimate-subject is the agent/causer and an animate head-noun is the patient/theme. The finding that ORCs are dispreferred because passives are the more acceptable form appears to have a lot in common with English RCs (Gennari & MacDonald, 2009). As argued by Gennari and MacDonald (2008), many of the verbs that can take an inanimate subject or causer in English are most naturally expressed in the passive voice, rather than in the active voice. The passive structure is less common in Chinese than in English (Wang, 2004; Wang & Wang, 1995; Zhang & Chen, 1981), and some sentences can acquire a passive-like meaning without an explicit marker BEI (as illustrated by the

main clause of the sample sentence (5a) in Experiment 2). Nevertheless, a passive marker BEI is still necessary by default in the case of an inanimate referent serving as a nonprototypical agent that causes changes to an animate referent serving as a patient. We hypothesise that this causes the parser to activate the passive alternatives and makes the ORC structure in reversed animacy configuration less available and thus more difficult.

In contrast, for ambiguous [VO. . .] sequences that occur in SRCs, an RC analysis may be more probable than a matrix clause with a dropped subject when there is no discourse context (as in the case of our stimuli) to license a null/dropped subject (e.g., Li & Thompson, 1981). Prior work suggests that: (1) an SRC analysis would be preferred over a possessive complement clause analysis on the grounds of structural simplicity, immediate interpretation, and contingent frequency (Hsieh, Boland, Zhang, & Yan, 2008; Zhang et al., 2000); and that (2) gapless complementation structures are more frequent than SRCs (Kuo & Vasishth, 2006). Because both the possessive complement clause and the gapless complementation structure contain the marker DE, it may not be difficult for a Chinese comprehender to expect a nonmatrix structure in these situations. Furthermore, as suggested by the results of Experiment 1, a sentence-initial verb together with its subcategorised object seem to bias participants to posit an SRC and anticipate an upcoming subject head.

In sum, we suggest that the processing advantage observed for SRCs relative to ORCs when both have reversely contrastive animacy configurations is due to the RC being less available to the parser with [$S_{inanimate}$ V] sequences than with [V $O_{animate}$] sequences. We hypothesise that this results from an interaction of syntactic cues and animacy information.

## GENERAL DISCUSSION

We presented three experiments that investigated the role of animacy in the processing of head-final RCs in Mandarin. The starting point for these experiments was an extensive corpus study of the Chinese 5.0 Treebank Corpus (Wu, 2009) which showed that SRCs are more frequent than ORCs. On the basis of the corpus patterns we proposed three Animacy Preference Constraints: (1) subjects tend to be animate; (2) head nouns in ORCs tend to be inanimate; (3) a contrastive animacy configuration tends to occur in ORCs with inanimate heads and in SRCs with animate heads that modify sentential subjects. The self-paced reading studies presented in this paper investigated whether these animacy patterns also modulate ease of real-time processing.

Experiment 1 tested SRCs and manipulated the animacy of the RC head (subject) and the animacy of the RC-internal object. We found marginal effects of head-noun animacy at the RC-internal object, even before the head noun actually occurs. Reading times for the RC-object were numerically faster when the head/subject was animate than when it was inanimate. This pattern was also found at the sentence-final position where the overall meaning was integrated. We also found marginal effects of the animacy of the RC-object at the main verb. Reading times were numerically faster when the RC-internal object was inanimate than when it was animate.

Experiment 2 tested ORCs, that is, the head noun is the object within the RC. The animacies of the RC-internal subject and the head were again crossed to create four conditions. Significant effects of head animacy were found at the RC-internal verb and

at the head/object within the RC, where conditions with inanimate heads were read faster than conditions with animate heads.

Because Experiments 1 and 2 suggest that animacy affects both SRCs and ORCs, in Experiment 3 we directly compared the processing of SRCs and ORCs in a within-subjects design, testing how the relative processing ease of SRCs versus ORCs is affected by the animacy of the head noun and the embedded noun. This is important in light of the diverging findings regarding whether subject or object RCs are easier to process.

The results of Experiment 3 showed that when RCs had animate subjects and inanimate objects (i.e., the preferred animacy configuration), SRCs and ORCs were equally easy to process. However, when RCs had the reversed animacy configuration (an inanimate subject and an animate object), ORCs were more difficult than SRCs. We interpret this as an indication that SRCs are relatively easy to process, regardless of the animacy configuration, whereas ORCs are harder. We argue that this is due to the more indeterministic nature of ORCs than SRCs at different word positions. We typically do not map inanimate causers (“stone”) into the subject position, and are more likely to focus on the experiencer or animate participant (“reporter”) due to the salience of animacy. Thus, we hypothesise that ORCs with reversed animacy configuration are more likely to activate a passive structure ultimately, in order for comprehenders to complete the reanalysis from a matrix clause to an RC structure with success, mapping the inversed thematic roles that were expressed in an active structure onto their corresponding syntactic positions. In other words, the comprehender may very likely posit a passive structure retrospectively, possibly after processing the animate head (“reporter”) or upon encountering the adverb of the matrix clause (“successfully”), to help them obtain the meaning of a causative construction with an inanimate causer and an animate experiencer. Thus the structural ambiguity continues into the main clause until the passive construction is ultimately construed without the actual presence of a passive marker BEI. We think the ultimately correct passive structure that Chinese comprehenders need to activate in order to make sense out of the reversed animacy configuration mapped onto the active structure results in processing difficulties. In contrast, the structure of an SRC is likely to be highly activated in discourse-null contexts; coupled with a sentence-initial verb and its object argument signaling the animacy information of the subject, the cost of an inanimate subject is likely to be resolved early in SRCs.

Thus, our results indicate that the only time ORCs can compete with SRCs is when both are “disadvantaged” by a marked animacy configuration (i.e., the reversed animacy configuration). This means that to assess the relative processing ease of SRCs and ORCs, animacy must be taken into account. Although Chinese RCs are typologically different from English RCs, the underlying animacy constraints are likely to be the same.

## Evaluation of sentence processing models

When one considers the three major accounts of language processing considered in this paper, it seems that the findings of the corpus analyses summarised at the start of this paper (Wu, 2009) as well as the self-paced reading studies reported here are most consistent with a constraint-satisfaction account. The predictions of Gibson’s memory-based DLT (1998, 2000) and Traxler et al’s (2002) syntax-driven reanalysis model do not fit straightforwardly with our results. On the whole, we found SRCs to be easier to process, contrary to what is predicted by the DLT. In addition, we

observed animacy effects very early on during RC processing, a finding which is not predicted by the reanalysis model. Below we discuss these issues in detail.

When applying Traxler et al.'s (2002) syntax-driven parsing model to Chinese head-final RCs, we assume that online parsing is guided by an active filler strategy (analogous to the active gap strategy) and that animacy cues guide processing at later stages or during reanalysis. On the whole, our results fit well with the idea of the active-filler strategy. In Experiment 1, we found that SRCs with inanimate heads were read more slowly than SRCs with animate heads at the RC-object region—that is, before the head had actually been encountered. This suggests that the Active Gap strategy may be at work: Upon encountering the sentence-initial verb and the object argument it subcategorises, participants posit a pre-verbal gap (at the RC-subject position), or at least activate this analysis as among possible alternatives.

However, it is not clear whether our results fit with the idea that animacy guides second-stage reanalysis, given that our results show participants being sensitive to the animacy of the upcoming filler (head noun) even before it was encountered. Thus, our results suggest that animacy information guides parsing in a rapid, incremental manner.

Gibson's DLT (1998, 2000) states that SRCs in Mandarin Chinese involve a longer distance and more head-dependency relationships than ORCs, and that SRCs should be more difficult to process than ORCs. However, our results in Experiment 3 showed that overall, SRCs were easier to process than ORCs. In fact, we suggest that the underlying preference for SRCs in Mandarin Chinese emerges most clearly when the animacy configuration cannot provide a facilitatory boost for ORCs. In other words, our data suggest that *when processing is facilitated by certain animacy configurations, the processing differences between SRCs and ORCs are harder to detect*.

Now we turn to the constraint-satisfaction model (e.g., Boland, Tanenhaus, & Garnsey, 1990; MacDonald et al., 1994; Tanenhaus, Carlson, & Trueswell, 1989; Trueswell et al., 1994), which seems to best fit our data. This model posits that parsing is highly incremental, maintaining several alternative analyses in parallel. The parser readily uses whatever information is available as sentence fragments unfold, integrating verb subcategorisation information, thematic role assignment, animacy, statistical probability, etc., in a rapid manner, until the correct analysis is reached.

As discussed earlier, our data in Experiment 1 with SRCs is compatible with the idea that participants can use the information available early on (such as the verb and the following object) to start building expectations about the animacy of the upcoming subject head at a position well before its actual presence. This suggests a highly incremental parser. Furthermore, the general head-animacy effect that was observed in Experiment 2 indicates that the parser is sensitive to the semantic properties of nouns. In fact, the strength of the animacy cue is straightforwardly illustrated by the results of Experiment 3. Experiment 3 showed that when the animacy configuration was preferably contrastive, subject and object RCs were processed equally fast. This suggests that a purely syntax-driven account is not sufficient.

The constraint-based model posits that animacy is among a variety of cues that comprehenders can use to estimate probabilities of upcoming words and structures (e.g., Gennari & MacDonald, 2008). Since the preferred animacy configuration is highly frequent, as demonstrated by our corpus analyses (Wu, 2009), it is expected to increase comprehenders' consideration of an RC structure, thereby facilitating processing. This fits well with our finding that overall, there is no processing difference between subject and object RCs when both have preferred animacy configurations.

In conclusion, the results of the three self-paced reading experiments presented here show that animacy plays an important role in guiding the processing of RCs in Chinese. Manipulating the animacy of the head and the RC-internal noun allowed us to gain new insights into the debate regarding the ease of processing subject and object RCs, and indicates that subject RCs are intrinsically easier to process than object RCs even in Chinese.

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APPENDIX 1

Stimuli of Experiment 1 (the expectation and plausibility ratings given to each sentence within the RC by conditions are given in parenthesis)

| | | | |
|---|---|---|---|
| 1 | a/b | 绕开大门/保安的记者悄悄地溜了进去。'The reporter who bypassed the gate/the guard slipped in quietly.' | (5.8,5)/(6.4,5.73) |
| | c/d | 砸中保安/大门的鸡蛋粘糊地流了一地。'The egg that smashed into the guard/the gate splashed onto the ground messily.' | (6.2,5.45)/(5.9,5.82) |
| 2 | a/b | 看穿阴谋/间谍的外交官小心地保护自己。'The diplomat who saw through the plan/the spy carefully protected himself.' | (6,6.18)/(5.9,5.55) |
| | c/d | 告发间谍/阴谋的匿名信立刻得到了重视。'The anonymous letter that exposed the spy/the plan immediately got attention.' | (6.5,6.09)/(6.7,6.91) |
| 3 | a/b | 背负弹药/伤员的战士飞快地冲进战壕。'The soldier who carried the ammunition/the wounded person ran into the trench quickly.' | (6.3,6.82)/(6.3,6.27) |
| | c/d | 捆扎伤员/弹药的绷带牢牢地打了一个结。'The bandage that bound the wounded person/the ammunition tightly formed a knot.' | (5.6,4.73)/(4.75,4.64) |
| 4 | a/b | 追赶船只/船夫的少年响亮地吹了一声口哨。'The teenager who chased the boat/the boatman blew a whistle loudly.' | (6.75,4.36)/(6.67,5.36) |
| | c/d | 阻挡船夫/船只的风暴猛烈地摇断了桅杆。'The storm that impeded the boatman/the boat broke the mast violently.' | (7,6.73)/(6.2,6.82) |
| 5 | a/b | 迷恋美食/美女的总裁全然忘记了时间。'The CEO that madly clung to delicacies/pretty women completely forgot the time.' | (6.1,6.3)/(6.6,6.36) |
| | c/d | 介绍美女/美食的画报醒目地摆放在摊头。'The magazine that features pretty women/delicacies lay noticeably on the vendor's stand.' | (6.8,6.82)/(6.1,6.82) |
| 6 | a/b | 抢救财产/村民的消防员奋勇地冲入火海。'The firefighter who rescued the valuables/the villagers bravely ran into the fire.' | (6.4,6.18)/(6.4,6.73) |
| | c/d | 吞噬村民/财产的泥石流整整地持续了一天。'The debris flow that engulfed the villagers/the valuables lasted a whole day.' | (6.9,6.27)/(6.8,6.64) |
| 7 | a/b | 鄙视流言/权贵的艺术家不屑地甩了甩头发。'The artist who despised the rumor/those in power swung his hair scornfully.' | (6.1,6.45)/(5.7,6.64) |
| | c/d | 抨击流言/权贵的文章尖锐地直中要害。'The article that responded to those in power/the rumor got right to the point sharply.' | (6.1,6.91)/(6.75,6.09) |
| 8 | a/b | 误解答案/嘉宾的女主持顿时失去常态。'The TV anchorwoman who misunderstood the answer/the guest speaker immediately lost her poise.' | (5.875,6)/(6.33,6.45) |
| | c/d | 提示嘉宾/答案的大屏幕在实录前安装完毕。'The big screen that prompted the guest speaker/the answer was in place before the live broadcast.' | (6.6,5.73)/(5.5,5.64) |
| 9 | a/b | 反对预算/候选人的议员激动地陈述理由。'The senator who opposed the budget/the candidate stated his reasons vociferously.' | (6.2,6.45)/(6.375,6.09) |
| | c/d | 批准候选人/预算的决议顺利地通过了表决。'The resolution that approved the candidate/the budget smoothly passed the voting procedure.' | (6.22,6.18)/(6.5,5.73) |
| 10 | a/b | 揭发内幕/贪官的作家不幸遭到了报复。'The writer who disclosed the inside story/the corrupt official unfortunately got retaliation.' | (6,6.45)/(5.4,6.18) |
| | c/d | 披露贪官/内幕的新闻今天上了头版头条。'The report that exposed the corrupt official/the inside story became headline news today.' | (6.5,6.36)/(5.89,6.73) |
| 11 | a/b | 打造品牌/明星的经纪人兴奋地构想未来。'The manager who built the brand/the pop star was conceiving the future in fantasy.' | (6.56,6.45)/(6.3,6.82) |
| | c/d | 评价明星/品牌的网站大大地提高了点击率。'The website that ranked pop stars/the brands greatly improved its click rate.' | (6.5,4.27)/(6.875,4.55) |
| 12 | a/b | 推开话筒/抗议者的官员匆匆地离开现场。'The official who pushed away the megaphone/protesters left the scene in a hurry.' | (6.625,5.45)/(6.44,5.82) |
| | c/d | 扔向抗议者/话筒的石块顿时造成混乱。'The stone that was being thrown at the protesters/the megaphone immediately caused a disturbance.' | (6,4.27)/(4.1,4.55) |
| 13 | a/b | 检查胸腔/病人的医生耐心地询问病情。'The doctor who inspected the thoracic cavity/the patient asked about the situation with patience.' | (7,7/6.6), (6.36) |
| | c/d | 扫描病人/胸腔的仪器迅速地显示出结果。'The apparatus that scanned the patient/the thoracic cavity gave the results in no time.' | (6.5,6.27)/(5.7,6.18) |

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|---|---|---|---|
| 14 | a/b | 打理店铺/新娘的美发师挑剔地审视细节。'The hairdresser who took care of the shop/the bride pickily looked into details.' | (5.7,6.18)/(6.6,6.73) |
| | c/d | 点缀新娘/店铺的鲜花别致地扎成花环。'The flowers that decorate the bride/the shop are exquisitely arranged into a garland.' | (6.6,6.73)/(6.25,6.55) |
| 15 | a/b | 追踪脚印/歹徒的警察警惕地观察周边情况。'The policeman who followed the footprints/the bandit vigilantly observed situations.' | (6,6.55)/(6.8,6.91) |
| | c/d | 拍摄歹徒/脚印的镜头隐秘地藏在暗处。'The camera that videotaped the bandit/the footprints was hidden secretly in the dark.' | (6.1,6.55)/ (6.5,6.82) |
| 16 | a/b | 质疑野史/名人的教授详细地列举了事实。'The professor who challenged the unofficial history/the famous people cited facts in detail.' | (6.625,6.18)/(6.4,6.82) |
| | c/d | 记录名人/野史的书册在民间广为流传。'The books that record famous people/the unofficial history are popular among the masses.' | (6.6,6.18)/(4.9,6) |
| 17 | a/b | 审查文件/证人的律师在同行间享有盛名。'The lawyer who examined the documents/the witness was well known in the field.' | (6.4,6.09)/(6.75,6.18) |
| | c/d | 溅脏证人/文件的墨水很快扩散了一大片。'The ink that splashed on the witness/the documents (to get them dirty) quickly spread to a large area.' | (5,4.36)/(6.5,6.36) |
| 18 | a/b | 声援议案/贫困生的民众自发地走上街头。'The citizens who supported the proposal/the poverty-stricken student had been running around doing so voluntarily.' | (5.7,5.82)/(6.2,5.36) |
| | c/d | 支持贫困生/议案的舆论逐渐地引起关注。'The public opinion that supported the poverty-stricken student/the proposal has gradually attracted attention.' | (6.5,6.27)/(6.2,6.09) |
| 19 | a/b | 射中靶心/逃犯的神枪手再次得到奖励。'The sharpshooter who hit the target/the escaped convict got an award one more time.' | (6.67,6.55)/(6.5,6.64) |
| | c/d | 击中逃犯/靶心的飞刀清晰地刻着记号。'The flying dart that hit the escaped convict/the target was clearly carved with a mark.' | (5.8,6.36)/(6.125,6.82) |
| 20 | a/b | 指挥战斗机/特种兵的总司令沉着地应对战势。'The chief commander who directed the fighter craft/the special force calmly conducted the battle.' | (6.375,5.45)/(6.56,5.82) |
| | c/d | 定位特种兵/战斗机特种兵的侦察系统瞬间完成部署。'The detection system that pinpointed the special force/the fighter craft had been in place for only a short time.' | (6.1,6)/(6.1,6) |
| 21 | a/b | 监听信号/敌人的士兵曾经立过战功。'The solider who monitored the signal/the enemy had once distinguished himself in the war.' | (6.3,5.91)/(6.875,5.73) |
| | c/d | 干扰敌人/信号的噪音一直查不出来源。'It was hard for a long time to trace the source of the noise that disturbed the enemy/the signal.' | (6.22,6.18)/(6.2,5.36) |
| 22 | a/b | 寻找机翼/落水者的捕捞员仔细地搜索湖岸。'The fish worker who looked for the plane wing/the drowned person carefully searched the lake bank.' | (6.1,5.36)/(6.1,6.55) |
| | c/d | 缠绕落水者/机翼的水草茂密地长满湖底。'The weeds that entwined the drowned person/the plane wing grew thickly at the bottom of the lake.' | (6.375,6.55)/(4.11,3.45) |
| 23 | a/b | 缉查毒品/奸商的干警很快地锁定目标。'The inspector who checked drugs/profiteers soon identified the target.' | (6.22,6.27)/(6.2,5.64) |
| | c/d | 打击奸商/毒品的法律非常顺应民心。'The law that cracks down on drugs/profiteers is being well received by people.' | (5.4,6.18)/(6.875,5.91) |
| 24 | a/b | 走近宣传栏/小男孩的老领导缓缓地放慢了脚步。'The senior leader who was approaching the bulletin board/the little boy gradually slowed down his steps.' | (6.75,6.55)/(6.44,6.73) |
| | c/d | 踢中小男孩/宣传栏的足球重重地弹回草丛。'The football that hit the little boy/the bulletin board bounced heavily onto the lawn.' | (4.3,4.73)/(5.3,6.27) |

APPENDIX 2
Stimuli of Experiment 2

| | | | |
|---|---|---|---|
| 1 | a/d | 记者绕开/鸡蛋砸中的大门凌乱地贴着广告。 | The gate that the reporter bypassed/the egg smashed into had flyers messily posted on it. |
| | b/c | 记者绕开/鸡蛋砸中的保安生气地环顾四周。 | The guard that the reporter bypassed/the egg smashed into looked about his surroundings angrily. |
| 2 | a/d | 外交官看穿/匿名信告发的阴谋最终没能施行。 | The scheme that the diplomat saw through/the anonymous letter exposed failed to be carried out in the end. |
| | b/c | 外交官看穿/匿名信告发的间谍小心地保护自己。 | The spy that the diplomat saw through/the anonymous letter exposed carefully protected himself. |
| 3 | a/d | 战士背负/绷带捆扎的弹药重重地掉在地上。 | The ammunition that the soldier carried/the bandage was wrapped around dropped onto the ground heavily. |
| | b/c | 战士背负/绷带捆扎的伤员顽强地忍住疼痛。 | The wounded person that the solider carried/the bandage was wrapped around endured the pain courageously. |
| 4 | a/d | 少年追赶/风暴阻挡的船只缓缓地靠近河岸。 | The boat that the teenager chased/the storm impeded slowly got close to the river bank. |
| | b/c | 少年追赶/风暴阻挡的船夫无奈地停下脚步。 | The boatman that the teenager chased/the storm impeded stopped running resignedly. |
| 5 | a/d | 总裁迷恋/画报介绍的美食整齐地摆在桌上。 | The delicacies that the CEO madly clung to/the magazine featured were presented on the table exquisitely. |
| | b/c | 总裁迷恋/画报介绍的美女优闲地吐着烟圈。 | The pretty women that the CEO madly clung to/the magazine featured blew circles of smoke gracefully. |
| 6 | a/d | 消防员抢救/泥石流吞噬的财产大部分属于私有。 | The valuables that the firefighter rescued/the debris flow engulfed mostly belonged to private individuals. |
| | b/c | 消防员抢救/泥石流吞噬的村民无力地呼喊亲人。 | The villagers that the firefighter rescued/the debris flow engulfed were calling out for their beloved in vain. |
| 7 | a/d | 艺术家鄙视/文章抨击的流言一时传遍全城。 | The gossip that the artist despised/the article responded to quickly spread to the whole city. |
| | b/c | 艺术家鄙视/文章抨击的权贵变相地谋取暴利。 | Those in power that the artist despised/the article criticized exploited profits indirectly. |

| | | | |
|---|---|---|---|
| 8 | a/d | 女主持误解/大屏幕提示的答案似乎另有含义。 | The answer that the TV anchorwoman misunderstood/the big screen prompted appeared to have an alternative meaning. |
| | b/c | 女主持误解/大屏幕提示的嘉宾总是发挥失常。 | The guest speaker that the TV anchorwoman misunderstood/the big screen prompted always made mistakes. |
| 9 | a/d | 议员反对/决议批准的预算明显地偏重军事。 | The budget that the senator opposed/the resolution approved apparently tilted toward military expenditure. |
| | b/c | 议员反对/决议批准的候选人普遍地得到拥护。 | The candidate that the senator opposed/the resolution approved won wide support. |
| 10 | a/d | 作家揭发/新闻披露的内幕在全国引发讨论。 | The inside story that the writer exposed/the newspaper exposed induced nation-wide debates. |
| | b/c | 作家揭发/新闻披露的贪官肆意地挥霍公款。 | The corrupt officials that the writer exposed/the newspaper exposed recklessly wasted public funds. |
| 11 | a/d | 经纪人打造/网站评价的品牌逐渐地享有口碑。 | The brand that the manager built/ the website ranked gradually gained its popularity. |
| | b/c | 经纪人打造/网站评价的明星默默地忍受辛酸。 | The pop stars that the manager built/the website ranked endured grief without words. |
| 12 | a/d | 官员推开/石块扔向的话筒啪地一声掉在地上。 | The megaphone that the official pushed away/the stone was being thrown at fell to the ground with a noise. |
| | b/c | 官员推开/石块扔向的抗议者愤怒地喊起口号。 | The protestants that the official pushed away/the stones were being thrown at indignantly chanted slogans. |
| 13 | a/d | 医生检查/仪器扫描的胸腔大面积地充满积水。 | The thoracic cavity that the doctor inspected/the apparatus scanned was largely full of waters. |
| | b/c | 医生检查/仪器扫描的病人已经陷入了昏迷。 | The patient that the doctor inspected/the apparatus scanned already fell into a coma. |
| 14 | a/d | 美发师打理/鲜花点缀的店铺到处洋溢着喜庆。 | The shop that the hairdresser took care of/the flowers decorate was permeated with joy everywhere. |
| | b/c | 美发师打理/鲜花点缀的新娘在镜中像个天仙。 | The bride that the hairdresser took care of/the flowers decorate looks like a fairy maiden in the mirror. |
| 15 | a/d | 警察追踪/镜头拍摄的脚印清晰地印在地板上。 | The footprints that the policeman followed/the camera videotaped clearly printed on the floor. |
| | b/c | 警察追踪/镜头拍摄的歹徒惊慌地逃离现场。 | The bandit that the policeman followed/the camera videotaped fled the scene in panic. |

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|---|---|---|---|
| 16 | a/d | 教授质疑/书册记录的野史基本上缺乏依据。 | The unofficial history that the professor challenged/the books recorded basically lacks in credibility. |
| | b/c | 教授质疑/书册记录的名人得意地炒作自己。 | The famous people that the professor challenged/the unofficial history recorded bragged himself complacently. |
| 17 | a/d | 律师审查/墨水溅脏的文件明确地写着批示。 | The document that the lawyer examined/the ink splashed was clearly written with remarks. |
| | b/c | 律师审查/墨水溅脏的证人极力地保持镇定。 | The witness that the lawyer examined/the ink splashed keeps calm with great efforts. |
| 18 | a/d | 民众声援/舆论支持的议案顺利通过了表决。 | The proposal that the citizens supported/the public opinion supported has smoothly passed the voting procedure. |
| | b/c | 民众声援/舆论支持的贫困生如愿地上了大学。 | The poverty-stricken student that the citizens supported/the public opinion supported went to college as wished. |
| 19 | a/d | 神枪手射中/飞刀击中的靶心早已布满了弹孔。 | The target that the sharpshooter hit/the flying dart hit had already been full of holes. |
| | b/c | 神枪手射中/飞刀击中的逃犯直挺挺地倒在路边。 | The escaped convict that the sharpshooter hit/the flying dart hit fell straight to the side of the road. |
| 20 | a/d | 总司令指挥/侦察系统定位的战斗机瞬间摧毁了敌营。 | The fighter craft that the chief commander directed/the detection system pinpointed destroyed one whole division for only a short time. |
| | b/c | 总司令指挥/侦察系统定位的特种兵迅速地占领了敌营。 | The special force that the chief commander directed/the detection system pinpointed quickly took over the whole division. |
| 21 | a/d | 士兵监听/噪音干扰的信号不断地更换频率。 | The signals that the soldier monitored/the noise disturbed constantly changed frequencies. |
| | b/c | 士兵监听/噪音干扰的敌人烦躁地踱着步子。 | The enemy that the soldier monitored/the noise disturbed paced his steps in a fidget. |
| 22 | a/d | 捕捞员寻找/水草缠绕的机翼悄然地沉在湖底。 | The plane wing that the fish worker looked for/the weeds entwined silently sank into the river bottom. |
| | b/c | 捕捞员寻找/水草缠绕的落水者挣扎着沉入湖底。 | The drowned person that the fish worker looked for/the weeds entwined sank into the river bottom while in struggles. |
| 23 | a/d | 干警缉查/法律打击的毒品已经得到处理。 | The drugs that the inspector checked/the law cracks down have already been dealt with. |
| | b/c | 干警缉查/法律打击的奸商终于落入法网。 | The profiteers that the inspector checked/the law cracks down have been caught finally. |

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| 24 | a/d | 老领导走近/足球踢中的宣传栏花花绿绿地贴满了布告。 | The bulletin board that the senior leader was approaching/the football hit was full of posts in different colors. |
| | b/c | 老领导走近/足球踢中的小男孩伤心地坐在台阶上。 | The little boy that the senior leader was approaching/the football hit sadly sat on the stairs. |



## APPENDIX 3

Stimuli of Experiment 3 (the expectation and plausibility ratings given to each sentence within the RC by conditions are given in parenthesis)

| | | | |
|---|---|---|---|
| 1 | a/d | 躲开石块/石块砸中的记者成功地混入营地。The reporter that dodged the stone/the stone hit successfully slipped into the camp. | (5.58,6.1)/(5.15,6.5) |
| | b/c | 砸中记者/记者躲开的石块重重地落在地上。The stone that hit the reporter/the reporter dodged fell to the ground heavily. | |
| 2 | a/d | 破译密电/密电告发的间谍小心地保护自己。The spy that detected the classified information/the classified information revealed carefully protected himself. | (5.89,6.5)/(5.21,5.45) |
| | b/c | 告发间谍/间谍破译的密电悄悄地发送出去。The classified information that revealed the spy/the spy detected was sent out without being noticed. | |
| 3 | a/d | 松开绷带/绷带包扎的伤员顽强地忍住疼痛。The wounded person that loosened bandage/the bandage wrapped endured the pain courageously. | (5.79,6.1)/(5.74,6.65) |
| | b/c | 包扎伤员/伤员松开的绷带大片地染着鲜血。The bandage that was wrapped around the wounded person/the wounded person loosened was stained with blood in large areas. | |
| 4 | a/d | 追赶船只/船只阻挡的少年无奈地停下脚步。The teenager that chased the boat/the boat impeded stopped running resignedly. | (5.05,4.9)/(5.32,5.05) |
| | b/c | 阻挡少年/少年追赶的船只迅速地驶离河岸。The boat that impeded the teenager/the teenager chased swiftly left the river bank. | |
| 5 | a/d | 迷恋美食/美食吸引的总裁全然忘记了时间。The CEO that madly clung to delicacies/the delicacies attracted forgot his time completely. | (6,6.65)/(6.26,6.7) |
| | b/c | 吸引总裁/总裁迷恋的美食整齐地摆在桌上。The delicacies that attracted the CEO/the CEO madly clung to were presented on the table in a neat way. | |
| 6 | a/d | 挽救生意/生意烦扰的促销员深深地吸了一口气。The salesman that rescued the business/the business worried deeply took in a breath. | (6,6.6)/(5.47,4.4) |
| | b/c | 烦扰促销员/促销员挽救的生意逐渐地有了转机。The business that worried the salesman/the salesman rescued gradually improved to a better direction. | |
| 7 | a/d | 鄙视流言/流言诋毁的艺术家高傲地穿过人群 .The artist that despised the rumor/the rumor involved proudly walked through the crowd. | (6,5.95)/(6.05,6.1) |
| | b/c | 诋毁艺术家/艺术家鄙视的流言一时传遍全城。The rumor that involved the artist/the artist despised quickly spread to the whole city. | |
| 8 | a/d | 误读文稿/文稿批判的女主持竭力地掩饰不安。The TV anchorwoman that misread the paper/the paper criticized tried her best to cover her nervousness. | (5.74,6.15)/(5.47,4.9) |
| | b/c | 批判女主持/女主持误读的文稿凌乱地堆在桌上。The paper that criticized the anchoress/the TV anchorwoman misread piled up on the desk messily. | |
| 9 | a/d | 抨击议案/议案批准的候选人普遍地得到了拥护。The candidate that critiqued the proposal/the proposal approved won wide support. | (5.32,5.7)/(5,5) |
| | b/c | 批准候选人/候选人抨击的议案顺利地通过了表决。The proposal that approves the candidate/the candidate critiqued has smoothly passed the voting procedure. | |
| 10 | a/d | 否认指控/指控攻击的贪官肆意地挥霍完公款。The corrupt official that denied the accusation/the accusation attacked recklessly wasted public funds. | (5.84,6.5)/(5.32,5.5) |
| | b/c | 攻击贪官/贪官否认的指控暂时缺乏证据。The accusation that attacked the corrupt officials/the corrupt official denied lacks in evidence for now. | |

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|---|---|---|---|
| 11 | a/d | 访问网站/网站评比的明星进一步增加了知名度。The pop star that visited the website/the website ranked has greatly improved his fame. | (6.58,6.55)/ (6,6.7) |
| | b/c | 评比明星/明星访问的网站大大地提高了点击率。The website that ranks pop stars/ the pop star visited has greatly increased its click rate. | |
| 12 | a/d | 引爆手雷/手雷炸伤的抗议者激昂地喊起口号。The protesters that initiated the grenade/the grenade injured indignantly chanted slogans. | (5.42,5.5)/ (5.53,5.35) |
| | b/c | 炸伤抗议者/抗议者引爆的手雷顿时造成骚乱。The grenade that injured the protesters/the protestant initiated immediately caused disturbance. | |
| 13 | a/d | 检测疫情/疫情困扰的医生努力地寻找病源。The doctor that checked the plague/ the plague perplexed looked for its source with great efforts. | (6.26,6.2)/ (6.16,6.65) |
| | b/c | 困扰医生/医生检测的疫情已经蔓延全村。The plague that perplexed the doctor/ the doctor checked has pervaded the whole village. | |
| 14 | a/d | 挑选鲜花/鲜花点缀的新娘开心地哼起歌曲。The bride that picked flowers/the flowers decorated happily hummed a song. | (6.32,6.75)/ (6.05,6.35) |
| | b/c | 点缀新娘/新娘挑选的鲜花别致地扎成花环。The flowers that decorated the bride/ the bride picked were elegantly arranged into a garland. | |
| 15 | a/d | 发现镜头/镜头拍摄的匪徒惊慌地逃离现场。The bandit that found the camera/the camera videotaped fled the scene in panic. | (5.47,6)/ (5.58,6.85) |
| | b/c | 拍摄歹徒/歹徒发现的镜头隐秘地藏在暗处。The camera that videotaped the bandit/the bandit found was secretly hidden in the dark. | |
| 16 | a/d | 质疑野史/野史记录的名人大多博览群书。The famous people that challenged unofficial history/the unofficial history recorded mostly have read lots of books. | (6.05,5.35)/ (5.74,5.35) |
| | b/c | 记录名人/名人质疑的野史在民间流传很广。The unofficial history that recorded famous people/the famous people challenged was popular among the masses. | |
| 17 | a/d | 审查案件/案件难倒的律师在同行间享有盛名。The lawyer that examined the case/ the case puzzled was well-known in the field. | (5.74,6.2)/ (5.53,6.7) |
| | b/c | 难倒律师/律师审查的案件果然存在漏洞。The case that puzzled the lawyer/the lawyer examined indeed has loopholes. | |
| 18 | a/d | 声援提案/提案保护的消费者合理地提出要求。The consumers that supports the proposal/the proposal protects make a demand reasonably. | (5.47,5.95)/ (5.53,6.2) |
| | b/c | 保护消费者/消费者声援的提案广泛地引起了关注。The proposal that protects the consumers/the consumers support widely attracts attention. | |
| 19 | a/d | 闪开飞镖/飞镖击中的神枪手迅速地隐入树林。The sharpshooter that avoided flying dart/the flying dart hit swiftly disappeared into the woods. | (5.05,6.45)/ (5,5.45) |
| | b/c | 击中神枪手/神枪手闪开的飞镖清晰地刻着记号。The flying dart that hit the sharpshooter/the sharpshooter avoided was clearly carved with a mark. | |
| 20 | a/d | 控制侦查系统/侦查系统定位的特种兵迅速地占领了敌营。The special force that controlled the detection system/the detection system positioned quickly took over the enemy's camp. | (5.37,5.85)/ (5.79,5.9) |
| | b/c | 定位特种兵/特种兵控制的侦查系统瞬间完成部署。The detection system that positioned the special force/the special force controlled completed the deployment for only a short time. | |
| 21 | a/d | 监听信号/信号干扰的士兵曾经立过战功。The soldier that monitored the signals/ the signals disturbed had once distinguished himself in the war. | (5.53,6.45)/ (5.32,5.4) |
| | b/c | 干扰士兵/士兵监听的信号不断地更换频率。The signals that disturbed the soldier/ the soldier monitored constantly changed its frequencies. | |
| 22 | a/d | 穿过水草/水草缠绕的捕捞员吃力地游到岸边。The fish worker that went through the weed/the weed entwined swam to the bank with great effort. | (5.11,6.15)/ (6.05,6.5) |
| | b/c | 缠绕捕捞员/捕捞员穿过的水草密密地长满湖底。The weed that entwined the fish worker/the fish worker went through grew thickly at the bottom of the lake. | |
| 23 | a/d | 违反税法/税法打击的奸商乖乖地缴了罚款。The profiteers that violated the tax law/the tax law cracks down paid the fines obediently. | (6.68,6.75)/ (5.11,5.35) |
| | b/c | 打击奸商/奸商违反的税法迫切地需要完善。The tax law that cracks down the profiteers/the profiteers violated is badly in need of improvement. | |
| 24 | a/d | 拍打皮球/皮球打中的小男孩使劲地跺了下脚。The little boy that played football/ the football hit thumped his foot forcefully. | (6.42,6.75)/ (5.61,6.55) |
| | b/c | 打中小男孩/小男孩拍打的皮球轻轻地弹入草丛。The football that hit the little boy/the little boy played bounced lightly onto the lawn. | |