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<table>
<thead>
<tr>
<th>Authors</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yaqing Hu</td>
<td>Remnant Movement in Chinese ‘Clausal’ <em>bi</em>-Comparatives</td>
<td>3</td>
</tr>
<tr>
<td>Liulin Zhang</td>
<td>Topic-Prominent versus Subject-Prominent: Cross-Modal Priming in the Processing of Chinese OSV Sentences</td>
<td>28</td>
</tr>
<tr>
<td>Yihan Zhou</td>
<td>Classifying roots, quasi-affixes and affixes in Chinese: quantitative and statistical approaches</td>
<td>67</td>
</tr>
</tbody>
</table>
Remnant Movement in Chinese ‘Clausal’ bi-Comparatives

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This paper deals with the syntax of Chinese ‘clausal’ bi-comparatives (e.g., Liu, 2011) through two aspects: adopting the configuration of Remnant Movement as originally proposed for German and taking the information structure of Chinese into account. I show here that the remnant vPs (i.e., after the extraction of the comparison predicate), bearing a feature [+contrast], in the matrix clause of Chinese ‘clausal’ bi-comparatives obligatorily move to a higher position due to two reasons: (i) to establish a contrastive relation with the constituents in the bi-phrase (Liu, 2011); (ii) to overtly mark the domain of contrast for the moved element in surface syntax (e.g., Neeleman et al., 2009; Neeleman & Vermeulen, 2012). Theoretically, the results support the explications concerning the co-occurrence of some modals with the bi-phrase, as well as the obviation of the Condition C effect, in Chinese ‘clausal’ bi-comparatives.

Key Words: Chinese bi-comparatives, remnant movement, information structure, contrastive foci, contrastive topics, the Condition C.

I. Introduction

In Chinese ‘phrasal’ bi-comparatives (i.e., those involving only one constituent in the bi-phrase), the bi-phrase is structurally flexible under certain circumstances, such as (1).

(1) a. Yuehan yinggai bi Mali gao.
   John should BI Mary tall
   “John may be taller than Mary.”

b. * Yuehan bi Mali yinggai gao.
   John BI Mary should tall

(2) a. Yuehan yinggai bi Mali gao wu gongfen.
   John should BI Mary tall five centimeter
   “John may be five centimeters taller than Mary.”

b. Yuehan bi Mali yinggai gao wu gongfen.
   John BI Mary should tall five centimeter

As shown by the examples in (1), while co-occurring with the epistemic expression yinggai (should), the bi-phrase can only follow it if there is no differential phrase; conversely, the

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presence of a differential phrase, as in (2), seems to license the structural flexibility of the 
bi-phrase, which can either precede or follow the epistemic expression. This phenomenon is more clearly exemplified by Chinese ‘clausal’ bi-comparatives (i.e., those involving more than one constituent in the compared and standard phrase), as in (3).

(3) a. Yuehan yinggai qi ma bi Mali qi che qi-de kuai yixie.
   John should ride horse BI Mary ride bike ride-DE fast a little
   “John may ride horses a little faster than Mary rides bikes.”

b. Yuehan qi ma yinggai bi Mali qi che qi-de kuai yixie.
   John ride horse should BI Mary ride bike ride-DE fast a little

c. Yuehan qi ma bi Mali qi che qi-de yinggai kuai yixie.
   John ride horse BI Mary ride bike ride-DE should fast a little

While occurring in the examples like (3), yinggai (should) may occupy various positions in syntax, as represented by (3a-c) respectively. More importantly, the displacement of this modal does not lead to any change in semantics. In (3b-c), qi ma (ride horses), as a vP, is in a position higher than that of the modal which usually occupies a position higher than vP but under T (e.g., Adger, 2003). Then, it is not unreasonable to assume that some part of the examples in (3) may undergo movement since yinggai (should) is supposed to scope over the entire construction before any movement.

Adopting Neeleman et al. (2009), Neeleman & Vermeulen (2012), and Szendrői (2017), I propose that vP in Chinese ‘clausal’ bi-comparatives undergoes movement, following an extraction of the comparison predicate out of vP. This can be attributed to the fact that compared constituents in the compared phrase and the standard phrase respectively need to set up a contrastive relation, i.e., contrastive foci or contrastive topics (Kiss, 1998; Krifka, 2008). In terms of their positions, Belletti (2015:42) argues that there are two different positions in a clause, “a low vP peripheral one dedicated to host new information focus constituents, and a high left peripheral one dedicated to express contrastive focalization”.

Based on this argument, I further postulate that the remnant vPs (i.e., after the extraction of the comparison predicate), bearing a feature [+contrast], in the matrix clause of Chinese ‘clausal’ bi-comparatives obligatorily move to a higher position due to two reasons: (i) to establish a contrastive relation with the constituents in the bi-phrase; (ii) to overtly mark the domain of contrast for the moved element in surface syntax. Overall, such configuration squares well with the analysis of Remnant Movement as originally proposed for German (Besten & Webelhuth, 1990; Müller, 1998, 2015), which will be adopted in this paper.

II. Analysis of Some Fundamental Issues

There are several debatable issues concerning Chinese bi-comparatives, including the status of the bi-phrase, phrasal (e.g., Xiang, 2005) or clausal (e.g., Liu, 1996), as well as the projection of DegP in Chinese bi-comparatives (e.g., Gu & Guo, 2015). While I agree with some of the fundamental assumptions, before getting into the details of my analysis, it is necessary to present my response to those debates, which would play a key role in further explications.
2.1 Chinese \textit{bi}-Comparatives are Clausal Comparatives

Two major types of analyses concerning degree syntax and semantics have been suggested for English comparatives, namely the Reduction Analysis (e.g., von Stechow, 1984) and the Direct Analysis (e.g., Heim, 1985). Such clausal – phrasal debate has also been extended to Chinese \textit{bi}-comparatives. The in-depth comparison of two kinds of analysis is beyond the scope of this paper. In this section, I will show that Chinese \textit{bi}-comparatives are potentially clausal comparatives, in line with Liu (1996) and Erlewine (2017). However, unlike previous assumptions, I will further adopt the idea that the morpheme \textit{bi} takes a non-finite clause as its complement based on Hsieh (2017).

This argument stems from the structural flexibility of the \textit{bi}-phrase, as in (4) and (5).

   John should BI Mary tall five centimeter
   “John may be five centimeters taller than Mary.”

   John BI Mary should tall five centimeter

   John should BI Mary tall
   “John may be taller than Mary.”

   John BI Mary should tall

In (4) and (5), the modal \textit{yinggai} (should) is used as a diagnostic to show that, when there is a differential phrase, the \textit{bi}-phrase can be in a position higher than that of the modal. On the contrary, when the differential phrase is absent, the \textit{bi}-phrase is not allowed to be flexible, as the contrast shown by (5a-b). Then a natural question to ask is why this is the case. In semantics, gradable adjectives map objects onto an abstract representation of measurement formalized as sets of values (e.g., Kennedy, 1999). In other words, there is a degree argument inside the gradable adjective that needs to be saturated (Creswell, 1977; von Stechow, 1984; Kennedy & McNally, 2005). Following this assumption, Liu (2010) suggests that the degree argument of gradable adjectives in Chinese \textit{bi}-comparatives has to be \( \theta \)-bound by the \textit{bi}-phrase. For instance, in (5a), [\textit{bi} Mary] denotes a degree \( \theta \)-binding the degree argument of the gradable adjective \textit{gao} (tall).

Adding to this line of argument, I adopt the proposal that measure phrase, like \textit{wu gong-fen} (five centimeters), can also bind the degree argument of the gradable adjective (Schwardzschild, 2005). Consequently, when there is a differential phrase, as shown by (4a-b), I propose that the degree argument of gradable adjectives in Chinese \textit{bi}-comparatives can be \( \theta \)-bound by the \textit{bi}-phrase or a differential phrase or by both simultaneously. When the differential phrase binds that degree argument, the \textit{bi}-phrase may be free to move and adjoin to a higher projection, such as ModP in (4b). However, in
(5a), since the *bi*-phrase has to θ-bind the degree argument, it means that it is not free to move any more, as indicated by the ungrammaticality in (5b).

That the *bi*-phrase may undergo movement under certain conditions points to a fact that it denotes a degree that θ-binds the degree argument of the gradable predicate. This offers a strong support to the claim that the morpheme *bi* in effect subcategorizes for a clause-like structure. If this analysis is on the right track, we should expect that, as long as the degree argument of the gradable predicate is θ-bound, either a differential phrase or a degree adverb, the *bi*-phrase is free to move. This expectation is borne out in (6).

    John should BI Mary even-more tall
    “John may be even taller than Mary.”

    John BI Mary should even-more tall

If the degree argument is bound by the degree adverb *geng* (even-more), then the *bi*-phrase may move up to a position higher than that of the modal *yinggai* (should), as shown by (6b). If we follow the phrasal analysis, namely, there is only one instance of the gradable predicate, it is impossible for the *bi*-phrase in (4) and (5) to denote a degree since the morpheme *bi* takes a DP as its complement.

In order to champion the premise that Chinese *bi*-comparatives are potentially clausal comparatives, one obvious challenge is how to explain the unavailability of subcomparatives and embedded comparatives in Chinese, as in (7) and (8).

(7) a. This desk is longer than that chair is wide.

b. * zhe zhang zhuozi [bi na ba yizi kuan] chang.
    this CL desk BI that CL chair wide long

(8) a. John is taller than Tom thinks Mary is.

    John BI Tom think Mary tall

Instead of assuming that *bi* subcategorizes for a full-fledged CP as in English, I extend Hsieh’s (2017) proposal2 that the complement of the morpheme *bi* is a small clause and short of all the higher projections, and further argue that *bi* takes a non-finite TP as complement involving rescue-by-PF-deletion mechanism (Boškvić, 2011) to avoid grammatical violations. The defective T in the complement clause of *bi* has these properties: it has an EPP feature which causes the subject to raise to [Spec, TP], but it cannot license the Agree relation with the predicate. Thus, I propose that a PF-deletion is obligatory: delete as small a constituent as possible, but enough to avoid a grammatical violation. Take

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2 Hsieh (2017) assumes that adjectives in Chinese are verbal heads, and the small clause analysis of the *bi*-phrase is based on Wurmbrand’s (2014) definition of Agree.
(9a) as an example, an overt occurrence of *kaixin* (happy) inside the *bi*-phrase has to be deleted as it cannot be licensed by any T, which corresponds to *v’* in (9b).

(9) a. Yuehan jitian zaijia [bi Mali zuotian zaixuexiao] kaixin.

John today at-home BI Mary yesterday at-school happy

“No John is happier today at home than Mary was yesterday at school.”

b.

Following Hsieh (2017), I take it that adjectives in Chinese are verbal heads, and that is why *vP* is adopted here. The structure in (9b) suggests that the adjective *happy* needs to Agree with a finite T so that its uninterpretable feature [*uT*] can be valued. However, this cannot be done given the defective T inside the *bi*-phrase and the intervention of the *bi*-phrase as an island. Thus, what is elided inside the *bi*-phrase is *v’* containing the unlicensed *happy*, as indicated by the box, which saves the derivation from crash after Spell-Out. In line with Hsieh (2017:279-280), in the case of subcomparatives, the overt realization of a gradable predicate inside the *bi*-phrase, as in (7b), bears an unvalued feature [*uT*] that cannot be valued by the closest T bearing a valued feature since *bi* subcategorizes for a non-finite TP and the *bi*-phrase is an island blocking the Agree relation between the verbal head inside it and T of the matrix clause. Hence, the derivation will be crashed if there is no PF-deletion. Likewise, when it comes to the embedded comparatives, such as (8b), the verbal head *renwei* (think) inside the *bi*-phrase carries an unvalued feature [*uT*] that is neither valued by the closest T nor deleted at PF. This then leads to ungrammaticality.

2.2 The Projection of Comparison Predication Phrase (CPredP)

In terms of cross-linguistic variations in comparative constructions, three parameters have been proposed, including Degree Semantics Parameter, Degree Abstraction and Degree Phrase Parameter (Beck, Oda & Sugisaki, 2004; Beck, et al., 2010), as illustrated in (10).

(10) a. **Degree Semantics Parameter (DSP)**

A language {does/does not} have gradable predicates (type <d,<e,t>> and related), i.e. lexical items that introduces degree arguments.

b. **Degree Abstraction Parameter (DAP)**
A language \{does/does not\} have binding of degree variable in the syntax.

c. **Degree Phrase Parameter (DegPP)**

The degree argument position of a gradable predicate \{may/may not\} be overtly filled.

Following Beck, et al. (2010), the dependencies between these parameters are described in the following: determine [DSP] in the first place, if we have a setting [-DSP], then we must have a setting [-DAP]; only there is a setting [+DAP], then we would have a setting [+DegPP], namely a DegP in syntax, since DegPs are operators over degrees.

Gradable predicates are usually used to construct Chinese bi-comparatives, which means Chinese has a setting [+DSP]. According to Krasikova (2008) and Beck, et al. (2010), Chinese has a negative setting of [DAP], which comes from the following evidence: lack of English-like negative island effects, scope interactions, degree question, measure phrase, subcomparatives, and embedded comparatives.

(11) **a. negative island effects**

1. * John bought a more expensive cellphone than Mary didn’t.
2. Yuehan mai-de shouji bi Mali mei mai-de gui.
   
   John buy-DE cellphone BI Mary not buy-DE expensive
   
   “John bought a more expensive cellphone than the one Mary didn’t buy.”

**b. scope interaction**

1. (This box of strawberry is 10 kg.) The box of strawberry is required to be exactly 5 kg heavier than that.
2. Yuehan xuyao bi Mali shao mai yixie caomei.
   
   John must BI Mary less buy some strawberry
   
   “John has to buy less strawberry than Mary does.”

**c. degree question**

* Yuehan shi duo gao?
   
   John is how tall
   
   “How tall is John?”

**d. measure phrase**

? zhe-xiang caomei shi shi gongjin zhong.
   
   this-CL strawberry is ten kilogram heavy
   
   “This box of strawberry is 10kg heavy.”
It can be readily seen that, in (11a), the bi-phrase hosts a negation, which does not lead to unacceptability, contrary to its English counterpart. The Chinese example in (11b) only means that the minimum amount of strawberry John has to buy is exceeded by the minimum amount of strawberry Mary has to buy, which does not exhibit any ambiguity. Yet, Beck et al. (2010) suggest that Chinese does not have degree questions and measure phrase structure, as in (11c-d), which is not necessarily the case.

(12) a. **degree question**

Yuehan you duo gao?

John have how tall

“How tall is John?”

b. **measure phrase**

zhe-xiang caomei you shi gongjin zhong.

ding-CL strawberry have ten kilogram heavy

“This box of strawberry is 10kg heavy.”

As (12) shows, instead of using a copular to construct degree questions and measure phrase structures, Chinese resorts to an auxiliary verb `you` (have) to form such constructions. Furthermore, as argued in 2.1, the unavailability of subcomparatives and embedded comparatives is due to the non-finite clause structure in the bi-phrase, in which the unvalued feature of the verbal head cannot be valued, leading to a crash in derivation. Even if I agree that Chinese bi-comparatives lack negative island effects and scope interactions, the arguments on the unavailability of degree questions, measure phrase structure, subcomparatives and embedded comparatives seem to be inconclusive. Hence, that Chinese has a negative setting [DAP] is open to question and needs further investigation.

Since the setting of [DAP] in Chinese is not conclusive based on the empirical evidence provided above, if following dependencies argued by Beck, et al. (2010), it seems difficult to determine the setting of [DegPP] in Chinese. This may leave the legitimacy of DegP in Chinese open. I thus take it that the degree argument position of a gradable predicate in Chinese may not be overtly filled, namely, Chinese has a negative setting of [DegPP]. Consequently, three parameters in Chinese and English are summarized below, which partly differs from Beck, et al. (2010).

(13) Three parameters of cross-linguistic variations in Chinese and English comparatives

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<th>[DSP]</th>
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<td>Chinese</td>
<td>+</td>
<td>?</td>
<td>-</td>
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<tr>
<td>English</td>
<td>+</td>
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Apart from these three parameters, there is a syntactic constraint on Chinese bi-comparatives (Su, 2015; Lin, 2009), as illustrated below.
(14) **A constraint on the compared constituents of the bi-comparatives**

In a bi-comparative, the compared constituent and its correlate must be arguments of the comparison predicate, and both of them must have the same dimension.

The above constraint is purely syntactic in the sense that it requires the compared phrase and the standard phrase form a grammatical sentence with the comparison predicate respectively. I use the example (15) to illustrate this.

    John BI Mary tall
    “John is taller than Mary.”

b. ① Yuehan hen gao. / ② Mali hen gao.
    John very tall / Mary very tall
    “John is tall.” / “Mary is tall.”

As can be seen from (15b), as long as the compared phrase and the standard phrase can form a grammatical sentence with the comparison predicate respectively, then they can be compared along the scale denoted by the predicate. This constraint, in effect, is consistent with the basic definition of “predicate”, stated in Bowers (2001:299), “a predicate is an unsaturated expression that must combine with an entity expression to form a proposition”.

In 2.1, I argued that Chinese bi-comparatives are potentially clausal comparatives, which indicates that the compared phrase and the standard phrase both form a proposition with the comparison predicate. Thus, following theories of predication (Bowers 2001), I propose that there is a projection of Comparison Predication Phrase (hereafter CPredP) in Chinese bi-comparatives instead of a DegP, and schematically:

(16)

Following Cresswell (1977), von Stechow (1984), and Kennedy & McNally (2005), I assume that there is a degree argument in the gradable adjectives when they are the comparison predicate. As shown before, the bi-phrase may be structurally flexible under certain circumstances, namely when that degree argument is bound by something else also
denoting a degree argument, such as a degree adverb or a differential phrase (Schwardzschild, 2005). AdvP, DiffP (differential phrase) and biP (bi-phrase) must be in a position to bind the degree argument of the head of CPredP locally (e.g., Liu, 2010). When the degree argument of the comparison predicate is bound by a degree adverb or a differential phrase, I conjecture that the bi-phrase is free to move to a higher position since it may be an active goal for a probe bearing a feature that needs to be checked off. Given the structural flexibility of the bi-phrase, I further hold that it functions like participant PPs in Chinese, namely expressing additional roles in a comparing event (Ernst, 2014). In other words, the bi-phrase hosts new information focus constituents, explicitly expressing with which the constituents in the compared phrase are comparing (Belletti, 2015).

III. The Syntax of Chinese ‘Clausal’ bi-Comparatives

In this section, I will investigate the syntactic structure of Chinese ‘clausal’ bi-comparatives, namely comparatives involving the comparison of multiple topics, as in (17b), following remnant movement analysis (e.g., Müller, 1998, 2015).

(17) a. Yuehan [VP1 qi ma] [VP2 qi-de hen kuai].
    John ride horse ride-DE very fast
    “John rides horses very fast.”

b. Yuehan qi ma bi Mali qi che qi-de kuai yixie.
    John ride horse BI Mary ride bike ride-DE fast a little
    “John rides horses a little faster than Mary rides bikes.”

3.1 Several Issues

Before proceeding, five issues need to be dealt with. First, in terms of the structure for verb-copy constructions like (17a), traditionally, they are analyzed as consisting of two VPs, with VP1 being an adjunct or an adverbial clause and VP2 being the main predication (e.g., Huang, 1988). This analysis would be problematic if facing examples including three VPs, as in (18), adapted from Fang & Sells (2007).

(18) Yuehan [VP1 qi ma] [VP2 qi-le yi tian] [VP3 qi-de hen lei].
    John ride horse ride-ASP one day ride-DE very tired
    “John rode horses for a day and is/was tired.”

We may assume that VP1 and VP2 are adjuncts if following Huang (1988). However, according to Fang & Sells (2007), the attachment of the aspect marker le to the head of VP2 indicates that VP2 is a verb phrase as VP3 since le only attaches to the heads in Mandarin Chinese. Another piece of evidence comes from the adjunct distribution.

(19) Yuehan [zai muchang] [VP1 qi ma] [VP2 qi-de hen lei].
    John at ranch ride horse ride-DE very tired
    “John rode horses at ranch and is/was tired.”
Generally, an adjunct of a VP usually adjoins to the head of that VP. (19) entails “John rode horses at ranch” and “John is/was very tired at ranch”, showing that the adjunct zai muchang (at ranch) is distributed to both VP₁ and VP₂. It then strongly suggests that VP₁ and VP₂ are both verb phrases, contrary to the traditional perspective. These two pieces of evidence discussed above lend substantial support to the analysis of (17b), in which qi ma (ride horses) is a verb phrase (Fang & Sells, 2007).

Second, in terms of semantics, (17a) yields “object result” reading since, in this case, ma (horse) is linked to the predicate hen kuai (very fast). This supports Sybesma’s (1999) assumption about VP₂ in (17a):

(20) \[ [\text{VP}_2 \text{ride} [\text{deP} \text{de} [\text{SC horse fast}]]] \]

For VP₁ in (17a), Cheng (2007) proposes that it is the result of verb copying rather than base-generated. In ba-constructions, ba usually occupies the small v; when verb-copying is comparable to this construction, the verb is copied and moved to v to replace ba. After the verb is raised, its lower copy is fused with de in terms of its morphology, which is invisible to Linear Correspondence Axiom (Kayne, 1994) and Chain Reduction (Nunes, 2004). Both copies, therefore, are allowed to be phonologically realized. By adopting Sybesma (1999) and Cheng (2007), I assign a structure for (17a), as represented in (21).

(21)

In (21), ma (horse) forms with hen kuai (very fast) a small clause, producing the right meaning ‘horses’ speed is very fast’, and then moves to [Spec, VP]. The verb qi (ride) is copied and raised to the small v, and the two ends of a movement chain are both phonologically realized.

Third, according to Tsao (1989) and Liu (2011), compared constituents in the standard phrase have to be parallel to their correlates in the compared phrase in terms of syntax, semantics, and category. This assumption is instrumental in obtaining an underlying form for (17b), as shown in (22a).

(22) a. Yuehan \_ qi \_ ma \_ qi-de \_ bi \_ Mali \_ qi \_ che \_ qi-de \_ kuai \_ yixie.

John ride horse ride-DE BI Mary ride bike ride-DE fast a little
b. [Yuehan qi ma qi-de] bi [Mali qi che qi-de] kuai yixie.
c. [Yuehan qi ma qi-de] bi [Mali qi che qi-de] kuai yixie.

Based on the surface structure, the two underscored constituents are syntactically and semantically parallel to each other, and the comparison predicate is *kuai* (fast) that names the dimension of comparison. Yet, comparative ellipsis may be involved (Liu, 2011; Su, 2012), which results in various surface forms, as shown by (22b-c) respectively.

Forth, in Chinese *bi*-comparatives, compared constituents in the compared phrase and the standard phrase respectively are in a contrastive relationship (e.g., Liu, 2011). Thus, they are in fact two foci in Chinese comparatives, represented by […]*F*, following Krifka (2008)\(^3\).

(23) a. [YUEHAN]\(^F\) bi [MALI]\(^F\) xihuan meiguo.
    John BI Mary like US
    “John likes US more than Mary does.”

b. [Yuehan qi ma]\(^F\) bi [Mali qi che]\(^F\) kuai yixie.
   John ride horse BI Mary ride bike fast a little
   “John rides horses a little faster than Mary rides bikes.”

According to Kiss (1998), a focus is contrastive if there is a complementary alternative set with clearly identifiable elements. Following this argument, in (23b), the focalized *John rides horses* has *Mary rides bikes* as the identifiable element of the alternative set. Thus, the contrastive relationship between these two compared constituents is established. In order to accommodate this fact, I propose that there is a covert Focus head (represented as OP\(^F\)) projecting a Focus Phrase (FocP) above CPredP in Chinese *bi*-comparatives.

Last but not least important, the occurrence of a differential phrase in Chinese *bi*-comparatives may be accompanied by aspect markers.

(24) Yuehan bi Mali gao-le/-chu\(^4\) wu gong-fen.
    John BI Mary tall-ASP five centimeter
    “John is five centimeters taller than Mary.”

As shown by (24), two aspect markers are compatible with the comparison predicate (i.e., *gao*) in Chinese *bi*-comparatives. In the meanwhile, the differential phrase obligatorily co-occurs with these two aspect markers. Thus, I argue that the occurrence of aspect markers indicates that the comparing event implied by the gradable adjective has been initiated

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\(^3\) “Focus indicates the presence of alternatives that are relevant for the interpretation of linguistic expressions.”

\(^4\) Gu & Guo (2015) treats –*chu* as the head of Degree Phrase since its presence obligatorily requires the overt realization of differential phrase. However, –*chu* is more reasonably treated as an aspect markers.

(i) Yuehan zuotian jiahuachu yi-fen caoan.
    John yesterday draft-ASP one-CL project
    “John drafted a project yesterday.”

Following Liu’s (2015) argument, I believe that –*chu* indicates that the event denoted by the verb has been completed.
(Kennedy & McNally, 2005; Liu, 2015). The presence of a differential phrase suggests that the comparing event implied has been completed (Liu, 2005). In other words, the aspect marker cooperates with the differential phrase to guarantee the completeness of the comparing event denoted by the gradable adjective.

Following Grano (2013), I then propose that aspect markers are base-generated in Chinese and then attached to the verbal head. When the differential phrase is present in syntax, as in (24), the gradable predicates enter into the derivation aspectually suffixed by \( u \) (whose overt realizations are \( le \) and \( chu \)), in which case it bears an uninterpretable and valued A feature – \([uA:PERF]\). In addition, Aspect enters into the derivation without overt phonological material, in which case it has an interpretable and unvalued A feature – \([iA:__]\). A feature on Asp acts like a probe, which is valued as PERF via Agree relation with the gradable predicate, then the uninterpretable feature \([uA:PERF]\) on the gradable predicate is deleted. When the differential phrase is absent, as in (1 a), A feature on Asp receives a default feature \([NEUT]\). The proposal is schematized in (25).

\[
(25) \begin{align*}
\text{a. Asp } [iA:__] \ldots V-\mu [uA:PERF] & \Rightarrow Asp [iA:PERF] \ldots V-\mu [uA:PERF] \\
\text{b. Asp } [iA:__] \ldots V & \Rightarrow Asp [iA:NEUT] \ldots V
\end{align*}
\]

On the basis of this argument, I further propose that, following Liu (2004), there is an Aspect Phrase (hereafter AspP) above CPredP in Chinese \( bi \)-comparatives, whose position is fixed. In line with Rizzi (1997) and Paul (2005), take (17b) as an example, I propose that Chinese ‘clausal’ \( bi \)-comparatives involve at least the following projections.

\[
(26) TP > FocP > AspP > CPredP > vP
\]

### 3.2 The Internal Structure of Chinese ‘Clausal’ \( bi \)-Comparatives

By comparing (17b) with (3a-c), \( qi ma \) (ride horses), as a \( vP \), seems to move from a lower position since it may obviously occupy a position higher than that of modals in surface syntax. Then a natural question to ask is what licenses its movement to a higher position. Before providing my assumption, it is worthy of noting that such \( vP \)-movement resembles Focus Fronting in Italian, as in (27) and (28), cited from Bianchi (2015).

\[
(27) \text{A: Gianni ha licenziato Silvia.} \\
\quad \text{John has fired Sylvia} \\
\quad \text{“John fired Sylvia.”} \\
\text{B: [Lucia] } e_2 \text{ ha licenziato __, (non Silvia).} \\
\quad \text{Lucy (he) has fired (not Sylvia)} \\
\quad \text{“It is Lucy who he fired (not Sylvia).”}
\]

\[
(28) \text{A: Maria ha detto [che le hanno regalato un braccialetto].} \\
\quad \text{Mary has said that her-CL have.3PL given a bracelet} \\
\quad \text{“Mary said that they gave her a bracelet.”}
\]
B: No, e ha detto [che [un anello] e le hanno regalato __].

“No, she said that they gave her a ring.”

In (27), the focus is on the fronted direct object, i.e., Lucia (Lucy), which moves to the periphery of the TP, and in (28), the fronting of an embedded focus, i.e., un anello (a ring), which moves to the edge of the embedded TP, is also permitted. As argued by Bianchi (2015:62), what is expressed in (27A) and (28A) is a member of the set of focus alternatives of (27B) and (28B), and this would give rise to the contrast across the utterance. In other words, the fronting of focus phrase is to help establish contrastive interpretation in syntax.

According to Neeleman et al. (2009) and Neeleman & Vermeulen (2012), contrastive foci or contrastive topics, bearing a feature [+contrast], may move to a position where the sister of the moved element is the ‘domain of contrast’ (DoC), as shown by (29).

(29) a. \[YP \ldots \text{XP}_{\text{contrast}} \ldots\]

\[
\text{part of DoC \hspace{1cm} contrastive element \hspace{1cm} part of DoC}
\]

b. \[\text{XP}_{\text{contrast}} \hspace{1cm} \text{YP} \ldots \text{tXP} \ldots\]

\[
\text{contrastive element \hspace{1cm} DoC}
\]

As (29a) shows, if XP stays in-situ, the domain of contrast is a discontinuous constituent consisting of elements preceding and following XP; whereas in (29b), when XP moved to a higher position, its sister YP is now a single syntactic constituent serving as its domain of contrast. Adopting this argument, Szendrői (2017) argues that the motivation for fronting contrastive foci in Italian is to create a syntactic constituent in surface syntax that can mark the domain of contrast. In other words, “the movement ensures that the surface syntactic representation of the contrastive element and its domain of contrast reflect their LF scope relation” (Szendrői, 2017:20).

Likewise, adopting Neeleman et al. (2009), Neeleman & Vermeulen (2012), and Szendrői (2017), I propose that movement of vP in Chinese ‘clausal’ bi-comparatives can be attributed to the fact that compared constituents in the compared phrase and the standard phrase respectively need to set up a contrastive relation, i.e., contrastive foci. In terms of the position of contrastive foci, Belletti (2015:42) argues that there are two different positions in a clause, “a low vP peripheral one dedicated to host new information focus constituents, and a high left peripheral one dedicated to express contrastive focalization”. Based on Belletti’s proposal, I postulate that the remnant vPs (i.e., after the extraction of the comparison predicate), bearing a feature [+contrast], in the matrix clause of Chinese ‘clausal’ bi-comparatives obligatorily move to a higher position due to two reasons: (i) to establish a contrastive relation with the constituents in the bi-phrase; (ii) to overtly mark the domain of contrast for the moved element in surface syntax.

Based on all the arguments made above, I suggest that Chinese ‘clausal’ bi-comparatives like (17b), are assigned a structure in (30).
Let’s look at the main structure first. As proposed in 2.2, there is a projection of Comparison Predicate Phrase (CPredP) in Chinese bi-comparatives, following Bowers (2001), the head of which names the dimension of comparison. Hence, kuai (fast) undergoes movement from its original position in vP to the head of CPredP. Since the comparison predicate is gradable, either a verb or an adjective, having a degree argument that needs to be bound (Liu, 2010), bi-phrase or differential phrase denotes a degree argument that can bind the degree argument of the head of CPredP locally (cf. Creswell, 1977; von Stechow, 1984; Kennedy & McNally, 2005). This explains why the bi-phrase and the differential phrase both are in [Spec, CPredP]. Due to the parallelism requirement, the presence of a bi-phrase in the structure is licensed by two conditions: a constituent or constituents compatible with it in terms of syntax, semantics, and category while also establishing a contrastive relation with it. This motivates movement of the remnant vP to [Spec, FocP] after the extraction of the comparison predicate. The internal structure of the remnant vP is the same as the structure in (21). Also note that the presence of a differential phrase guarantees the completeness of the comparing event (Liu, 2005), and thus there is an aspect marker, which is covert (i.e., u) in this case, attached to the head of CPredP, indicating a perfective aspect, Agreeing with the head of AspP.

The bi-phrase part of (30) is also a verb-copy construction, due to the parallelism requirement, whose basic structure is referred to (21). What concerns us here is my previous assumption in 2.1 about the complement of the morpheme bi, which is a TP with a defective T, having the property of causing the subject to raise to [Spec, TP], but not licensing the Agree relation with the predicate. In order to save PF from crash, it is obligatory to delete as small a constituent as possible, but enough to avoid grammatical violation, following the rescue-by-PF-deletion mechanism (Bošković, 2011).
In this case, the overt d-fast has to be deleted, which is shown by putting a frame around its projection in (31), to save the structure from crash as it cannot be licensed by the defective T having a feature [-finite].

3.3 Legitimizing Remnant Movement in Chinese ‘Clausal’ bi-Comparatives

According to the structure in (30), the derivation squares well with the general configuration of Remnant Movement (RM) (Müller, 1998): the comparison predicate moves out of vP first, followed by movement of the remnant vP with a trace of the comparison predicate in it. In this section, Müller’s (2015) derivational approach for remnant movement configuration (or α-over-β configuration) is adopted to legitimize the structure in (30) that is assigned to Chinese ‘clausal’ bi-comparatives.

In Müller (2015:69-70), three important concepts are proposed to account for the legitimacy of RM following a local derivational approach, which are defined in (32).

(32) a. Contamination:

Movement of β from a position within α to a position outside of α values a movement-related feature γ on α with β’s index.

b. Decontamination:

Movement of β to a criterial position deletes β’s index on all movement-related features of items that c-command it.

c. Index Filter

A movement-related feature (like [wh], [top]) must not have an index as (part of) its value in a criterial position.

In other words, the fundamental idea in Müller (2015) is that extracting β out of α would contaminate α since it provides a defective value for α’s movement-related feature, such as
[wh] and [top]. Such defective value is unproblematic as long as a criterial position is not reached, but may lead to derivational crash if it is not removed. The moved β can decontaminate α by removing this defective value when it reaches its own criterial position under c-command. Only under this circumstance, movement of the remnant α to its criterial position is legitimate, and schematically:

In the first step, XP₁ (β) moves out of XP₂ (α) to [Spec, YP], as shown by t₁’, and this movement now contaminates XP₂ by valuing X₂’s (the head of XP₂) movement-related feature (γ) with XP₁’s index, represented as [γ:1]. Next, XP₂ undergoes intermediate movement to [Spec, YP] and [Spec, ZP], as shown by (1) and (2) respectively. When XP₁ moves to [Spec, ZP], if it is its criterial position, as shown by (3), XP₁ decontaminates XP₂ by removing its index from X₂’s movement-related feature since it is c-commanded by XP₂. At this point of derivation, XP₂ is able to target its criterial position in accordance with Index Filter.

According to Müller (2015), the structure in (33) applies to the prototypical situation where both XP₁ and XP₂ undergo two steps of intermediate movement. One possible case under the prototypical configuration that concerns us here is that extraction of XP₁ to [Spec, YP] is a criterial movement, and XP₂ undergoes intermediate movement to a higher position where it c-commands XP₁. Then, the defective value on XP₂ can be deleted, and the derivation in this case is legitimate. Following this possibility, I propose that, in Chinese ‘clausal’ bi-comparatives, as in (30), after the extraction of the comparison predicate to the head of CPredP, which is a criterial movement, the remnant vP, contaminated and then bearing a defective value, moves to the edge of CPredP where it c-commands the head of CPredP. Under this circumstance, the defective value (i.e., i) on movement-related feature of the remnant vP, i.e., [+contrast] (represented by γ), can be removed by criterial movement of the comparison predicate. Then, the remnant vP is free to target its criterial position, i.e., [Spec, FocP], which is schematized in (34), based on the example in (17b).

---

In the case of multiple movement to phase edges, Müller (2015:71) makes the following assumptions about the order of operations:

a. If α c-commands β in the pre-movement structure, then α moves first and β moves after that, to a lower specifier.

b. If α does not c-commands β in the pre-movement structure, the order is not fixed; the second item that moves ends up in a higher specifier.

6 There are still two possible cases concerning the criterial movement of XP₁, XP₂ or both XP₁ and XP₃, and interested readers are referred to Müller (2015).
Following Citko (2014) who argues that Predication Phrase is a phase, I extend her idea and further contend that Comparison Predication Phrase (CPredP) in Chinese bi-comparatives is also a phase, which means that movements out of CPredP have to proceed through the edge of CPredP. In (34), when the comparison predicate moves to its criterial position, i.e., the head of CPredP, the remnant vP undergoes a step of intermediate movement to [Spec, CPredP] – the edge of CPredP where it can be decontaminated, under c-command. In other words, fast removes the index i from the remnant vP's movement-related feature in line with Decontamination and Index Filter, as shown by the arrow.

Adopting Müller’s (2015) derivational approach for remnant movement helps legitimize this configuration in Chinese ‘clausal’ bi-comparatives, and what happens next is to identify whether such RM is in accordance with some of its constraints. According to Cecchetto (2004), in RM, extraction of sub-constituent from a constituent must be ‘very local’, following Phase Impenetrability Condition (PIC), which means that the moved sub-constituent only targets a position inside the first TP it encounters. From the structure assigned to the examples like (17b) in (30), the extracted sub-constituent – kuai (fast) targets the head of CPredP, which is indeed inside the first TP, and then the remnant vP undergoes intermediate movement to the edge of CPredP where it can be accessible to the head of FocP, which conforms to PIC.

Another constraint on remnant movement is ‘Just Outside’ Constraint (JOC), proposed by Hunter (2012), as in (35).

(35) The ‘Just Outside’ Constraint (JOC)

Remnant movement is permitted only if the base position of the remnant is in the same maximal projection as the target position of the extracted sub-constituent.

In (30), first, the comparison predicate kuai (fast) is extracted out of vP to the head of CPredP. Then, as shown by (34), the remnant vP undergoes RM to [Spec, CPredP], which...
seems to violate JOC since vP is traditionally regarded as a maximal projection. Yet, as pointed out by Hunter (2010), each maximal projection corresponds to one phrase where other constituents may be adjoined to or be arguments of, suggesting that maximal projection is more appropriately taken to be an interpretive cycle. Take (34) as an example, following the lines of an extended projection by Grimshaw (2005), interpretive cycle by Hunter (2010) and the phasehood of Predication Phrase by Citko (2014), it is not unreasonable to argue that CPredP is a maximal projection, which indicates that the target position of the comparison predicate and the base position of the remnant are indeed in the same maximal projection. If this is on the right track, remnant movement configuration proposed for Chinese ‘clausal’ bi-comparatives complies with JOC, which is another piece of evidence buttressing the structure in (30).

IV. Some Consequences

As can be seen from (3a-c), the epistemic expression yinggai (should), if occurring in Chinese bi-comparatives, may occupy various positions. Another important question to be answered is how to account for the obviation of the Condition C effect in Chinese bi-comparatives, as indicated by the following example:

(36) wo jiao tai/j [bi Yuehan_i jiao wo] duo zuo-le san-jian shi7.

I require him BI John require me much do-ASP three-CL work

“I require him to do three more works than John requires me to do.”

According to the Condition C of Binding Theory, Yuehan (John), as an R-expression, should be free, which indicates that (36) is expected to be ungrammatical. However, its well-formedness clearly contradicts with our expectation. In this section, I will adopt the RM analysis proposed above to account for these two issues.

4.1 An Asymmetry in Chinese ‘Clausal’ bi-Comparatives

All these examples in (3) clearly demonstrate that the epistemic expression yinggai (should) may occupy various positions: preceding the compared phrase – (3a), preceded by the compared phrase – (3b), and following the bi-phrase – (3c). In line with the architecture of the domain below IP and above vP area proposed in 3.1, take (3a) as an example, Chinese ‘clausal’ bi-comparatives at least have the following projections:

(37) TP > ModP > FocP > AspP > CPredP > vP

As argued before, in Chinese bi-comparatives, compared constituents in the compared phrase and the standard phrase respectively are in a contrastive relationship (e.g., Liu, 2011), which is in line with the basic definition of Focus (Kiss, 1998; Krifka, 2008). This provides solid proof that there is a projection of FocP. Yet, topics can also be in a contrastive relationship, which has been validated cross-linguistically. Neeleman et al. (2009:1) motivate the following four-way typology concerning the contrastive elements based on Dutch, Japanese, and Russian:

---

7 According to my informants, the pronoun ta (him) can refer to Yuehan (John) or someone else under the conversational context.
Leaving aside other aspects of information structure, one important fact from the table is that both topic and focus can be interpreted contrastively. In terms of Chinese, following Paul (2005, 2015), object preposing and focalization in Chinese involve separate constructions with distinct syntactic and semantic properties, which leads to the proposal that preposed objects in Chinese are sentential internal topic (hereafter InTopP). Yet, these two constructions share a same property: both foci and topics can be used contrastively. The hierarchy of projections concerning internal topics and focalized constituents that holds for Chinese, according to Paul (2005, 2015), is ‘InTopP > FocP’

By extending this argument to Chinese bi-comparatives, this means that constituents in the compared phrase and the standard phrase may not only be contrastive foci, but also be contrastive topics. It is then not unreasonable to propose that the left-periphery of Chinese ‘clausal’ bi-comparatives at least includes the projections in (39), following Paul (2005, 2015) and Neeleman et al. (2009).

(39) TP > InTopP > FocP > AspP > CPredP > vP

Another problem that needs to be dealt with is how to fit the position of the epistemic expression yinggai (should) with the overall picture in (39). See (40) first.

(40) a. * Yuehan yinggai [wufan]InTop shi zai [shitang]F chi-de, [wancan]InTop shi John should lunch is at canteen eat-DE dinner is zai [jiali]F chi-de. at home eat-DE

b. Yuehan [wufan]InTop yinggai shi zai [shitang]F chi-de, [wancan]InTop shi John lunch should is at canteen eat-DE dinner is zai [jiali]F chi-de. at home eat-DE

“John may have had lunch at canteen, and may have had dinner at home.”

c. * Yuehan [wufan]InTop shi zai [shitang]F yinggai chi-de, [wancan]InTop shi John lunch is at canteen should eat-DE dinner is zai [jiali]F chi-de. at home eat-DE

<table>
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<th></th>
<th>Topic</th>
<th>Focus</th>
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<tbody>
<tr>
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<td>aboutness topic [topic]</td>
<td>new information focus [focus]</td>
</tr>
<tr>
<td>Contrastive</td>
<td>contrastive topic [topic, contrast]</td>
<td>contrastive focus [focus, contrast]</td>
</tr>
</tbody>
</table>
Examples in (40) illustrate that the epistemic expression *yinggai* (should) can only be in a position between InTopP and FocP, as in (40b), otherwise, ungrammaticality would follow, either in a position higher than InTopP – (40a) or lower than FocP – (40c). Thus, when the epistemic expression *should* is involved, the clause-internal left periphery of Chinese ‘clausal’ *bi*-comparatives includes the projections in the following:

\[(41) \quad \text{TP} > \text{InTopP} > \text{ModP} > \text{FocP} > \text{AspP} > \text{CPredP} > vP\]

A word is in order here before we move on. In Section 2, I argued that both *bi*-phrase and differential phrase denote a degree argument θ-binding the degree argument of gradable predicates respectively. The presence of a differential phrase in the structure indicates that the degree argument of gradable predicates has been θ-bound, and under this circumstance, the *bi*-phrase may be free to move and target a higher position. To make this assumption more explicit, I propose that comparison predicates in Chinese *bi*-comparatives bear a strong unvalued comparative feature \[u\text{Comp}^*\], and *bi*-phrases and differential phrases both have a valued comparative feature \[\text{Comp}\] that values the feature on the comparison predicate. Further, adopting the argument that modal expressions may denote gradability (e.g., Kratzer, 2012; Lassiter, 2017), I assume that epistemic modals in Chinese, such as *yinggai* (should), bear an unvalued comparative feature \[u\text{Comp}\], which can be checked off by movement of a phrase having a valued comparative feature \[\text{Comp}\] or it can enter into an Agree relation with that phrase.

Based on the architecture in (41), I propose that, when the remnant \(vP\) (i.e., after the extraction of the comparison predicate to the head of \(\text{CPredP}\)) moves to the edge of \(\text{CPredP}\) where it can be decontaminated, there are two criterial positions for the decontaminated \(vP\), namely \([\text{Spec, FocP}]\) and \([\text{Spec, InTopP}]\). Let’s take (3a) as an example to illustrate this.
According to the assumption above, the head of CPredP has a strong unvalued feature \([u\text{Comp}^*]\), which is valued and deleted by the valued feature \([\text{Comp}]\) on \(bi\)-phrase or differential phrase or by both simultaneously. When co-occurring with a gradable modal that also bears an unvalued feature \([u\text{Comp}]\), there are two choices for the \(bi\)-phrase: either it stays in-situ and enters into an Agree relation with the head of ModP or it overtly moves to [Spec, ModP] where it values that unvalued feature.

In (42)\(^8\), after the remnant \(vP_j\) is decontaminated, there are three scenarios: (i) the remnant \(vP_j\) may move to its first criterial position – [Spec, FocP], resulting in the word order in (3a); (ii) the remnant \(vP_j\) may successively move to its second criterial position – [Spec, InTopP], giving rise to the word order in (3b); (iii) when the remnant \(vP_j\) reaches its second criterial position, the \(bi\)-phrase overtly moves to [Spec, ModP], deriving the word order in (3c). In scenarios (i) and (ii), the \(bi\)-phrase stays in-situ and enters into an Agree relation with the modal; yet in the scenario (iii), the \(bi\)-phrase values and deletes the unvalued feature on the modal through overt movement since the degree argument of the comparison predicate has already been bound by the differential phrase. Movement of the remnant \(vP\) is attributed to the need of establishing contrastive relation for compared constituents in the compared and standard phrase. In other words, the motivation for fronting contrastive foci or contrastive topics is to create a syntactic constituent in surface syntax that can mark the domain of contrast (Neeleman et al., 2009; Neeleman & Vermeulen, 2012; Szendrői, 2017). Overall, by adopting the projection of InTopP and FocP in Chinese and RM analysis, the word order exemplified by (3) can be well explained.

### 4.2 The Obviation of the Condition C effect

Chinese comparatives exhibit the obviation of the Condition C effect, as noted by Liu (2014), and consider the example in (36)\(^9\), repeated below in (43).

(43) wo jiao tai [bi Yuehan jiao wo] duo zuo-le san-jian shi.

*I require him BI John require me much do-ASP three-CL work*

According to Liu (2011:1789), “the standard constituents in \(bi\) clausal comparatives must be minimally c-commanded by their corresponding correlates”, which means that Yuehan (John) is always c-commanded by \(ta\) (him), namely a direct violation of the Principle C of Binding Theory. This at least indicates that this view is theoretically untenable. Before we proceed, a word is in order here regarding the basic structure of the root clause in (43), which is a control structure in Chinese. Let’s consider the following examples first.

(44) a. wo jiao ta zuo-le san-jian shi.

*I require him do-ASP three-CL work*

“I require him to do three pieces of works.”

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\(^8\) Only the major part of the internal structure for (225a) is shown since only this part is relevant to the analysis here, within which there is a covert head of sentential internal topic (represented as OPTop) projecting an InTopP.

\(^9\) Examples like (36) is called Differential Verbal Comparatives (Li, 2013), involving a non-gradable comparison predicate that can be coerced into being gradable while modified by a degree adverb.
b. * wo jiao-*le ta zuo san-jian shi.

I require-ASP him do three-CL work

c. * wo jiao-*le ta zuo-*le san-jian shi.

I require-ASP him do-ASP three-CL work

When the aspect marker *le* is embedded in a controlled complement, i.e., (44a), it is construed with the matrix clause; whereas, if *le* is attached to verbs in the matrix clause, or attached to verbs both in the matrix and embedded clause, as in (44b) and (44c) respectively, the ungrammaticality would immediately follow. The contrast between (44a) and (44b-c) motivates the proposal made by Grano (2013:21): in Mandarin, an aspect marker in a controlled complement clause – when grammatical at all – instantiates matrix aspect. This further leads to his another argument: control predicates in Chinese take vP complements10. In this case (i.e., (43)), jiao (require) is a control predicate taking a vP as its complement (Grano, 2013), within which zuo (do), as the comparison predicate, undergoes movement to the head of CPredP naming the dimension of comparison. Based on the basic structure of CPredP proposed for Chinese bi-comparatives in Section 2, the bi-phrase is in [Spec, CPredP]. In line with Remnant Movement proposed for Chinese ‘clausal’ bi-comparatives in (30), the structure for (43) is shown in (45).

\[(45)\]

10 According to Grano (2013), controlled complements in Mandarin are vPs that do not project Asp, whereas non-control clause-embedding predicates take a CP complement. Interested readers are referred to Grano (2013) for a detailed analysis.
In terms of aspect markers in Chinese, following Grano (2013), the head of AspP has an interpretable feature, i.e., [iA:__] in this case, and enters into an Agree relation with the aspect marker that is base-generated to the verb. In (45), the head of AspP agrees with le that is base-generated to zuo (do), indicating a perfective aspect – [iA: PERF]. In the pre-movement structure, i.e., vP is still the complement of the head of CPredP, him obviously does not c-command John. After the comparison predicate moves to its criterial position, i.e., the head of CPredP, the remnant vP undergoes movement to [Spec, FocP] or [Spec, InTopP] where it establishes a contrastive relation with the bi-phrase. When the remnant vP is in its criterial position, him still does not c-command John. Given that Yuehan (John) is not c-commanded by ta (him), either in the pre-movement or post-movement structure, I take it that implementing remnant movement analysis offers direct empirical evidence to account for the obviation of the Condition C effect in Chinese bi-comparatives.

V. Conclusion

In this paper, the internal structure of Chinese ‘clausal’ bi-comparatives is discussed. Based on the configuration of Remnant Movement originally proposed for German (e.g., Müller, 1998, 2015), I proposed that the remnant vP in the matrix clause of Chinese ‘clausal’ bi-comparatives undergoes movement, after the extraction of the comparison predicate to the head of CPredP, to a higher position to establish a contrastive relation with the bi-phrase, either as contrastive foci or contrastive topics. The motivation for such overt movement is to create a syntactic constituent in surface syntax that can mark the domain of contrast (Neeleman et al., 2009; Neeleman & Vermeulen, 2012; Szendrői, 2017). Arguments adopted here are instrumental in explaining several issues that have not been successfully tackled before, including an asymmetry concerning the co-occurrence of modals and bi-phrases, and the obviation of the Condition C effect. Overall, the advantage of the analysis proposed in this paper is that it can account for those previously unexplained phenomena without resorting to Degree Phrase.

VI. References


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The underlying form of the bi-phrase in this example is as follows:
(i) bi Yuehan jiao wo zuo-djian-shi.
Bi John require I do d-CL work

Based on the Parallelism Requirement argued in 3.1, the bi-phrase at least has an instance of the comparison predicate – zuo (do). Yet, as argued before, the morpheme bi takes a non-finite clause as its complement, so the rescue-by-PF-deletion mechanism is involved to save the structure from being crashed (Bošković, 2011), as shown by the strikethrough.


Topic-Prominent versus Subject-Prominent:
Cross-Modal Priming in the Processing of Chinese OSV Sentences

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An OSV word order (Object – Subject - Verb) that deviates from the canonical SVO (Object – Subject - Verb) word order is typically viewed as derived from movement. This theory has been widely supported by psycholinguistic studies showing that the displaced constituents are mentally reactivated at the gap positions. However, theoretical and experimental discussions about Chinese have proposed an alternative account: as a topic-prominent language, Chinese sentences take a bamboo-like structure lacking underlying levels of syntax. The present study adopts the cross-modal antecedent priming technique to test whether the sentence-initial object is structurally associated with the verb in native speakers’ online processing. Results of two experiments show that the sentence-initial object is not associated with the verb whatsoever, neither lexically nor structurally, shedding light on the bamboo-like structure of the Chinese OSV topic sentence. However, the processing of the antecedent object was shown facilitated at the post-quantifier position.

Key words: psycholinguistics, cross-modal priming, Chinese, topic structure, OSV, topic-prominent language

1. Introduction and Background

1.1 The Chinese OSV Topic Sentence

In addition to the canonical SVO word order, Chinese also allows variations of SOV and OSV.

(1) Canonical order:
我 很 喜欢 音乐。
Wo hen xihuan yinyue.
‘I very like music.’

(2) Variations:
   a. 音乐 很 我 喜欢。
      Yinyue, wo hen xihuan.
      ‘Music, I like.’
      -SOV
   b. 我 音乐 很 喜欢。
      Wo yinyue hen xihuan.
      ‘I, music, like.’
      -OSV

(Examples from Huang, Li, & Li 2009: 199)
With regard to the OSV variation, formal syntacticians believe that it is derived from wh-movement (e.g., Qu 1994; Shi 1992, 1998, 2000; Shyu 1995; Yuan 1996). In *The Syntax of Chinese*, Huang, Li & Li (2009: 210-211) proposed that topicalization of the object, such as in (3), has applied first within the embedded clause, resulting in a pro occurring at the peripheral position of the sentential subject.

(3) 这 个  小孩, [[李四 照顾  e]最 合适]。

Zhe-ge xiaohai, [[Lisi zhaogu e]Zui  heshi].
This-CL child Lisi care most appropriate
‘This child i, that Lisi takes care of [him] is most appropriate.’

(Huang, Li, & Li 2009: 210)

This suggestion is schematically represented below:

(4) Topic[ , [Clause [Subject  pro  . . .  t] . . . ]  

\[ \text{GCR} \rightarrow \text{Move} \]

(Generalized Control Rule’)

Under this analysis, the sentence-initial object leaves a trace in the original direct object position.

However, this account is not accepted by functionalists or cognitive linguists, who maintain that Chinese is a topic-prominent language and that the topic is independent of the verb (Li & Thompson 1976). In fact, Li & Thompson (1976, 1981:15) analyzed OSV and SOV sentences together with gapless topic sentences such as (5) and argued that the notion of topic in Chinese is as basic as that of subject in general grammar description.

(5) 那  场  火, 幸 亏    消  防  队  来  得  快。

Nei-chang huo, xingkui  xiaofangdui lai  de kuai.
that CL fire fortunately fire-brigade come DE fast
‘(As for) that fire, fortunately the fire brigade came fast.’

(Li & Thompson 1981: 96)

Li & Thompson’s (1976, 1981) understanding of topic is in the same vein as Chafe (1976: 50) in that a topic sets a spatial, temporal, or individual framework within which the main
predication holds. The independence of the topic from the verb entails that Chinese topic sentences, including OSV sentences, take a linear bamboo-like structure, rather than the hierarchical tree-like structure. This perspective is reaffirmed by Wang (1984: 468-472) and Pan (2003). With the bamboo-like structure, Chinese grammar is said to exhibit typological features shared by sign languages and young creole languages (Haiman 1985; Tai 2008).

So far, the dispute over the structure of Chinese OSV sentences—whether it is movement-derived or not—occurs primarily at the theoretical level. Limited evidence has been presented in the experimental paradigm.

1.2 Literature Review

1.2.1 Online processing of dislocated constituents: TRH vs DAH

Within Chomsky’s (1995, and later) minimalist framework, movement traces are conceived of as silent copies of their antecedents. A series of experimental studies have lent support to this theory by showing that at gap sites the moved constituents are mentally reactivated (e.g., Bever & McElree 1988; Clahsen & Featherston 1999; Love & Swinney 1996; Nicol 1993). This interpretation is known as the trace reactivation hypothesis (TRH), according to which the parser recovers or reactivates the grammatical and semantic features of the dislocated constituent at a potential gap site by creating a silent syntactic copy of the antecedent, just as Chomskians claimed (Robert et al. 2007).

Several studies in support of TRH employed the cross-modal priming technique. For example, Love & Swinney (1996) studied English sentences containing object-relative clauses, such as Jimmy used the new pen that his mother-in-law recently #1 purchased #2, in which the dislocated object (the new pen) leaves a trace at #2. Love & Swinney (1996) found that lexical decision times at the position indicated by #2 were significantly shorter for visual targets that were semantically related to the objects of the embedded verbs than for unrelated ones, whereas at the control position (#1) preceding the verb purchased, there was no such
difference. Similar results were observed by Clahsen & Featherston (1999) for the processing of German scrambling constructions, Nakano, Felser & Clahsen (2002), Miyamoto & Takahashi (2002) for the processing of Japanese scrambling constructions, as well as Felser & Roberts (2007) for the processing of English indirect object relative clauses.

Despite the considerable body of literature arguing for it, TRH has been faced with the challenge from an alternative explanation for the facilitated processing of the dislocated constituents at the gap positions, the *direct association hypothesis* (DAH), which maintains that the antecedent reactivation is triggered by lexical rather than structural information. According to DAH, antecedent reactivation effects are best explained in terms of direct associations between a subcategorizing head and its arguments (Pickering & Barry 1991; Pickering 1993; Sag & Fodor 1994; Traxler & Pickering 1996). Under this view, as soon as the subcategorizer is processed, a displaced argument will be linked to it directly, without the mediation of the traces. This view provides an alternative explanation for Love & Swinney’s (1996) finding because the gaps in their example sentences are adjacent to the verb subcategorizers. For head-initial languages such as English, it is virtually impossible to determine whether antecedent reactivation effects are due to the existence of traces or result from lexically driven direct association, because a putative object trace is always located immediately after the verb, which is also the lexical subcategorizer (e.g., Gibson & Hickok 1993; Sag & Fodor 1994). The impossibility of teasing apart TRH and DAH with head-initial languages forced researchers to focus on head-final languages such as German or Japanese. Although DAH has not received much support from L1 processing of head-final languages (e.g., Clahsen & Featherston 1999; Miyamoto & Takahashi 2002; Nakano et al. 2002), it has been shown fairly explanatory for online L2 processing (e.g. Felser & Roberts 2007; Marinis et al. 2005).

1.2.2 Online processing of Chinese OSV topic sentences
Only a handful of studies, employing various methodologies, have looked into the online processing of Chinese OSV sentences, and findings diverge.

Set within the framework of generative grammar and assuming there are gaps in Chinese OSV sentences, Huang & Kaiser (2008) and Liu (2014) conducted moving-window self-paced reading experiments to attest the filler-gap dependency of Chinese OSV topic sentences, while Yang & Liu (2013) adopted the event related potentials (ERPs) technique to measure the electrical activity at the scalp—the small changes in voltage at different points across the scalp. Huang & Kaiser (2008) found that the mean reading times for the verb region in the transitive-implausible condition were significantly longer than those in the transitive-plausible condition, thus claimed “when parsing topic structures, native speakers of Chinese tend to construct a filler-gap dependency incrementally (i.e., after a transitive verb in an adverbal clause, a possible site for the gap)”. Liu (2014) compared the processing of sentences with coordinated verb phrases to that of sentences with post-verbal adjunct phrases, and found that parsers actively searches for a gap after positing a gap in the first coordinated VP while no gap-filling is observed in the post-verbal adjunct phrases. In Yang & Liu’s (2013) study, participants were displayed with words (one word after another) of sentences and asked to judge the grammaticality. P600 components indicating “the reconstruction of the dependency between the dislocated constituent and the trace” were found to occur later in the processing of grammatical topic sentences than in the processing of ungrammatical topic sentences. These findings were all taken to be evidence of TRH by the authors, although the hypothesized gap sites in the stimulus sentences were all adjacent to the verbs.

On the other hand, as the only study employing the cross-modal antecedent priming technique, Cai & Dong (2010) presented a radically different situation. In their experiment, participants were presented with auditory stimuli of OSV topic sentences and visual stimuli of target words (identical or unrelated to the object-topic) popping out at certain points (post-
verb positions or the pre-verb control positions) during the sentences. The antecedent priming effect, instantiated by processing facilitation (shorter reaction time) of the antecedent, was only observed at the control position, but not at the post-verb position, which is also the gap position proposed by formalists. This study thus casts doubt on whether there is a gap at all.

In sum, previous studies of OSV sentence processing show contradictory results regarding whether this structure is movement-derived or not. Besides, it is worth reiterating that in the stimulus sentences of all the above-mentioned studies, the hypothesized gap site is adjacent to the verb, which means even if the filler-gap dependency is detected, it may be the object-topic that is structurally related to the trace (as predicted by TRH), or directly associated with the verb subcategorizer (as predicted by DAH). Therefore, to evidently argue that the movement leaves a trace after the verb, DAH has to be dissociated from TRH.

2. The Present Study: The Cross-Modal Antecedent Priming

In an attempt to reveal the structure of Chinese OSV sentences—whether it is derived by movement, involving an underlying level of syntax—the present study investigates whether the sentence-initial object is mentally reactivated at the hypothesized gap position in native speakers’ online processing.

Similar to Cai & Dong (2010), the cross-modal antecedent priming technique was adopted to attest the hypothesized trace reactivation effect. In the traditional form of this task, participants are normally required to make a word-based (e.g., a word/nonword discrimination) decision to visually presented targets while listening to stimulus words or sentences spoken at normal speed (Swinney et al. 1979). If dislocated constituents are reactivated at gap positions, participants’ responses to targets semantically related or identical to the antecedents should be facilitated at the point of gap, relative to non-gap (control) positions (Felser & Roberts 2007). This prediction is based on the well-documented phenomenon of automatic priming, the observation that the processing of visual targets is
facilitated if they are presented immediately after the auditory presentation of an identical or semantically related word, or ‘prime’ (see Neely 1991).

It is noteworthy that in sentence processing research, the antecedent priming effect has been taken as a major form of evidence for movement traces, indicating that traces access their antecedents during sentence processing (e.g., Nicol 1993; Nicol & Swinney 1989). Moreover, Clahsen & Featherston (1999) argues that unlike techniques such as self-paced reading, cross-modal priming allows the subject to parse the linguistic input at a normal speed and therefore plausibly taps online syntactic processing.

3. Experiment 1

3.1 Materials

A commonly discussed Chinese OSV sentence is like (6):

\[(6) \quad \text{苹果 张三 拿了。} \]
\[\text{Pingguo Zhangsan na-le.} \]
\[\text{‘(In terms of) the apple, Zhangsan took (it).’} \]

In (6), according to the formalist’ analysis, the topic 苹果 ‘apple’ leaves a trace after the verb (with the aspect marker 了 le), which means even if the antecedent priming effect is attested at the post-verb position, it can be attributed to the direct association between the verb and the object, as claimed by DAH. So, in order to show that the sentence-initial object is really movement-derived, there ought to be a distance between the hypothesized gap position and the verb. Fortunately, in Chinese, a quantifier is allowed between the verb and the putative gap position, as shown in (7).

\[(7) \quad \text{苹果， 张三 一口气① 拿了② 十多个③， 李四 一共 才 拿了两个。} \]
\[\text{Pingguo Zhangsan yikouqi① na-le② shiduo-ge③, Lisi yigong cai na-le liang-ge.} \]
\[\text{‘Mary took over ten apples in one breath, while John just took two apples in total.’} \]
In sentences like (7), ① indicates the pre-verb control position, ② represents the post-verb position, and ③ stands for the real gap position suggested by formalists.

It is worth mentioning that in online sentence processing when parsers do not have an idea where the sentences end, ② can also be conceived as a gap position if the movement-derived hypothesis is true. In fact, previous studies have discovered an active dependency formation process (cf., Chacon et al. 2016; Crain & Fodor 1985; Fodor 1978; Frazier 1987; Frazier & Flores d’Arcais 1989; Marinis et al. 2005; Stowe 1986), in which parsers virtually always prefer early resolution when multiple possibilities are available. The preference to make an early commitment to a gap is commonly regarded as arising from constraints on resources, i.e., maintaining a filler in memory is costly and therefore it is preferable to resolve filler-gap dependencies earlier (Wanner & Maratsos 1978; Chacon et al. 2016). Particular to sentence (7), if the topic 苹果 pingguo ‘apple’ is derived from movement, ②, as well as ③, will witness the antecedent priming effect in online processing: TRH predicts that parsers’ responses to targets semantically identical to the antecedents are facilitated at ② and ③, in comparison with ①. In contrast, DAH predicts that parsers’ responses to targets semantically identical to the antecedents are facilitated at ②, in comparison to ① and ③, but this lexical association between the verb and the object-topic provides little information as to whether the topic is base-generated or movement-derived. Whereas the non-movement hypothesis predicts no significant antecedent priming effect at ② and ③, in comparison with ①. The predictions of different hypotheses are put together below in Table 1.
Table 1 Predications of different hypotheses (experiment 1)

<table>
<thead>
<tr>
<th>Processing strategy</th>
<th>Pre-verb control position</th>
<th>Post-verb position</th>
<th>Post-quantifier position</th>
</tr>
</thead>
<tbody>
<tr>
<td>The sentence-initial object is movement-derived</td>
<td>TRH</td>
<td>Antecedent priming effect</td>
<td>Antecedent priming effect</td>
</tr>
<tr>
<td>DAH</td>
<td>Antecedent priming effect</td>
<td>No antecedent priming effect</td>
<td></td>
</tr>
<tr>
<td>No movement is involved with OSV topic sentences</td>
<td>The topic sets the scope for the sentence.</td>
<td>No antecedent priming effect</td>
<td>No antecedent priming effect</td>
</tr>
</tbody>
</table>

The materials for the cross-modal priming task are composed of 36 critical experimental sentences like (7), 64 filler sentences and four practice sentences similar in length but various in structure, all of which have some contrastive meaning since OSV topic sentences may sound odd out of context (Huang & Kaiser 2008). There is a quantifier between the verb and the suggested gap. All initial words (also the topics of the sentences) are disyllabic or trisyllabic. They, together with the verbs, were chosen from the 5000 words in HSK (Hanyu Shuiping Kaoshi ‘Chinese Proficiency Test’, designed by Hanban) Level 1-6 vocabulary guideline. The designer of HSK vocabulary guideline claimed the selection of words is based on frequency as well as the principles of economy and efficiency (Zhang, et al. 2010).

All 100 sentences were read by a female native speaker of Mandarin Chinese with normal speed and intonation, and pre-recorded on a digital voice recorder. Pictures of edible (50%), including drinkable, and non-edible (50%) objects (all clipart pictures) were employed as visual targets. For each experimental sentence, I selected two visual targets: an identical target showing the referent of the topic, and a picture showing an unrelated object opposite to the identical target in terms of edibility. Each target was used twice, once as the identical target and once as the unrelated target. The pictures appeared at one of the three test positions demonstrated in the example sentence (7), spelled out below in (8):

(8) ① the pre-verb position at the offset of the syllable before the verb;
② the post-verb position (the plausible gap in online processing) at the offset of the verb (including the aspect marker 了 le/过 guo/着 zhe);

③ the post-quantifier position (the real gap posited by formalists) at the offset of the quantifier.

This 2 * 3 design yields six different experimental conditions for the example sentence (7).

(9) a. Pre-verb position, identical picture target:

Pingguo, Zhangsan yikouqi na-le shiduo-ge, Lisi yigong cai na-le liang-ge.

Apple Zhangsan in one breath take-LE over ten-CL, Lisi in total only take-LE two-CL.

b. Pre-verb position, unrelated picture target:

Pingguo, Zhangsan yikouqi na-le shiduo-ge, Lisi yigong cai na-le liang-ge.

Apple Zhangsan in one breath take-LE over ten-CL, Lisi in total only take-LE two-CL.

c. Post-verb position, identical picture target:

Pingguo, Zhangsan yikouqi na-le shiduo-ge, Lisi yigong cai na-le liang-ge.

Apple Zhangsan in one breath take-LE over ten-CL, Lisi in total only take-LE two-CL.

d. Post-verb position, unrelated picture target:

Pingguo, Zhangsan yikouqi na-le shiduo-ge, Lisi yigong cai na-le liang-ge.

Apple Zhangsan in one breath take-LE over ten-CL, Lisi in total only take-LE two-CL.

e. Post-quantifier position, identical picture target:

Pingguo, Zhangsan yikouqi na-le shiduo-ge, Lisi yigong cai na-le liang-ge.

Apple Zhangsan in one breath take-LE over ten-CL, Lisi in total only take-LE two-CL.

f. Post-quantifier position, unrelated picture target:

Pingguo, Zhangsan yikouqi na-le shiduo-ge, Lisi yigong cai na-le liang-ge.

Apple Zhangsan in one breath take-LE over ten-CL, John in total only take-LE two-CL.

A complete list of experimental sentences and targets is provided in Appendix I. With a Latin square design, the 36 critical sentences were distributed across six counterbalanced presentation lists so as to ensure that each participant listens to each sentence only once, and with all presentation lists including an equal number of identical and unrelated picture targets, displayed at three test positions for an equal number of times. The experimental sentences in each list were pseudo-randomized.
3.2 Procedure

In experiment 1, each participant was asked to listen carefully to the pre-recorded sentences over headphones, and to watch the screen for pictures that would appear at some point during each sentence. Participants were told that whenever a picture appeared on the screen they had to decide as quickly as possible whether the object in the picture is edible (including drinkable) or not by pressing specific keys on a response pad. Participants’ reaction times (RTs) were measured from the point at which the picture appears on the screen to their pressing one of the response keys. Picture targets disappeared immediately after participants pressed a key. If participants were not responding, picture targets disappeared automatically as soon as the auditory stimuli ended. In order to ensure that participants make an active effort to comprehend the stimulus sentences, a comprehension-check statement appeared on the screen after each stimulus sentence for participants to judge whether it is true according to the sentence heard. Among all the 100 trials including 36 critical trials and 64 fillers, half of the comprehension-check statements were true and another half of the statements were false. The 36 experimental items were preceded by a short practice phase containing four trials to allow the participants to get familiar with the cross-modal edible decision task.

In terms of the instrumentation, all stimuli in experiment 1 were presented by E-Prime 2.0 run on a laptop and participants responded by pressing color-marked buttons on the Cedrus RB-830 Response Pad (http://cedrus.com/support/rb_series/tn1047_eprime.htm) connected to E-Prime. The sequence of stimuli presentation was pseudo-randomized so that no more than two critical items or three filler items occurred consecutively.

3.3 Participants

36 Chinese native speakers (16 females, 20 males; mean age: 29.19; range: 18-56) participated in experiment 1. They were recruited from students, faculty, and staff members in a large university in China. Informed consent was obtained for experimentation with
participants. They all reported normal or corrected-to-normal vision and normal hearing. Participants were tested individually in quiet settings. The experiment, from the instruction, was conducted entirely in Chinese.

3.4 Results

Participants answered 88.12% of the end-of trial comprehension questions correctly, and the accuracy rate of the edible decision task was 94.44%. Probably due to misunderstanding of the instruction and/or difficulty in coping with the dual-task demands of the cross-modal priming experiment, one participant behaved near chance in the edible judgment (accuracy rate: 55.56%), three participants behaved near chance in the end-of-trial comprehension check (accuracy rate: 44.44%, 50%, and 61.11%, respectively). At the same time, the participant attained 50% accuracy rate in the comprehension check also showed exceptionally long mean reaction time (4065.8611ms). Data of these four participants were excluded from analysis. In the remaining data from 32 participants, trials that were answered wrong in the edible judgment and/or end-of-trial comprehension check were trimmed off (affecting 12.23% of the data). Extreme RTs longer than 4000ms or shorter than 200ms were removed (affecting 1.98% of the data). Individual outliers beyond 2.5 SDs from each participant’s mean were also eliminated (affecting 3.03% of the data). After data trimming RTs in all conditions can be graphed in Figure 1, with error bars representing standard errors.

![Figure 1](image)

**Figure 1** Experiment 1 mean RTs (in ms) to picture targets for six conditions
Because the RT distribution is severely positively skewed even after trimming, a logarithmic transformation was applied to normalize the data before analysis. The mean RTs and logRTs in all six conditions are aggregately shown in Table 2.

**Table 2** Experiment 2 mean RTs (in ms) and log RTs of six conditions

<table>
<thead>
<tr>
<th>Position</th>
<th>Pre-verb</th>
<th>Post-verb</th>
<th>Post-quantifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Picture Target</td>
<td>Identical</td>
<td>Unrelated</td>
<td>Identical</td>
</tr>
<tr>
<td>RT</td>
<td>985.2349</td>
<td>1090.1847</td>
<td>1041.5767</td>
</tr>
<tr>
<td>logRT</td>
<td>2.953730</td>
<td>2.993922</td>
<td>2.966831</td>
</tr>
</tbody>
</table>

It can be observed in Table 2 as well as in Figure 1 that in the pre-verb control and the post-quantifier positions, the RT to the identical target is shorter than the RT to the unrelated target. Bayesian linear mixed effect models were employed in the data analysis. Compared to traditional approaches such as repeated measures ANOVA and paired t-tests, a single linear mixed effect model can take all sources of variances into consideration, including random effects of participants and items, and is also robust in handling missing data points (e.g., Baayen, Davidson & Bates 2008; Barr et al. 2013). Within a Bayesian framework, we do not rely on the notion of repeating an event (or experiment) infinitely as in the frequentist framework (Van de Schoot & Depaoli 2014). Instead, we incorporate prior knowledge and personal judgment into the process to aid in the estimation of parameters, and hence Bayesian statistics do not assume large samples (Van de Schoot & Depaoli 2014; Van de Schoot et al. 2015). Bayesian linear mixed models were estimated using the function `brm` in the `brms` package (Bürkner 2017) for R, which fits Bayesian multilevel models using the Stan programming language (Stan Development Team 2017). The aim of Bayesian Linear Regression is not to find the single “best” value of the model parameters, but rather to
determine the posterior distribution for the model parameters (Koehrsen 2018). For all analyses, I report estimates with 95% credibility intervals (CrI). Picture target (identical/unrelated), position (pre-verb/post-verb/post-quantifier), and the picture target * position interaction were entered as fixed effects, among which the factor of picture target was centered (identical = -0.5; unrelated = 0.5). For the factor of position, the pre-verb control position was treated as a baseline against which the effects of two other positions were compared. Participants and items were entered as random effects. Model fitting was performed using default priors. The results are shown in the following table.

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Est. Error</th>
<th>l-95% CI</th>
<th>u-95% CI</th>
<th>Eff. Sample</th>
<th>Rhat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>2.98</td>
<td>0.03</td>
<td>2.92</td>
<td>3.04</td>
<td>429</td>
<td>1.01</td>
</tr>
<tr>
<td>PositionPostVerb</td>
<td>-0.00</td>
<td>0.01</td>
<td>-0.03</td>
<td>0.02</td>
<td>3365</td>
<td>1.00</td>
</tr>
<tr>
<td>PositionPostQuantifier</td>
<td>-0.01</td>
<td>0.01</td>
<td>-0.04</td>
<td>0.01</td>
<td>3858</td>
<td>1.00</td>
</tr>
<tr>
<td>PictureTargetContrast</td>
<td>0.05</td>
<td>0.02</td>
<td>0.02</td>
<td>0.08</td>
<td>2215</td>
<td>1.00</td>
</tr>
<tr>
<td>PositionPostVerb:</td>
<td>-0.06</td>
<td>0.02</td>
<td>-0.10</td>
<td>-0.01</td>
<td>2376</td>
<td>1.00</td>
</tr>
<tr>
<td>PictureTargetContrast</td>
<td>0.01</td>
<td>0.02</td>
<td>-0.03</td>
<td>0.05</td>
<td>2686</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Rhat = 1.00 or 1.01 indicates that chains have converged. Results show that the reaction time to the identical picture target is overall shorter than the reaction time to the unrelated picture target (95% CrI [0.02, 0.08]), but there is no significant difference between the three positions (all CrIs contain 0). Target * position has an interaction effect between the pre-verb position and the post-verb position (95% CrI [-0.10, -0.01]), yet not between the pre-verb position and the post-quantifier position (95% CrI [-0.04, 0.01]): similar patterns of antecedent priming are seen in the pre-verb control position and the post-quantifier position, but not in the post-verb position.
### 3.5 Discussion

The results of experiment 1 can be compared to the predictions of different hypotheses, as shown below in Table 4.

**Table 4** Experiment 1 results & predictions of different hypotheses

<table>
<thead>
<tr>
<th>Processing strategy</th>
<th>Pre-verb control position</th>
<th>Post-verb position</th>
<th>Post-quantifier position</th>
</tr>
</thead>
<tbody>
<tr>
<td>The sentence-initial object is movement-derived</td>
<td>TRH</td>
<td>Antecedent priming effect</td>
<td>Antecedent priming effect</td>
</tr>
<tr>
<td>DAH</td>
<td>Antecedent priming effect</td>
<td>No antecedent priming effect</td>
<td></td>
</tr>
<tr>
<td>No movement is involved with OSV topic sentences</td>
<td>The topic sets the scope for the sentence.</td>
<td>No antecedent priming effect</td>
<td>No antecedent priming effect</td>
</tr>
<tr>
<td>Results of Experiment 1</td>
<td>Antecedent priming effect</td>
<td>No antecedent priming effect</td>
<td>Antecedent priming effect</td>
</tr>
</tbody>
</table>

The results of experiment 1 show that in online processing, Chinese OSV topics are not associated with the verbs at all, either structurally or lexically, and thus DAH is clearly rejected. Meanwhile, TRH and the non-movement hypothesis are not fully supported either.

For TRH, it was assumed that parsers would take an active formation strategy, which means that we should be able to observe the antecedent priming effect at the post-verb position, but clearly this is not the case in experiment 1. In contrast, the facilitation of the antecedent is only observed at the real gap positon posited by formalists, pointing at the possibility of a last-resort strategy or a delayed effect of trace reactivation, albeit inconsistent with previous literature arguing for the active dependency process in L1 processing (cf., Chacon et al. 2016; Crain & Fodor 1985; Fodor 1978; Frazier 1987; Frazier & Flores d’Arcais 1989; Marinis et al. 2005; Stowe 1986).

As for the non-movement hypothesis, it is based upon the typological theory that in topic-prominent languages, a topic sets a spatial, temporal, or individual framework within which the main predication holds (Chafe 1976: 50), and thus predicts that Chinese OSV...
sentences take a linear bamboo-like structure without any underlying levels of syntax or empty categories. If there is no movement, there is no trace, and then trace reactivation will be out of the question. The antecedent priming effect detected at the post-quantifier position is unexplainable under this analysis. Were it not the trace reactivation, it can only be understood as an association between the quantifier and the sentence-initial object.

To summarize, experiment 1 is only able to reject DAH, but is not sufficient to address the fundamental research question as to whether the sentence-initial object is derived from movement or not. Specifically, it is unknown that the antecedent priming effect captured at the post-quantifier position is due to the last resort or delayed effect of the filler-gap dependency (according to the movement-derived hypothesis), or an unexpected association between the quantifier and the sentence-initial object (according to the non-movement hypothesis). Experiment 2 is hereby called for to tell apart these two possibilities.

4. Experiment 2

4.1 Materials

As discussed in section 3.1, the rationale of having a quantifier after the verb in experiment 1 was to tease apart TRH and DAH. Since no antecedent priming effect was observed at the post-verb position, experiment 1 has already rejected DAH. The quantifier is thus no longer needed in the stimulus sentences. Without the quantifier, a stimulus sentence in experiment 2 is exemplified in (10).

(10) 手机，小陆上体育课的时候弄丢了，后来小红找到了。
    Shouji, Xiaolu shang tiyuke de shihou nongdu-le, houlai Xiaohong zhaodao-le.
    ‘Xiaolu lost his cellphone in the PE class. Xiaohong found it later.’

Built upon the results of experiment 1, the predictions of different hypotheses are spelled out in Table 5.
Table 5 Predications of different hypotheses (experiment 2)

<table>
<thead>
<tr>
<th>Processing strategy</th>
<th>500 milliseconds before the post-verb position</th>
<th>Post-verb position</th>
<th>500 milliseconds after the post-verb position</th>
</tr>
</thead>
<tbody>
<tr>
<td>The sentence-initial object is movement-derived</td>
<td>Last-resort strategy</td>
<td>Antecedent priming effect</td>
<td>No antecedent priming effect</td>
</tr>
<tr>
<td></td>
<td>Delayed effect</td>
<td>No antecedent priming effect</td>
<td>Antecedent priming effect</td>
</tr>
<tr>
<td>No movement is involved with OSV topic sentences</td>
<td>The topic sets the scope for the sentence.</td>
<td>No antecedent priming effect</td>
<td>No antecedent priming effect</td>
</tr>
</tbody>
</table>

The stimuli in experiment 2 consist of 36 sentences like (10), mixed with 64 fillers and preceded by four practice trials. A complete list of experimental sentences and targets is provided in Appendix II. Fillers and practice trials are the same as experiment 1. Different from experiment 1, experiment 2 sets the pre-verb control position 500 milliseconds before the post-verb position, and the last position 500 milliseconds after the post-verb position, primarily because without considering the length of the quantifier, the distances between testing positions can be more accurately manipulated. The Latin square design of six counterbalanced lists was the same as experiment 1.

4.2 Procedure

All stimuli in experiment 2 were presented by PsychoPy. Participants responded by pressing the F (for ‘false/inedible’) or J (for ‘true/edible’) key on the keyboard. Apart from the difference in instrumentation, all other settings were exactly the same as experiment 1.

4.3 Participants

36 Chinese native speakers (19 females, 17 males; mean age: 19.81; range: 18-40) participated in experiment 2. They were recruited from students, faculty, and staff members in a large university in China. Informed consent was obtained for experimentation with participants. They also reported normal or corrected-to-normal vision and normal hearing.
4.4 Results

Participants answered 88.87% of the end-of-trial comprehension questions correctly, and the accuracy rate of the edible decision task was 96.71%. All participants attained mean accuracy rates above 75% in the end-of-trial comprehension check, and above 91% in the edible decision. One participant showed unusually long mean reaction time (3575.7903ms), and is thus excluded from analysis. In the remaining data, trials that were answered wrong in the edible judgment and/or the end-of-trial comprehension check were taken away (affecting 13.91% of the data). Extreme RTs longer than 4000ms or shorter than 200ms were removed (affecting 0.625% of the data). Individual outliers beyond 2.5 SDs from each participant’s mean were also trimmed off (affecting 2.34% of the data). After data trimming RTs in all conditions can be graphed in Figure 2, with error bars representing standard errors.

![Figure 2](image)

**Figure 2** Experiment 2 mean RTs (in ms) to picture targets for six conditions

The distribution of RTs in experiment 2 is also severely positively skewed, so the logarithmic transformation was applied again for normalization. The mean RTs and logRTs in all six conditions are aggregately shown in Table 6.
Table 6 Experiment 2 mean RTs (in ms) and log RTs of six conditions

<table>
<thead>
<tr>
<th>Position</th>
<th>Pre-verb</th>
<th>Post-verb</th>
<th>Last</th>
</tr>
</thead>
<tbody>
<tr>
<td>Picture Target</td>
<td>Identical</td>
<td>Unrelated</td>
<td>Identical</td>
</tr>
<tr>
<td>RT</td>
<td>992.7574</td>
<td>1096.0328</td>
<td>1083.6087</td>
</tr>
<tr>
<td>logRT</td>
<td>2.965538</td>
<td>3.018070</td>
<td>3.013124</td>
</tr>
</tbody>
</table>

I employed the same Bayesian linear mixed effect model as I used for experiment 1 data analysis. The results are shown in the following table.

Table 7 Results from the statistical analysis (experiment 2)

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Est. Error</th>
<th>l-95% CI</th>
<th>u-95% CI</th>
<th>Eff. Sample</th>
<th>Rhat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>2.99</td>
<td>0.02</td>
<td>2.96</td>
<td>3.03</td>
<td>405</td>
<td>1.01</td>
</tr>
<tr>
<td>PositionPostVerb</td>
<td>0.02</td>
<td>0.01</td>
<td>-0.00</td>
<td>0.04</td>
<td>4354</td>
<td>1.00</td>
</tr>
<tr>
<td>PositionPostQuantifier</td>
<td>0.00</td>
<td>0.01</td>
<td>-0.01</td>
<td>0.02</td>
<td>4456</td>
<td>1.00</td>
</tr>
<tr>
<td>PictureTargetContrast</td>
<td>0.06</td>
<td>0.01</td>
<td>0.03</td>
<td>0.08</td>
<td>2102</td>
<td>1.00</td>
</tr>
<tr>
<td>PositionPostVerb: PictureTargetContrast</td>
<td>-0.06</td>
<td>0.02</td>
<td>-0.10</td>
<td>-0.02</td>
<td>2398</td>
<td>1.00</td>
</tr>
<tr>
<td>PositionPostQuantifier: PictureTargetContrast</td>
<td>-0.06</td>
<td>0.02</td>
<td>-0.09</td>
<td>-0.02</td>
<td>2313</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Rhat = 1.00 or 1.01 indicates that chains have converged. Results show that the reaction time to the identical picture target is overall shorter than the reaction time to the unrelated picture target (95% CI [0.03, 0.08]), but there is no significant difference between the three positions (all CIs contain 0). Target * position has an interaction effect between the pre-verb position and the post-verb position (95% CI [-0.10, -0.02]), as well as between the pre-verb position and the last position (95% CI [-0.09, -0.02]): the antecedent priming effect seen in the pre-verb control position is not seen in the post-verb position or the last position.

4.5 Discussion

The results of experiment 2 can be compared to the predictions of different hypotheses, as shown in Table 8.
Table 8 Experiment 2 results & predictions of different hypotheses

<table>
<thead>
<tr>
<th>Processing strategy</th>
<th>500 milliseconds before the post-verb position</th>
<th>Post-verb position</th>
<th>500 milliseconds after the post-verb position</th>
</tr>
</thead>
<tbody>
<tr>
<td>The sentence-initial object is movement-derived (TRH)</td>
<td>Last-resort strategy</td>
<td>Antecedent priming effect</td>
<td>No antecedent priming effect</td>
</tr>
<tr>
<td></td>
<td>Delayed effect</td>
<td>No antecedent priming effect</td>
<td>Antecedent priming effect</td>
</tr>
<tr>
<td>No movement is involved with OSV topic sentences</td>
<td>The topic sets the scope for the sentence.</td>
<td>No antecedent priming effect</td>
<td>No antecedent priming effect</td>
</tr>
<tr>
<td>Results of Experiment 2</td>
<td>Antecedent priming effect</td>
<td>No antecedent priming effect</td>
<td>No antecedent priming effect</td>
</tr>
</tbody>
</table>

Notably, the results of Experiment 2 coincide with the prediction of the non-movement hypothesis. As the processing of the sentence-initial object is not facilitated at any position after the verb, no evidence of trace reactivation is presented, which casts doubt on whether there is any trace or movement at all.

5. General Discussion

The antecedent priming effect is observed at the pre-verb position in both experiments, which can be accounted for by the adjacency effect commonly seen in cross-modal priming tasks—words that are recently heard will be easier to retrieve than words heard a while ago. In sharp contrast, no effect is ever seen at the post-verb position, contrary to the prediction of both TRH and DAH, suggesting that in the online processing of Chinese OSV sentences, the sentence-initial object is not associated with the verb whatsoever, neither structurally nor lexically. Such findings run counter to two basic assumptions of the formalist account of Chinese OSV topic sentences: (1) the object is subcategorized by the verb; (2) OSV topic sentences are derived from some other structure. Conversely, the non-movement theory maintained by functionalists and cognitive linguists is supported. The sentence-initial object can best be understood as a topic that is independent from the verb, and meanwhile, sets a
spatial, temporal, or individual framework for the sentence. In this sense, without any underlying levels of syntax or empty categories, the structure of Chinese OSV sentences does resemble bamboo.

Noteworthily, it is also a fundamental approach of cognitive construction grammar that “what we see is what we get”, and that “no underlying levels of syntax or any phonologically empty elements are posited” (Goldberg 1995, 2003). Within this framework, language is assumed to be usage-based instead of rule-generated: “we learn linguistic constructions while engaging in communication” (Bybee 2010), and “contextualized exposure to input and frequency has an effect on language learning, processing, and novel use of language” (Langacker 1988, 2008; Bybee 2012). As the basic unit of language, constructions are conventionalized form and function pairings entrenched in language use, and can have various levels of complexity and schematicity. Under this view, the OSV topic sentence is essentially a highly schematic construction. Like all other constructions, it is meaningless to think about how this structure is derived from another structure.

The present study replicates the finding of Cai & Dong (2010) in that the sentence-initial object is not associated with the verb. However, it is worth reiterating that previous studies had contradictory results. Taken together with the present study, apparently the two studies employing the cross-modal priming technique are standing against other studies employing the moving-window self-paced reading and the event related potentials (ERPs), pointing at a difference in experimental techniques.

Since TRH, either early resort or late resort or delayed effect, is rejected completely given the absence of the antecedent priming effect at the post-verb position in two experiments, the antecedent priming effect detected at the post-quantifier position in experiment 1 can only be attributed to an association between the sentence-initial object and the quantifier, which includes a classifier. When it comes to the classifier, it has now become
common knowledge that there is always a certain kind of semantic relation among a classifier and the associated nouns referenced by the classifier (cf., Tai & Wang 1990; Jiang 2017). This semantic relation has been shown facilitative for predicting the upcoming noun in the visual world paradigm (cf., Huettig et al. 2010; Klein et al. 2012; Tsang & Chambers 2011; Lau & Grüter 2015). Therefore, it is conceivable that in the present cross-modal antecedent priming task, the object-topics are also semantically associated with the quantifiers, or more specifically, the classifiers, that go with them, and the processing of picture targets identical to the sentence-initial objects is facilitated when the latter is encountered. Interestingly, the ERP waveforms observed by Yang & Liu (2013) also showed components indicating “reconstruction of the dependency between the dislocated constituent and the trace” at the post-quantifier position in the processing of grammatical OSV topic sentences such as (11).

(11) 桌 子 经理 踢了 两 脚。
   Zhuozi jingli ti-le liang-jiao.
   desk manager kick-LE two-foot
   ‘The manager kicked the desk twice.’

In conjunction with Yang & Liu (2013), the present study suggests that in Chinese sentence processing, antecedent priming effects similar to the filler-gap dependency can be observed between nouns and the corresponding quantifiers. This effect has never been discussed or observed in the processing of other languages before, so it is of great interest to explore whether this effect is stimulated by semantic information or structural relation, and whether it also exists in other classifier languages, etc.

6. Conclusion and Future Directions

With two cross-modal antecedent priming experiments, the present study did not find any evidence of trace reactivation or direct association, suggesting that in online processing the sentence-initial object is not associated with the verb whatsoever, neither structurally nor lexically, which is radically distinct from researches supporting trace reactivation of
dislocated constituents in other languages such as English, German, or scrambling in Japanese (cf., Clahsen & Featherston 1999; Nakano et al. 2002; Miyamoto & Takahashi 2002; Felser & Roberts 2007). This finding can be aligned with Li & Thompson’s (1976) claim about topic-prominent languages that the topic in a sentence is independent of the verb and needs not to be an argument of a predicative constituent in the sentences. Casting doubt on the movement-derived hypothesis and the existence of any empty categories, the present study sheds light on the bamboo-like structure of Chinese OSV topic sentences, and shares the same spirit as cognitive construction grammar. Along this line, investigations of other languages are called for, since apparently Chinese is not the only topic-prominent language in Li & Thompson’s (1976) typological theory.

Nevertheless, together with previous studies, a discrepancy is observed between the cross-modal antecedent priming technique and other experimental methods, and nothing is known about what drives this difference. The exploration of filler-gap dependency in Chinese is thus far from conclusive. An immediate interest is to look at why it can be detected in self-paced reading and ERPs, but not in cross-modal priming.

In addition, an unexpected finding arises with regard to the association between the sentence-initial object and the quantifiers detected in experiment 1, a phenomenon that was observed (Yang & Liu 2013) but never discussed before. More theoretical and empirical investigations are needed to account for this observation.

References


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Columbus, Ohio: The Ohio State University.


Appendix I
Experimental Sentences of Experiment 1

1. 手机，弟弟一共①丢过②五个③，……。
   Shǒujī, dìdi yígòng① diū-quò② wǔ-gè③, …
   ‘Younger brother has lost 5 cellphones in total, …’

2. 西瓜，妈妈一下①买了②二十个③，……。
   Xīguā, māmā yīxià① mǎi-le② èrshí-ɡè③, …
   ‘Mother bought twenty watermelons at once, …’

3. 电脑，弟弟已经①弄坏了②六台③，……。
   Diànnǎo, dìdi yǐjīnɡ① nònɡhuài-LE② liù-tái③, …
   ‘Younger brother has already broken six computers, …’

4. 蛋糕，妈妈一共①做了②三十几个③，……。
   Dànɡāo, māmā yígòng① zuò-le② sānshíjǐ-ɡè③, …
   ‘Mother made more than thirty cakes in total, …’

5. 饺子，我们一次就①点了②十二盘③，……。
   Jiǎozi, wǒmen yícì jiù① dǐān-le② shíèr-pán③, …
   ‘We ordered twelve plates of dumplings at once, …’

6. 电影，小王一连①看了②三部③，……。
   Diàn yǐnxìng, Xiǎowáng yīlián① kàn-le② sān-bù③, …
   ‘Xiaowang watched three movies in a row, …’

7. 比萨饼，妈妈一开始①订了②两个③，……。
   Bǐsàbǐng māmā yìkāishí① dìng-le② liǎng-ge③, …
   ‘Mother ordered two pizzas in the beginning, …’

8. 鸡蛋，小明慢慢吞吞①煮了②三个③，……。
   Jīdàn, Xiǎomíng mānmàn tūn① zhǔ-le② sān-ɡè③, …
   ‘Xiaoming boiled three eggs slowly, …’

9. 贺卡，玛丽一天①收到②二十一张③，……。
   Hèkǎ, Mǎlì yītiān① shōudào-le② èrshíyī-zhāng③, …
   ‘Mary received twenty-one cards in one day, …’
10.  邮 件，小琳 一眨眼 功夫①发出了②五个③，……。
    邮件, 小琳一眨眼 功夫① 发出了② 五个③，……。
    ‘Xiaolin sent five mails in one blink, …’

11.  面 包，哥哥 一共① 烤了② 七块③，……。
    面包, 哥哥 一共 ① 烤了 ② 七块 ③，……。
    ‘Older brother baked seven pieces of bread in total, …’

12.  玫瑰花，小金 一共① 送了② 九朵③，……。
    玫瑰花, 小金 一共 ① 送了 ② 九朵 ③，……。
    ‘Xiaojin gave nine roses in total, …’

13.  牛 肉，我 好不容易① 切了② 一盘③，……。
    牛肉, 我 好不容易 ① 切了 ② 一盘 ③，……。
    ‘I scarcely cut one plate of beef …’

14.  土豆，弟弟 好不容易① 削了② 半个③，……。
    土豆, 弟弟 好不容易 ① 削了 ② 半个 ③，……。
    ‘Younger brother scarcely peeled half a potato, …’

15.  毛 衣，奶奶 当年① 织过② 五六件③，……。
    毛衣, 奶奶 当年 ① 织过 ② 五六件 ③，……。
    ‘Grandma has woven five or six sweaters in those years, …’

16.  西红柿，我 仔仔细细① 洗了② 三个③，……。
    西红柿, 我 仔仔细细 ① 洗了 ② 三个 ③，……。
    ‘I carefully washed three tomatoes, …’

17.  盘子，妹妹 磨磨蹭蹭① 刷了② 两个③，……。
    盘子, 妹妹 磨磨蹭蹭 ① 刷了 ② 两个 ③，……。
    ‘Younger sister slowly washed two dishes, …’

18.  米饭，爸爸 一口气① 盛了② 两碗③，……。
    米饭, 爸爸 一口气 ① 盛了 ② 两碗 ③，……。
    ‘Father served two bowls of rice in one breath …’
19. 气球，弟弟跳来跳去①踩爆了②十几个③，……。
   Qìqiú，dìdi tiàoláitiàoqù① cǎi-bào-le② shíjiǐ-gè③，……。
   ‘Younger brother broke more than ten balloons by leaping around, …’

20. 啤酒，老王一个人①带来了②四瓶③，……。
   Píjiǔ，Lǎowáng yīrén① dài-lái-le② sì-pín③，……。
   ‘Laowang brought four bottles of beer on his own, …’

21. 可乐，小高二话不说①搬了②六箱③，……。
   Kělè，Xiǎogāo èrhuàbùshuō① bān-le② liù-xiānɡ③，……。
   ‘Xiaogao moved six boxes of cola without hesitation, …’

22. 苍蝇，爸爸一挥手①拍死了②四五个③，……。
   Cāngyīng，bàbɑ yī huīshǒu① pāi-dí-le② sìwǔ-gè③，……。
   ‘Father killed four or five flies in a wave, …’

23. 桌子，小丽慢慢吞吞①收拾了②三张③，……。
   Zhuōzi，Xiǎolì mànmàntūn① shōushi-le② sān-zhānɡ③，……。
   ‘Xiaoli slowly cleaned three tables, …’

24. 包子，方方毫不犹豫地①拿了②两个③，……。
   Bāozi Fāngfāng háobùyóuyù de① ná-le② liǎn-ɡè③，……。
   ‘Fangfang took two baozis without hesitation, …’

25. 戒指，王太太一共①戴了②四个③，……。
   Jièzhī，Wánɡ Tàitāi yìɡònɡ① dài-le② sì-ɡè③，……。
   ‘Mrs. Wang wears four rings in total, …’

26. 巧克力，李小姐轻松地①卖掉②二十几盒③，……。
   Qiǎokèlì，Lǐ Xiǎojīā qīngsōng de① mài-dào-le② èrshíjǐ-hé③，……。
   ‘Miss Li sold more than twenty boxes of chocolate effortlessly, …’

27. 饮料，伯伯一口气①运走②十几瓶③，……。
   Yǐnliào，bóbó yìqì① yùnzǒu-le② shíjiǐ-pínɡ③，……。
   ‘Uncle carried away more than ten bottles of drink in one breath …’
28. 杂志，刘老师一下子收了二十几本，……
   Zázhì, Liú Lǎoshī yíxiàzi shōu-le èrshí-jǐ-běn, …
   ‘Teacher Liu confiscated more than twenty magazines at once, …’

29. 汽车，爸爸轻轻松松修好了五辆，……
   Qìchē, bàbɑ qīngqīngsōngsōng xiū-hǎo le wǔ-liànɡ, …
   ‘Father repaired five cars effortlessly, …’

30. 铅笔，哥哥一共才用了两支，……
   Qiānbǐ, ɡēɡe yíɡònɡ cài yònɡ-le liǎnɡ-zhī, …
   ‘Older brother has only used two pencils in total, …’

31. 方糖，张先生一共加了三块，……
   Fāntánɡ, Zhānɡ Xiānshēnɡ yīɡònɡ jiā-le sān-kuài, …
   ‘Mr. Zhang added two sugar cubes in total, …’

32. 小说，刘同学一口气读了十几本，……
   Xiǎoshuō, Liú Tóngxué  yìqì dú-le shí-jǐ-běn, …
   ‘Student Liu read more than ten novels in one breath, …’

33. 味精，妈妈一开始放了三勺，……
   Wèijīng, māmɑ yīkāishi fànɡ-le sān-sháo, …
   ‘Mother put three spoons of miso in the beginning, …’

34. 硬币，赵先生一共收集了一百多种，……
   Yìnbì, Zhào Xiānshēnɡ yīɡònɡ shōu-jí-le yībǎidiú-zhǒnɡ, …
   ‘Mr. Zhao collected more than one hundred types of coins in total, …’

35. 面条，小军前前后后添了四碗，……
   Miàntiáo, Xiǎojūn qiánqiánhòuhòu tiān-le sì-wán, …
   ‘Xiaojun added four bowls of noodles from beginning to end, …’

36. 照片，小高一连拍了十几张，……
   Zhàopiān, Xiǎogāo yīlián pāi-le shí-jǐ-zhānɡ, …
   ‘Xiaogao took more than ten photos in a row, …’
Appendix II

Experimental Sentences of Experiment 2

Note: The post-verb position is at the offset of the underlined verb (including the aspect marker) in each sentence. The pre-verb position occurs 500 milliseconds before the post-verb position, and the last position occurs 500 milliseconds after the post-verb position.

1. 手机, 小陆 上 体育课 的时候 弄丢了, ……。
   Shǒujī, Xiǎolù shàng tǐyùkè de shíhòu nòngdiū-le, …
   ‘Xiaolu lost his cellphone while having the PE class, …’

2. 西瓜, 妈妈 在 回来 的路上 已经 买了, ……。
   Xīguā, mámà zài huílái de lù-shàng yǐjīng mǎi-le, …
   ‘Mom has already bought a watermelon on her way back, …’

3. 电脑, 王明去 上海 玩的 时候 弄坏了, ……。
   Diànnǎo, Wáng Míng qù Shànghǎi wán de shíhòu nònghuài-le, …
   ‘Wang Ming broke his computer when he was having fun in Shanghai, …’

4. 蛋糕, 陈阿姨 昨天 晚上 已经 做好了, ……。
   Dàngāo, Chén āyi zuótiān wǎnshàng yǐjīng zuò-hǎo-le, …
   ‘Aunt Chen has already made the cake last night, …’

5. 饺子, 刘叔叔 在 你来 之前 已经 订了, ……。
   Jiǎozi, Liú Shūshū zài nǐ lái zhìqián yǐjīng dīng-le, …
   ‘Uncle Liu had already ordered dumplings before you came, …’

6. 电影, 周小姐 星期天 刚和 男朋友 看过, ……。
   Diànyǐng, Zhōu Xíaojiě xīngqītiān gāng hé nánpéngyǒu kàn-guò, …
   ‘Lili has just watched the movie with her boyfriend on Sunday, …’

7. 比萨饼, 周小姐 在 聚会 之前 就 订了, ……。
   Bišābǐng, Zhōu Xíaojiě zài jùhuì zhīqíán jiù dīng-le, …
   ‘Miss Zhou has already ordered pizza before the party, …’
8. 鸡蛋, 姐姐 大清早 六点 多 就 煮好了, ……。
鸡蛋, 老二老早六点多就煮好了, ……。
The older sister already boiled the eggs early morning a little bit over six, …

9. 贺卡, 玛丽在圣诞节前几天就收到了, ……。
贺卡, 玛丽在圣诞节前几天就收到了, ……。
Mary has already received the cards a few days before Christmas, …

10. 邮件, 小琳在会议前一星期就发了, ……。
邮件, 小琳在会议前一星期就发了, ……。
Xiaolin already sent the mail one week before the meeting, …

11. 面包, 李大妈在你起床以前就烤好了, ……。
面包, 李大妈在你起床以前就烤好了, ……。
Aunt Li had already baked the bread before you got up, …

12. 玫瑰花, 小金在情人节的时候送过了, ……。
玫瑰花, 小金在情人节的时候送过了, ……。
Xiaojin has already given roses on Valentine’s Day, …

13. 牛肉, 顾大妈在卖的时候就切好了, ……。
牛肉, 顾大妈在卖的时候就切好了, ……。
Aunt Gu had already cut the beef when selling it, …

14. 土豆, 妹妹在我们做饭以前就削好了, ……。
土豆, 妹妹在我们做饭以前就削好了, ……。
The younger sister had already peeled the potatoes before we began to cook, …

15. 毛衣, 奶奶织了大半年总算织好了, ……。
毛衣, 奶奶织了大半年总算织好了, ……。
Grandpa finally finished weaving the sweater after almost a year, …

16. 西红柿, 赵大姐已经帮我们洗好了, ……。
西红柿, 赵大姐已经帮我们洗好了, ……。
Sister Zhao has already helped us wash the tomatoes, …
17. 盘子，妹妹居然一吃完饭就自己刷了，……。
   Pánzi, mèimei jūrán yī chī-fàn jiù zìjǐ shuā-le, …
   ‘Unexpectedly, my younger sister washed the dishes herself as soon as finishing the meal, …’

18. 米饭，班长在开饭前给每个人盛好了，……。
   Mǐfàn, bānzhǎng zài kāi fàn qián gěi měi-ren shèng-hǎo-le, …
   ‘The monitor had already served the rice for everybody before the meal started, …’

19. 气球，小赵刚才没看见不小心踩爆了，……。
   Qìqiú, Xiǎozhào gāngcái měi kànjiàn bùxiān cǎi-bào-le, …
   ‘Just now, Xiaozhao did not see and broke the balloon by stepping on it carelessly, …’

20. 啤酒，老郑一大早从家里都带来了，……。
   Píjiǔ, Lǎozhēng yìzhāng jiù cóng jiā-lǐ dōu dài-lái-le, …
   ‘Laozheng already brought all the beer from his home early morning, …’

21. 可乐，小高昨天带着一帮兄弟搬走了，……。
   Kělè, Xiǎogāo zuótiān dài-zhe yī-bāng xiōngdì bān-zǒu-le, …
   ‘Yesterday, Xiaogao led a group of brothers and moved away the cola, …’

22. 自行车，小偷趁没人注意就偷走了，……。
   Zìxíngchē, xiǎotōu chèn méi rén zhùyì jiù tōu-zǒu-le, …
   ‘While nobody is paying attention, the thief stole the bicycle, …’

23. 桌子，保姆吃完饭的时候就收拾好了，……。
   Zhuōzi, bǎomǔ chī-fàn de shíhòu jiù shōushì-hǎo-le, …
   ‘The maid already cleaned the table right after the meal, …’

24. 包子，方方在还没下课的时候就拿了，……。
   Bāozi, Fāngfāng zài hái méi xià kè de shíhòu jiù ná-le, …
   ‘Fangfang did not even wait until the class was over to take the baozi, …’

25. 戒指，孙小姐在订婚之前就戴上了，……。
   Jìezhī, Sūn Xiǎojīǎ zài dīnghūn zhǐqián jiù dài-shàng-le, …
   ‘Miss Sun had been wearing the ring before engaged, …’
26. 巧克力, 李梅不到上午就卖完了, ……。
Qiāokèlì, Lǐ Méi bù dào yī shàngwǔ jiù mài-wán-le, …
‘Li Mei sold out all the chocolate in the morning,…’

27. 饮料, 范大伯忙了一晚上都运来了, ……。
Yǐnliào, Fàn dàbó máng-le yī wǎnshàng dōu yùn-lái-le, …
‘Uncle Fan was busy the whole night and finally delivered all the drink here, …’

28. 杂志, 周老师在早自习的时候收走了, ……。
Zázhì, Zhōu lǎoshī zài zǎo zìxí de shíhòu shōu-zǒu-le, …
‘Teacher Zhou confiscated the magazine at the morning class, …’

29. 汽车, 张师傅上个星期已经修好了, ……。
Qìchē, Zhāng shīfù shàng-ge wěi qī jīngyǐn xiū-hǎo-le, …
‘Master Zhang already repaired the car last week, …’

30. 铅笔, 哥哥学画画的时候都用完了, ……。
Qiānbǐ, gēge xué huàhuà de shíhòu dōu yòng-wán-le, …
‘Your older brother has used up all the pencils while learning painting, …’

31. 方糖, 服务员在上咖啡的时候就加了, ……。
Fāngtáng, fúwùyuán zài shàng kāfēi de shíhòu jiù jiā-le, …
‘The waiter has already added sugar cubes while serving coffee, …’

32. 小说, 吴同学上高中的时候经常看, ……。
Xiǎoshuō, Wú tóngxué shàng gāozhōng de shíhòu jīngcháng kàn, …
‘Classmate Wu often read novels when he was in high school, …’

33. 酱油, 爸爸在肉煮烂之前已经放了, ……。
Jiàngyóu, bābā zài ròu zhǔ-làn zhúqiǎn yǐjīng fàng-le, …
‘Father already put soy sauce before the meat is well-done, …’

34. 硬币, 赵先生这些年走遍世界收集着, ……。
Yìngbì, Zhào xiānshēng zhěnèi nián zuò biàn shìjì shōují-zhē, …
‘These years, Mister Zhao has been travelling around the world to collect coins, …’
35. 面条，小军还没吃菜的时候就添过了，……。
Miàntiáo, Xiǎojūn hái méi chī cài de shíhou jiù tiān-guò-le, …
'Xiaojun had already add some noodles before having any dishes, …'

36. 照片，小高刚到加拿大就开始拍了，……。
Zhàopiàn, Xiǎogāo gāng dào Jiānàdà jiù kāishǐ pāi-le, …
'Xiaogao started photography when he just came to Canada, …'
Classifying roots, quasi-affixes and affixes in Chinese: quantitative and statistical approaches

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Abstract

Traditionally, morphemes are classified into roots and affixes. However, such a dichotomy seems insufficient in analyzing morphemes in Chinese and other languages. It is not rare in Chinese for a morpheme to have the characteristics of both a root and an affix. Lü (1979) first proposed the concept “quasi-affix” to refer to this phenomenon. Qualitative studies on the classification of roots, quasi-affixes, and affixes face the challenge of arbitrariness and incompleteness and quantitative studies are scarce. The current study proposed a quantitative model and a statistical model to classify roots, quasi-affixes, and affixes in Chinese. Ten word-endings were used for analysis, including 主 zhu3, 人 ren2, 员 yuan2, 士 shi4, 客 ke4, 家 jia1, 工 gong1, 师 shi1, 手 shou3, and 者 zhe3. Both the quantitative and statistical model yielded converging results when compared with qualitative results obtained in the literature. The results of the qualitative, quantitative, and statistical approaches supported that 者 zhe3 is an affix, 员 yuan2 is a quasi-affix, and 工 gong1, 客 ke4, 主 zhu3, and 人 ren2 are roots. The study also showed the advantage of using different approaches for the same question. The quantitative model provides more objective results and the statistical model proves to be a convenient tool as it is easy to construct and does not require any prior linguistic information.
1. Introduction

**Traditional classification**
Classification is the grouping of things based on shared characteristics. It makes things easier and is fundamental to our life (Hunter, 2000). In addition, classification plays an essential role in scientific research. As Jerry Norman (2017) put it, “classification seems to be a natural preliminary in many if not most sciences. In this, linguistics is no different.”

Morphemes are the minimal units in morphological studies. Naturally, the first step to study morphology is to classify the morphemes. Morphemes are traditionally classified as affixes and roots in the literature. However, the definitions of the two categories are very brief and vague: affixes generally carry grammatical meanings, while roots generally carry the lexical meanings; an affix only occurs when attached to some other morphemes but a root is the irreducible core of a word; an affix is an obligatory bound morpheme which does not realize a lexeme, whereas a root is a part of a word-form which remains when all affixes have been removed (Jensen, 1990, p.34; Katamba, 1993, pp.41-45; Bauer, 2003, p.324, p.340).

**Problems and solution**
If we follow the above definitions of affixes and roots, it becomes difficult to classify every morpheme into the dichotomy. An example in English is -holic described in Lehrer (1998). According to the paper, -holic does not have to be present in a word, it is always bound, and its position is fixed. These features suggest that -holic should be considered as an affix. Meanwhile, -holic also has a specific meaning indicating addiction, which is a property of a root. Kolin (1979) took an ambiguous a position and treated -oholic, a variation of -holic, as a pseudo-suffix. When applying the classification scheme to Chinese, the same problem arises. -hua retains the lexical meaning “change” as a root. At the same time, -hua can be removed from the derived words, which is similar to an affix (Yin, 2007). Similar phenomena have been observed in German and Italian, labeled with different terms such as “semi-suffixes” and “semi-words” (Olsen, 2014; Pirani, 2008).

The reason for the difficulty might be the historical progression from a root to an affix (Olsen, 2014). As a result, the distinction between affixes and roots only becomes clearer with the lapse of time. We inevitably encounter ambivalence when analyzing newly coined morphemes or morpheme-like units such as -tainment, -ercise, and cyber- (Saavedra, 2014).

Particularly, dividing morphemes into affixes and roots is not optimal for Chinese morphology as it leads to a strong distributional asymmetry of affixes and roots. On one hand, Duanmu (2017) pointed out that even though some affixes may exist in Chinese, the number is remarkably limited. In addition, linguists hardly reached a consensus on what counts as affixes in Chinese. On the other hand, Packard (2000, p.77, p.280) pointed out that bound roots make up the largest class of morpheme types in Chinese and most newly formed Chinese morphemes are bound roots.
To overcome the limitations of the affix/root dichotomy, it is necessary to assume a fuzzy boundary between roots and affixes and postulate a grey area between affixes and roots. In fact, this grey area has been discussed extensively and labeled by a variety of terms such as “quasi-lexeme”, “quasi-affix”, “combining forms”, and “splinters” (Saavedra, 2014). Interestingly, all these terms carry a connotation of ambiguity or mixing.

In the field of Chinese linguistics, the grey area is referred to as “quasi-affix”, first proposed by Lü (1979, p.48). According to him, quasi-affixes are morphemes that are similar to affixes but did not undergo a complete semantic bleaching and can sometimes appear as roots. Yin (2007) proposed that quasi-affix is a fuzzy set with roots on one end and affixes on the other end. Real affixes are typical members and quasi-affixes are atypical members on the continuum.

However, scholars have different opinions of the grey area in Chinese. Some scholars believed there is no grey area and the affix/root classification should be followed (Zhu, 1982, pp.28-29). Some scholars were aware of the grey area but did not treat it as a new category (Lu, 1964, p.132; Packard, 2000, pp.71-73). For example, Lu (1964, p.132) recognized something is similar though not completely identical to suffixes. However, he decided not to give it a term for the moment. Others noticed the grey area and defined it as a new category with “quasi-affix” or equivalents (Lü, 1979, p.48; Ren, 1981, pp.51-98).

**Purpose of the current study**

The current paper believes a grey area between affixes and roots exists in Chinese and it should be further investigated for three reasons. First, the traditional dichotomy of roots and affixes is insufficient for classifying morphemes because the classification scheme causes ambiguity when analyzing morphemes in multiple languages. Secondly, quasi-affixes are productive in word formation, especially for neologisms. Finally, some quasi-affixes are at the transitional stage from roots to affixes and others are borrowed from foreign languages. They can reflect language change and language contact.

The current paper thus assumes a three-way classification of morphemes into affixes, quasi-affixes, and roots. The next question is how to classify. While most studies were qualitative, and scholars revolved around the properties of affixes and made classification based on the qualitative definitions (Zhu 2001; Yang 2003; Wang 2005; Zhao 2014), the current study aims to apply quantitative and statistical methods in the classification task. It has two advantages over the qualitative studies. First, quantitative method provides more objective and measurable criteria of roots, affixes and quasi-affixes, whereas the qualitative studies can sometimes be subjective. Dong (2005) noted that affixes are not a clear morphological category in Chinese and do not have a strong psychological representation. Consequently, affixes proposed by some scholars based on linguistic intuition are often rejected by others. Second, Wang (2011) showed quasi-affixes are a dynamic system with new quasi-affixes occurring and old quasi-affixes
acquiring new meaning. A quantitative model can conveniently monitor the change of the same quasi-affixes at different time periods, but this may not be possible with qualitative methods.

According to Yang (1997), most affixes in Chinese are nominal suffixes. Among nominal suffixes, people-denoting nominal suffixes constitute the majority. The classification task in the current study focuses on suffixes, quasi-suffixes, and roots that denote people. These types of suffixes, quasi-suffixes, and roots are defined as morphemes appended to the end of a word which limit the meaning of the word to a kind of people or human-like entities. They are termed “people-denoting suffixes”, “people-denoting quasi-suffixes”, and “people-denoting roots” in the current study.

Given that we have no prior knowledge of which category the morphemes fall into, the candidates will be called “people-denoting word-endings” before the classification.

2. Literature review

Qualitative studies

Existing literature has made extensive discussion on the properties of affixes and quasi-affixes (Sproat and Shih 2001; Zhu 2001; Yang 2003; Yin 2007; Pirani 2008; Zhan 2015). Several essential properties were summarized as follows:

1. Position property: affixes tend to have a predetermined position in a word.
2. Semantic property: affixes or quasi-affixes must undergo semantic bleaching. Although the degree of semantic bleaching can be hard to determine, the affixes should not nevertheless retain their lexical meaning.
3. Syntactic property: affixes or quasi-affixes can mark the part-of-speech of the word they form.
4. Word-formation property: affixes or quasi-affixes should be productive and able to form many new words.
5. Morphological property: affixes or quasi-affixes should be bound morphemes and tend to select free roots as the stems.
6. Phonetic property: affixes or quasi-affixes may have phonetic weakening.

Assuming quasi-affixes are the intermediate stage between affixes and roots, a continuum of affixes, quasi-affixes and roots can be constructed, as shown in Table 1. However, the phonetic property was not included because phonetic weakening is not a universal characteristic of affixes and there is no significant difference in phonetic form between affixes and roots in Chinese (Zhu 2001; Dong 2005). In addition, the current study relied on text-based data which are not able to capture the phonetic property.

<table>
<thead>
<tr>
<th></th>
<th>Position</th>
<th>Semantic bleaching</th>
<th>POS marking</th>
<th>Productivity</th>
<th>Stems selected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affixes</td>
<td>Fixed position</td>
<td>Complete</td>
<td>Yes</td>
<td>High</td>
<td>Free morphemes</td>
</tr>
<tr>
<td>Quasi-affixes</td>
<td>Relatively</td>
<td>Some</td>
<td>Yes</td>
<td>High</td>
<td>Free</td>
</tr>
<tr>
<td>Roots</td>
<td>fixed position</td>
<td>morphemes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>----------------</td>
<td>------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>No</td>
<td>Bound</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: A continuum of affixes, quasi-affixes and roots across five properties

**Quantitative studies**

Some previous studies carried out quantitative analysis of quasi-affixes. Yin (2007) found that most of words formed by quasi-affixes are three-syllable words. Fifty-eight percent of words formed by quasi-prefixes are three-syllable words and sixty-seven percent of words formed by quasi-suffixes are three-syllable words. Wang (2011) showed that the old quasi-affixes are mostly combined with verbal stems, while the new quasi-affixes most frequently selected nominal stems. However, it is worth noting that the morphemes investigated in these studies are considered as *a priori* quasi-affixes based on the judgment of other scholars. To the best knowledge of the author, Zeng (2008) is the only study that used quantitative method to classify Chinese quasi-affixes in an exhaustive way.

Zeng (2008) extracted three-syllable words from more than eighty thousand words in *Modern Chinese Grammar Information Dictionary*. Next, high-frequency word-initial and word-ending morphemes were selected from the three-syllable words as candidates for quasi-affixes. The study used four parameters to determine if a morpheme is a quasi-affix: productivity, fixed position, semantic bleaching, and boundness. The most important insights from the study is the transformation of qualitative properties to quantitative measurements. For example, productivity is represented by frequency and fixed position is calculated by the ratio of left replacement and right replacement. With the quantitative data, the study finally determined 23 quasi-prefixes and 53 quasi-suffixes.

However, Zeng’s study can be improved in three ways. First, words of different lengths should be incorporated in addition to three-syllable words. Second, although Zeng proposed four properties of quasi-affixes, the four parameters were not integrated. It is important to bear in mind that a single parameter is not able to determine whether a morpheme is a root, a quasi-affix or an affix. As Yang (2013) suggested, some roots such as 只 dou ‘bean’, also have a fixed position in word formation. However, they should by no means be considered as affixes or quasi-affixes. Therefore, to increase the validity of the classification, all the parameters should be unified into one single model. Finally, using frequency to measure productivity may not be best way. Wang and Fu (2005) differentiated two concepts related to productivity: ability to form existing words and ability to create new words. They argued that the ability to create new words is the key feature separating quasi-affixes from affixes. In computational morphology, productivity is measured by the ability to create new words based on Good–Turing frequency estimation (Good, 1957). The method was simplified and introduced to morphological studies by later scholars (Baayen, 1989; Sproat and Shih, 1996; Arcodia and Basciano, 2012)

**Statistical analysis**
Up to now, no statistical analysis has been used for the classification of affixes, quasi-affixes, and roots in Chinese. However, statistical methods such as the multi-dimensional analysis have been used widely for other classification problems in linguistics, such as classifying genres, registers, and dialects (Biber 1993). Biber (1986) pointed out a weakness of qualitative studies on classification is that these studies often made inconsistent claims. He adopted a multi-dimension approach to classify spoken and written modes and concluded that the statistical method can resolve contradictory findings in previous works.

The multi-dimensional approach can be applied to the classification of morphemes because the qualitative studies also made opposing claims. However, Biber (1986) dealt with texts and he created different dimensions with contextual information. The current study dealt with individual words without any contextual information other than the word itself. The author designed a stem embedding model adapted from the word embedding model.

The word embedding model is the most popular model for calculating the semantic similarity between words. The intuition is best captured by Firth (1957)’s quote: “You shall know a word by the company it keeps”. Each word is constructed as a vector with the surrounding words being the dimensional space. A small angle between two vectors in the dimensional space indicates a high similarity between the two words represented by the vectors.

In addition to word embedding model, previous studies have proposed many fine-grained models such as character embedding, radical embedding, and stroke embedding (Chen et al., 2015; Shi et al., 2015; Cao et al., 2018). In a similar way, the stem embedding model constructs a vector for each word-ending using stems to create the dimensional space. As a result, comparing the similarity between the word-endings equates to comparing the angle between the vectors of each word-ending. The intuition can be stated as “You shall know a word-ending by the stem it combines”. With the help of this model, we should expect to see three clusters of affixes, quasi-affixes, and roots.

An important task in processing multi-dimension data is to identify the inner structure of the data. Unsupervised techniques are suitable for the current study because there is no prior knowledge of the groups of the morphemes (Baayen 2008). Principal Component Analysis (PCA) as an unsupervised method is commonly used. PCA can simplify the complex dataset and provide a low-dimensional visualization for analysis.

3. Method

Corpus
The current study used the State Language and Writing Commission modern Chinese balanced corpus (Jin et al., 2005; Xiao, 2010; Xiao, 2016). The corpus contains about 0.1 billion characters, including Chinese characters, digits, alphabet, and punctuations. The texts in the corpus were segmented and tagged with part-of-speech. The keyword query can search for frequency of the
words that contain, start with, or end with a keyword. It also supports word segmentation and part-of-speech tagging.

Data selection
54 word-endings were selected from Zhan (2015)’s summary of people-denoting word-endings in 19 books or journal articles. Each people-denoting word-ending was used as the keyword in the query. Words that end with the people-denoting word-endings and appear at least once were extracted from the corpus and monosyllabic words were eliminated. The people-denoting word-endings were ranked by the number of words they form. Finally, top ten people-denoting word-endings were selected for the current study, including 主 zhu3, 人 ren2, 员 yuan2, 士 shi4, 客 ke4, 家 jia1, 工 gong1, 师 shi1, 手 shou3, and 者 zhe3.

Pre-processing is necessary before running the models. First, the words are expected to be nouns. For instance, 好人 haoren ‘a good person’ should be selected and 打人 daren ‘beat a person’ should be excluded. In the corpus, there are nine tags for nouns: ‘ng’ for general nouns, ‘nt’ for nouns referring to time, ‘nd’ for nouns referring to direction, ‘nl’ for locative nouns, ‘nh’ for proper nouns for an individual person, ‘ns’ for proper nouns for a place, ‘nn’ for proper nouns for ethnic groups, ‘ni’ for proper nouns for institutions, and ‘nz’ for other proper nouns. For all words that end with the ten word-endings, only the tag ‘ng’ for general nouns were selected. After applying the filter of grammatical categories, 2008 words were selected.

In addition, the word-endings can be polysemous. For example, 手 shou means ‘hand’ in 左手 zuoshou ‘left hand’ and means ‘a person who does something’ in 水手 shuishou ‘sailor’. Therefore, it is necessary to add another semantic filter. This was done by manual annotations. Two native speakers of Chinese (one being the author) annotated the 2008 words using the following criteria:
1. Select next word from the list
2. Is the word a real word?
   Yes -> Go to step 3
   No -> Mark ‘0’, go to step 1
3. Does the word class or meaning change after removing the word-ending?
   Yes -> Go to step 4
   No -> Mark ‘0’, go to step 1
4. Is the word ambiguous?
   Yes -> Go to step 5
   No -> Mark ‘0’, go to step 1
5. Are the sentences grammatical after filling in the blank with the word?
   (a) He/she is a ________.
       (他/她是一个 ________)
   (b) ________ likes drinking tea.  (_______ 喜欢喝茶)
   (c) He/she is my ________.
       (他/她是我的 ________)

73
If at least one sentence is grammatical -> Mark ‘1’, go to step 1
If none of the sentences are grammatical -> Mark ‘0’, go to step 1

The inter-rater agreement is 82% and the Cohen’s kappa is 0.593. In the end, 1149 words agreed by both annotators were selected. The following chart shows the number of words containing each word-ending.

![Chart 1: number of words containing the word-endings before and after filtering](chart.png)

**Quantitative model**

The current study improved Zeng (2008)’s model and built a unified model for classifying personal word-endings. The model quantified the five parameters in Table 1 and the value of each parameter ranges from 0 to 1. Affix score is the sum of the five parameters and indicates the likelihood of a morpheme to be a root, quasi-affix, or affix. The higher the affix score, the more likely the morpheme is an affix and the lower the score, the more likely it is a root.

The position parameter is measured by the positional probability of a morpheme. The calculation is expressed by the following formula:

$$\text{Positional probability} = \frac{\text{Count (words that end with the morpheme in the corpus)}}{\text{Count (words that contain the morpheme in the corpus)}}$$

The productivity parameter is measured by the ratio of the number of singletons (words that appear only once) and the total number of words, a simplification of the Good-Turing smoothing by Baayen (1989) and Gale (1995). The mathematical expression is:

$$\text{Productivity} = \frac{\text{Count (words that end with the morpheme and appear only once in the corpus)}}{\text{Count (words that end with the morpheme in the corpus)}}$$
The degree of semantic bleaching is difficult to determine. The current study adopted the categories of lexicalization proposed by Packard (2000, p.222). He proposed five types of lexicalization from least lexicalized to most lexicalized: conventional, metaphorical, asemantic, agrammatical, and complete. This part was annotated manually by the author with reference to studies tracing the semantic change of word-endings. The complete lexicalization receives 1 point and the score decreases by 0.2 points across categories. Details of the categories were presented in Table 2.

<table>
<thead>
<tr>
<th>Lexicalization type</th>
<th>Word component meaning</th>
<th>Grammatical identity of relations</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete</td>
<td>Opaque</td>
<td>Absent</td>
<td>1</td>
</tr>
<tr>
<td>Agrammatical</td>
<td>Full or metaphorical</td>
<td>Absent</td>
<td>0.8</td>
</tr>
<tr>
<td>Asemantic</td>
<td>Opaque</td>
<td>Present</td>
<td>0.6</td>
</tr>
<tr>
<td>Metaphorical</td>
<td>Metaphorical</td>
<td>Present</td>
<td>0.4</td>
</tr>
<tr>
<td>Conventional</td>
<td>Full</td>
<td>Present</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Table 2: Categories of lexicalization in Packard (2000, p.222)

Stems were extracted from the 1149 selected words by removing the word-endings. The stems were fed into the segmentation and part-of-speech tool provided by the corpus. If a stem is not segmented and receive only one tag, the stem will be marked by the tag. For example, the POS tagging of the stem 穷 qiong ‘poor’ in the word qiongren ‘poor people’ returns “qiong/a”, then the stem qiong will be marked as “adjective”. The POS tagging of the stem jiemuzhuchi ‘program hosting’ in the word jiemuzhuchiren ‘program presenter’ returns ‘jiemu/n zhuchi/v’ with more than one tag. The stem will be marked as ‘miscellaneous’. The POS marking parameter is measure by the ratio of the number of verbal stems and the total number of stems, expressed by the following formula:

\[
\text{POS marking} = \frac{\text{Count (verbal stems selected by the morpheme in the 1149 words)}}{\text{Count (all stems selected by the morpheme in the 1149 words)}}
\]

Determining whether a stem is bound or free poses another challenge. In the current paper, the bound/free characteristics of stems are operationalized by the length of stems, because disyllabic and multisyllabic morphemes tend to be free morphemes while monosyllabic morphemes tend to be bound morphemes in Chinese. The weight of monosyllabic morphemes is set to 0 and the weight of other morphemes is set to 1. The bound/free parameter is measured by the weighted average of the stems of different lengths:

\[
\text{Bound/Free} = \frac{\text{Count (stems selected by the morpheme that have more than one syllable in the 1149 words)}}{\text{Count (all stems selected by the morpheme in the 1149 words)}}
\]
**Statistical analysis**

The current study constructed a stem embedding model using stems to create the dimensional space for each word-ending. Stems were extracted from the words by removing the word-endings. Repetitive stems were removed, and a total of 1053 unique stems remained.

The word-endings are used as the vertical labels and the 1053 stems as the horizontal labels. The value of each cell is the frequency of the word comprising a word-ending and a stem. A 10 by 1053 matrix was constructed with the word-endings and the stems. A sample of the matrix is shown in Table 3.

<table>
<thead>
<tr>
<th>Stems</th>
<th>主 zhu3</th>
<th>人 ren2</th>
<th>员 yuan2</th>
<th>士 shi4</th>
<th>客 ke4</th>
<th>家 jia1</th>
<th>工 gong1</th>
<th>师 shi1</th>
<th>手 shou3</th>
<th>者 zhe3</th>
</tr>
</thead>
<tbody>
<tr>
<td>病 bing4</td>
<td>0</td>
<td>955</td>
<td>82</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>游 you2</td>
<td>0</td>
<td>93</td>
<td>0</td>
<td>95</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>名 ming2</td>
<td>0</td>
<td>107</td>
<td>0</td>
<td>45</td>
<td>3</td>
<td>0</td>
<td>29</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>设计 she4ji4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>44</td>
<td>0</td>
<td>22</td>
</tr>
</tbody>
</table>

Table 3: A sample of the stem embedding model

Each word-ending can be viewed as a vector with the stems being different dimensions. After the word-ending embedding model has been constructed, a PCA was conducted using the R package version 3.5.2.

### 4. Results and discussion

**Qualitative results**

The qualitative results were summarized from eighteen books or journal articles (Chen, 1994, pp.18-27; Chen, 2006; Fu, 2014; Ge, 2001, pp.59-60; Guo, 1983; Liu, 2001, pp.36-45; Lu, 1957, pp.126-133; Lu, 2007, pp.59-60; Lü, 1979, p.48; Ma, 1998; Ren, 1981, pp.51-58; Shao, 2007, pp.117-118; Tang, 2001, pp.149-164; Wang, 1992, pp.170-186; Wang, 2001, pp.47-57; Xu, 1982; Zhang, 2002, pp.172-179; Zhou, 2006, pp.188-189). All the books and articles made a two-way categorization of affixes and quasi-affixes. The number of works that listed the word-endings as affixes or quasi-affixes were treated as “votes” for the word-endings from different scholars. The votes for affixes have a weight of two and the votes for quasi-affixes have a weight of one. The weighted votes were calculated and the more votes a word-ending receives, the more likely it is an affix.

<table>
<thead>
<tr>
<th>Ending</th>
<th>Votes for suffix</th>
<th>Votes for quasi-suffix</th>
<th>Weighted votes</th>
</tr>
</thead>
<tbody>
<tr>
<td>者 zhe3</td>
<td>6</td>
<td>9</td>
<td>21</td>
</tr>
<tr>
<td>家 jia1</td>
<td>1</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td>手 shou3</td>
<td>1</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>员 yuan2</td>
<td>1</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>师 shi1</td>
<td>1</td>
<td>10</td>
<td>12</td>
</tr>
</tbody>
</table>
Table 4: Weighted votes for word-endings

<table>
<thead>
<tr>
<th>Word</th>
<th>Positional probability</th>
<th>Semantic bleaching</th>
<th>POS marking</th>
<th>Productivity</th>
<th>Bound/Free</th>
<th>Affix score</th>
</tr>
</thead>
<tbody>
<tr>
<td>者 zhe3</td>
<td>0.971</td>
<td>1.000</td>
<td>0.676</td>
<td>0.174</td>
<td>0.867</td>
<td>3.688</td>
</tr>
<tr>
<td>员 yuan2</td>
<td>0.886</td>
<td>0.200</td>
<td>0.439</td>
<td>0.152</td>
<td>0.834</td>
<td>2.511</td>
</tr>
<tr>
<td>家 jia1</td>
<td>0.738</td>
<td>0.400</td>
<td>0.238</td>
<td>0.160</td>
<td>0.913</td>
<td>2.449</td>
</tr>
<tr>
<td>师 shi1</td>
<td>0.710</td>
<td>0.200</td>
<td>0.250</td>
<td>0.248</td>
<td>0.578</td>
<td>1.986</td>
</tr>
<tr>
<td>士 shi4</td>
<td>0.789</td>
<td>0.200</td>
<td>0.327</td>
<td>0.194</td>
<td>0.400</td>
<td>1.910</td>
</tr>
<tr>
<td>人 ren2</td>
<td>0.482</td>
<td>0.200</td>
<td>0.207</td>
<td>0.198</td>
<td>0.712</td>
<td>1.799</td>
</tr>
<tr>
<td>手 shou3</td>
<td>0.433</td>
<td>0.400</td>
<td>0.280</td>
<td>0.195</td>
<td>0.400</td>
<td>1.708</td>
</tr>
<tr>
<td>工 gong1</td>
<td>0.176</td>
<td>0.400</td>
<td>0.286</td>
<td>0.279</td>
<td>0.469</td>
<td>1.610</td>
</tr>
<tr>
<td>客 ke4</td>
<td>0.267</td>
<td>0.200</td>
<td>0.412</td>
<td>0.170</td>
<td>0.118</td>
<td>1.167</td>
</tr>
<tr>
<td>主 zhu3</td>
<td>0.113</td>
<td>0.200</td>
<td>0.190</td>
<td>0.245</td>
<td>0.381</td>
<td>1.129</td>
</tr>
</tbody>
</table>

Table 5: Affix scores of each word-ending

(1) Positional probability
The positional probability differs greatly for different word-endings. 者 zhe3 has the highest positional probability, whose position is almost fixed. In contrast, 工 gong1 and 主 zhu3 rarely appear in word-final position. Other word-endings such as 人 ren2 and 手 shou3 have a balanced distribution on word-ending position and other positions.

(2) Productivity
Productivity does not differ significantly among the word-endings. However, 工 gong1 and 主 zhu3 have very high productivity but very low affix scores. This may be a result of small sample size. As illustrated by the blue bar in Chart 1, 工 gong1 and 主 zhu3 form fewer words than other word-endings and the denominator becomes smaller in the formula. It also suggests that productivity alone cannot indicate whether a word-ending is an affix or not.

(3) POS marking
The POS marking parameter shows the percentage of verbal stems that can be combined with the word-ending. It indicates the ability of the word-endings to mark the part-of-speech regardless of
the types of stems. As can be seen from Table 6, 者 zhe3 has the highest score while 人 ren2 and 主 zhu3 have the lowest scores.

(4) Semantic bleaching
The case of 者 zhe3 is complicated. Its origin is believed to be a pronoun, a particle, or a word-ending by different scholars (Wang 2005). However, whatever the case is, 者 zhe3 has opaque lexical meaning and empty grammatical category. This makes it complete lexicalization. According to Li (2003), the word-ending 手 shou3 and 家 jia1 are formed through metaphor. The former comes from body part and the latter traces its origin to a location. Therefore, they are annotated as metaphorical lexicalization. Li (2003) also argued the word-ending 人 ren2 is derived from a word denoting people in general. Its lexical meaning and part-of-speech are retained. Consequently, 人 ren2 is conventional lexicalization. The word-endings 员 yuan2, 师 shi1, 客 ke4 originate from words referring to people of a specific profession. They also maintain the lexical meaning and part-of-speech, so they are also categorized as conventional lexicalization. The word-ending 士 shi4 comes from a word representing males. In the same light, it is labeled as conventional lexicalization.

In the current paper, 主 zhu3 is categorized as conventional lexicalization because 主 zhu3 and 客 ke4 are antonyms. In addition, the author believes the word-ending 工 gong1 and 手 shou3 are similar.

(5) Bound/Free
者 zhe3, 员 yuan2, 家 jia1, 人 ren2 are more likely to select free morphemes. According to Wang (2011), new quasi-affixes selected high percentage of monosyllabic stems than old quasi-affixes. 者 zhe3, 员 yuan2, 家 jia1, 人 ren2 prefer stems containing more than one syllable, implying these word-endings may have existed in the lexicon longer than those word-endings selecting more monosyllabic stems. That 客 ke4 has a very low Bound/Free score shows that it may be a new word-ending.

(6) Affix score
The word-endings obtained affix scores ranging from 1.1 to 3.7 and the difference between adjacent items is not significant. This supports that the change from roots to affixes is gradual.

Statistical analysis
The PCA of the word-ending matrix is plotted on two axes using the biplot function in R. The result is shown in Graph 1.
Graph 1: PCA plot
It is very clear from the plot that three clusters emerged: (1) 者 zhe3, 家 jia1; (2) 员 yuan2, 师 shi1; (3) 士 shi4, 人 ren2, 手 shou3, 工 gong1, 客 ke4, 主 zhu3. Again, if we assume affixes, quasi-affixes, and roots are on a continuum, the three clusters should naturally fall into three different categories, namely, affixes, quasi-affixes, and roots. Because PCA does not provide any linguistic information, we have no clue as to the membership of each cluster. However, it is very likely that the three clusters differ from each other. We will need results from qualitative and quantitative studies in order to interpret the results produced by PCA.

Correlation between qualitative, quantitative, and statistical results

<table>
<thead>
<tr>
<th></th>
<th>Affix scores</th>
<th>Weighted votes</th>
<th>PCA cluster</th>
</tr>
</thead>
<tbody>
<tr>
<td>者 zhe3</td>
<td>3.688</td>
<td>21</td>
<td>Cluster1</td>
</tr>
<tr>
<td>员 yuan2</td>
<td>2.511</td>
<td>14</td>
<td>Cluster2</td>
</tr>
<tr>
<td>家 jia1</td>
<td>2.449</td>
<td>17</td>
<td>Cluster1</td>
</tr>
<tr>
<td>师 shi1</td>
<td>1.986</td>
<td>12</td>
<td>Cluster2</td>
</tr>
<tr>
<td>士 shi4</td>
<td>1.910</td>
<td>11</td>
<td>Cluster3</td>
</tr>
<tr>
<td>人 ren2</td>
<td>1.799</td>
<td>3</td>
<td>Cluster3</td>
</tr>
<tr>
<td>手 shou3</td>
<td>1.708</td>
<td>15</td>
<td>Cluster3</td>
</tr>
<tr>
<td>工 gong1</td>
<td>1.610</td>
<td>5</td>
<td>Cluster3</td>
</tr>
<tr>
<td>客 ke4</td>
<td>1.167</td>
<td>1</td>
<td>Cluster3</td>
</tr>
<tr>
<td>主 zhu3</td>
<td>1.129</td>
<td>1</td>
<td>Cluster3</td>
</tr>
</tbody>
</table>

Table 6: A comparison of the results obtained by three approaches

At a first glance, the trends of the affix scores and the votes seem to be in the same direction. To show the correlation more clearly, Pearson Correlation coefficient between affix scores and votes was calculated. The correlation coefficient is 0.855, indicating a very strong correlation. The
strong correlation between the results of the quantitative model and linguistic intuition of eighteen linguists supported that the quantitative model is valid and reliable.

However, it is worth noting that 手 shou3 is the only outlier. The high votes for 手 shou3 indicates it is similar to an affix, but the lower affix score supports it is similar to a root. According to Table 5, 手 shou3 has low scores in all the parameters, which yield a low affix score. Compared to other word-endings, 手 shou3 has second highest score in “semantic bleaching” parameter. The rank is highly consistent with the votes. This discrepancy is thus not surprising given the underlying differences in the qualitative and quantitative approaches. Meaning is more salient when it comes to linguistic intuition, as a result, it is possible that the qualitative approach relies more on the “semantic bleaching” parameter than the quantitative approach which treats all parameter equally.

The PCA produced three clusters. As seen from Table 6, the three clusters fit the distribution of affix scores and weighted votes very well. We can see that the first cluster has the highest affix scores and votes, the third cluster has the lowest, and the second cluster stands in-between. If we assume affix, quasi-affixes, and roots are on a continuum, according to the affix scores, the first cluster should be categorized as affixes, the second cluster should be treated as quasi-affixes, and the third cluster should be considered as roots. The results showed that the classification given by PCA yielded three distinct categories and reflected the general pattern in both the qualitative and quantitative data.

Hierarchical clustering in qualitative, quantitative, and statistical results
It might be arbitrary to set threshold values for the affix scores and votes in order to classify the word-endings into three clusters of affix, quasi-affixes, and roots. Hierarchical clustering provides good support using the nearest distance principle.

The data in Table 6 were fed into the hierarchical clustering model and three clusters were produced for data obtained by each approach. Euclidean distance is used for the data in qualitative and quantitative approaches, whereas Cosine distance was used for multi-dimensional data in the statistical approaches.

The results of hierarchical clustering were shown in Graph 2 and the clusters were compared in Table 7. In the first cluster, the three approaches shared the item 者 zhe3. In the second cluster, the common subset is 员 yuan2. In the third cluster, the intersection includes 工 gong1, 客 ke4, 主 zhu3, and 人 ren2. The three approaches agree on six word-endings out of ten, which is a moderately high agreement rate. The results indicate that each approach has its own validity and they produced converging results in combination.

Based on the affix scores, the first cluster is interpreted as affix, the second cluster is labeled as quasi-affix, and the third cluster represents roots. The three approaches unanimously support that
者 zhe3 is an affix, 员 yuan2 is a quasi-affix, and 工 gong1, 客 ke4, 主 zhu3, and 人 ren2 are roots.

Graph 2: Hierarchical clustering of the results obtained by three approaches

<table>
<thead>
<tr>
<th></th>
<th>Qualitative</th>
<th>Quantitative</th>
<th>Statistical</th>
<th>Intersection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster1</td>
<td>者 zhe3</td>
<td>者 zhe3</td>
<td>者 zhe3</td>
<td>者 zhe3</td>
</tr>
<tr>
<td></td>
<td>家 jia1</td>
<td>家 jia1</td>
<td>家 jia1</td>
<td>家 jia1</td>
</tr>
<tr>
<td></td>
<td>师 shi1</td>
<td>师 shi1</td>
<td>师 shi1</td>
<td>师 shi1</td>
</tr>
<tr>
<td></td>
<td>士 shi4</td>
<td>士 shi4</td>
<td>士 shi4</td>
<td>士 shi4</td>
</tr>
<tr>
<td></td>
<td>手 shou3</td>
<td>手 shou3</td>
<td>手 shou3</td>
<td>手 shou3</td>
</tr>
</tbody>
</table>
5. Conclusion

The current study proposed a quantitative model and a statistical model for the classification of roots, quasi-affixes, and affixes in Chinese and the two approaches produced consistent results. The quantitative model assigns affix scores to ten word-endings ranging from 1.1 to 3.7. PCA produced three clusters of word-endings. The three clusters fit well with the three categories of affixes, quasi-affixes, and roots with each having high affix scores, mid affix scores, and low affix scores.

When comparing to the results in qualitative studies, the results are also satisfactory. The distribution of the affix scores is highly correlated with the judgment in qualitative studies, with a Pearson correlation coefficient of 0.855. The agreement rate of qualitative, quantitative, and statistical approaches is 60%. Linguistically, the results support that 者 zhe3 is an affix, 员 yuan2 is a quasi-affix, and 工 gong1, 客 ke4, 主 zhu3, and 人 ren2 are roots. Methodologically, the results suggested that the statistical model in the current study is a useful tool for classifying complex and unknown data, for it is easy to construct and does not require any prior linguistic information.

However, the current study has also several limitations. First, the annotation for semantic bleaching is oversimplified. The degree of semantic bleaching of may need to be analyzed for each word instead of for each word-ending. Li (2003) pointed out the word-ending 人 ren2 has no semantic bleaching in 读书人 du2shu1ren2 “student/people who study”, but it has a high degree of semantic bleaching in 主人 zhu3ren2 “host-person” because “host” entails “person”. Second, the quantitative model assumed equal weights for all the parameters. It is not clear if some parameters are more crucial in determining an affix. Third, it is important to test whether the quantitative model is applicable for affixes in general. Future studies can apply the paradigm to other quasi-affixes in Chinese as well as the quasi-affixes in other languages.

Table 7: A comparison of the clusters in three approaches

<table>
<thead>
<tr>
<th>Cluster3</th>
<th>工 gong1</th>
<th>客 ke4</th>
<th>主 zhu3</th>
<th>人 ren2</th>
<th>师 shi1</th>
<th>士 shi4</th>
<th>人 ren2</th>
<th>手 shou3</th>
<th>工 gong1</th>
<th>客 ke4</th>
<th>主 zhu3</th>
<th>人 ren2</th>
</tr>
</thead>
</table>

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References


