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Exploring the nature of the ‘subject’-preference: Evidence from the online comprehension of simple sentences in Mandarin Chinese

Luming Wang

*Independent Junior Research Group Neurotypology, Max Planck Institute for
Human Cognitive and Brain Sciences, Leipzig, Germany*

Matthias Schlesewsky

*Department of English and Linguistics, Johannes Gutenberg University Mainz,
Mainz, Germany*

Balthasar Bickel

Department of Linguistics, University of Leipzig, Leipzig, Germany

Ina Bornkessel-Schlesewsky

*Independent Junior Research Group Neurotypology, Max Planck Institute for
Human Cognitive and Brain Sciences, Leipzig, Germany*

In two visual ERP studies, we investigated whether Mandarin Chinese shows a subject-preference in spite of the controversial status of grammatical relations in this language. We compared ERP responses at the position of the verb and the second NP in object-verb-subject (OVS) and subject-verb-object (SVO) structures. While SVO is the basic word order in Chinese and OV

Correspondence should be addressed to Ina Bornkessel-Schlesewsky, Independent Junior Research Group Neurotypology, Max Planck Institute for Human Cognitive and Brain Sciences, Stephanstrasse 1A, 04103 Leipzig, Germany. E-mail: bornke@cbs.mpg.de

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with subject-drop is possible, OVS is strongly dispreferred. At the position of the verb, which disambiguated towards an object or a subject reading of NP1, Experiment 1 revealed an N400 for both subject-initial control conditions in comparison with the critical object-initial condition. Experiment 2 showed that this result was due to differences in lexical-semantic relatedness between NP1 and the verb. When these were controlled for, we observed an N400 for the disambiguation towards an object-initial order, i.e., evidence for a subject-preference. At the postverbal NP, the object-initial condition showed a biphasic N400-late positivity pattern in both experiments. We interpret the N400 as reflecting the processing of an unexpected argument and the late positivity as a correlate of a well-formedness mismatch. Overall, our results suggest that Mandarin Chinese shows a subject-preference for an initial argument, thus providing further converging support for the notion that the subject-preference might constitute a universal processing strategy. We argue that the functional basis for this strategy lies in cross-linguistically applicable economy principles that serve to constrain incremental interpretation.

INTRODUCTION

One of the most intriguing questions within the field of psycholinguistics is whether the language processing architecture – or at least certain aspects of it – can be considered to be universal, i.e., whether all languages are processed on the basis of a certain set of cross-linguistically applicable mechanisms or strategies. If this were indeed the case, we should be able to identify similar processing strategies across structurally and typologically varied languages. A promising candidate for such a potentially ‘universal’ processing strategy is the so-called ‘subject-preference’. This preference, which refers to the processing system’s tendency to: (a) analyse ambiguous initial arguments as subjects, and (b) prefer subject-extractions over object-extractions in relative clauses, is well established in a number of Indo-European languages such as Dutch (Frazier & Flores d’Arcais, 1989), English (King & Just, 1991; Lee, 2004), French (Holmes & O’Regan, 1981), German (Bader & Meng, 1999; Schriefers, Friederici, & Kühn, 1995), Italian (de Vincenzi, 1991; Penolazzi, de Vincenzi, Angrilli, & Job, 2005) and Spanish (Casado, Martín-Loeches, Muñoz, & Fernández-Frías, 2005). It has recently also been reported for Turkish, an Altaic language (Demiral, Schlesewsky, & Bornkessel-Schlesewsky, 2008).

For an illustration of the subject-preference, consider the following examples (from Demiral et al., 2008).

- (1) Turkish (Demiral et al., 2008)
 - a. Dün adam gördüm.
yesterday man see-PST-1.SG
‘I saw (a) man yesterday’

- b. Dün taş gördüm.
 yesterday stone see-PST-1.SG
 'I saw (a) stone yesterday'

In the examples in (1), the noun phrases *adam* ('man') and *taş* ('stone') are locally ambiguous between a subject (nominative) and an object (accusative) reading. At the position of the verb, this ambiguity is resolved towards the object reading via the first person agreement marker. Note that, in spite of the first person subject, no first person pronoun is present in the example sentences in (1) because Turkish allows subjects to be omitted (and this is the preferred option for first and second person pronouns). Furthermore, because the basic word order of Turkish is subject-object-verb, the sentences in (1) do not deviate from the normal word order pattern and are highly acceptable. Nevertheless, Demiral and colleagues observed that, in terms of event-related brain potentials (ERPs), sentences such as (1) engendered an early positivity at the position of the disambiguating verb in comparison with unambiguous control conditions (with objects that were clearly marked for accusative case). Like previous findings in other languages, this observation serves to illustrate the subject-preference: the tendency to analyse an initial ambiguous argument as the subject of the sentence. The fact that the ERP correlate of the dispreferred disambiguation (the early positivity) did not differ between sentences with animate (1a) and inanimate (1b) ambiguous arguments further suggests that the subject-preference cannot be reduced to semantic factors (e.g., a preference for an 'Agent'-interpretation of the first argument). Findings suggesting that the subject-preference is not thematic in nature have also been reported for German (Scheepers, Hemforth, & Konieczny, 2000; Schlesewsky & Bornkessel, 2006; Schlesewsky, Fanselow, Kliegl, & Krems, 2000).

If, as these findings suggest, the subject-preference is indeed a *grammatically based* processing strategy, it appears especially intriguing that it has been observed across a number of languages with rather different characteristics (English, Dutch, German, Italian, Spanish, Turkish). However, all of these languages have in common that the grammatical relation 'subject' is relatively undisputed and easily definable (e.g., in terms of structural position, case marking, agreement). Yet if the subject-preference is indeed a *universal* strategy of language processing, it should also be observable in languages for which it is controversial whether grammatical relations such as 'subject' even exist. As we will explain in more detail below, Mandarin Chinese is a good example of a language of this type. The present ERP investigation therefore used Chinese as a test case in order to examine whether a subject-preference can also be observed in a language in which the existence of grammatical relations is disputed in the theoretical literature. By investigating whether a language of this type shows a processing strategy

akin to the subject-preference or not, the present study aimed (a) to shed further light on the possible universal or language-specific status of this preference, and (b) to provide a more fine-grained characterisation of the precise nature of this preference.

Deriving the subject-preference

The subject-preference is traditionally modelled with reference to so-called ‘filler-gap’ relations, i.e., via the notion that a dislocated constituent (a ‘filler’) is identified and assigned to a ‘gap’ position (which determines its interpretation) later on in the sentence. This kind of situation typically occurs in relative clauses and wh-questions, in which the filler-status of the relative pronoun or wh-element is immediately apparent. There is now a consensus among filler-gap-based theories that the processing system attempts to establish a filler-gap relation as soon as possible. Hence, the filler is preferentially associated with the *subject gap* position, which is assumed to be ‘higher up’ in the syntactic structure than the competing object gap position (Crocker, 1994; de Vincenzi, 1991; Fodor, 1978; Frazier & Flores d’Arcais, 1989). Thus, filler-gap-based approaches derive the subject-preference via a tendency to minimise the distance between a filler and its associated gap.

However, ambiguities between a subject and an object analysis of an argument can also arise when, in contrast to the situation in relative clauses and wh-questions, this argument need not necessarily be identified as a ‘filler’, i.e., when the ambiguity is not between two different possible filler-gap relations, but rather between a filler and a non-filler analysis of the ambiguous argument. To address this type of ambiguity, de Vincenzi (1991) formulated the Minimal Chain Principle (MCP):

(2) Minimal Chain Principle (de Vincenzi, 1991)

Avoid postulating unnecessary chain members at S-structure, but do not delay postulating required chain members.

The MCP states that, under conditions of local ambiguity, the processing system prefers a base-generated structure over a structure involving movement. In addition, the MCP states that, when a filler has been unambiguously identified, it is associated with the closest gap site. These predictions are supported by findings from several languages (e.g., Italian: de Vincenzi, 1991; and German: e.g., Bader & Meng, 1999; Bornkessel, McElree, Schlesewsky, & Friederici, 2004; Friederici & Mecklinger, 1996).

However, the findings from Turkish that were illustrated with respect to example (1) suggest that the source of the subject-preference in simple sentences might be even more general in nature. Turkish allows – or even

favours – subject-drop and it has a basic SOV word order. Thus, an initial case ambiguous argument could either be analysed as the subject of the sentence (in an SOV or an SV construction) or as the object in an (unmarked, OV) sentence with a dropped subject. The MCP therefore does not make any clear predictions for Turkish, because both a subject and an object analysis of an initial argument are compatible with a base-generated structure. Nonetheless, Demiral et al. (2008) observed a subject-preference for sentences such as (1) in a visual ERP study.

Given that the observation of a subject-preference in Turkish is difficult to derive via structural considerations, Demiral and colleagues argued that it might rather be attributable to a preference for minimal events, i.e., for event interpretations involving only a single argument (such as *John slept*). By positing that an initial argument is the only argument in the sentence, the processing system can avoid additional assumptions about possible relations between the arguments (e.g., which argument is the Actor and which is the Undergoer of the event; Bornkessel & Schlesewsky, 2006). From this perspective, the subject-preference is an epiphenomenon of the processing system's endeavour to construct minimal interpretations and to thereby assume that an initial argument is the only argument in (and thereby the subject of) the sentence.

The minimal event interpretation of the subject-preference thus predicts that the subject-preference should be observable cross-linguistically and independently of the specific structural properties of a particular language. Specifically, all languages should be expected to show a preference to analyse an initial ambiguous argument as the sole argument in an intransitive event and, when an intransitive reading is no longer tenable, as the argument in a transitive relation that corresponds to the sole argument in an intransitive relation (i.e., as the 'subject' of the clause in all of the languages discussed so far).

In spite of their underlying differences, both structurally based (filler-gap-based) and minimal event-based explanations of the subject-preference make crucial reference to the existence of a 'subject' category in the languages under examination. Thus, whereas structurally based theories assume that subjects can be linked to a certain position in the syntactic structure of the sentence and the subject-preference can therefore be derived via structural considerations, the minimal event hypothesis assumes that it is driven by the correspondence between the subject of an intransitive relation and the subject of a transitive relation. From a cross-linguistic perspective, however, the assumption of a universal 'subject' category is rather controversial (e.g., Bickel, in press; Croft, 2001; Comrie, 1989; Farrell, 2005). Thus, the question arises of whether a similar processing strategy will also be observable in languages in which the status of grammatical relations (such as 'subject' and

‘object’) is controversial. As will become clear in the next section, Mandarin Chinese is a case in point.

The controversial status of grammatical relations in Mandarin Chinese

Grammatical relations such as ‘subject’ and ‘object’ are traditionally taken to specify the (morphosyntactic) relationship between an argument and a clause. However, the precise definition of grammatical relations varies considerably across different theoretical approaches. In Chomskyan theories of grammar, the subject or object status of an argument is determined by its position in the syntactic structure (Chomsky, 1981; see also Ura, 2000). In alternative approaches such as Lexical-Functional Grammar (Bresnan, 2001), by contrast, grammatical relations are assumed to be syntactic primitives which cannot be defined further. Finally, there are also grammatical theories (e.g., Role and Reference Grammar; Van Valin, 2005) which do not assume grammatical relations in the traditional sense at all.

Abstracting away from these theoretical controversies, grammatical relations can also be defined in a pre-theoretical way. Following Bickel (in press), grammatical relations are ‘equivalence sets of arguments, treated the same way by some construction in a language, e.g., being assigned the same case in a language, or triggering the same kind of agreement’. We will briefly illustrate this on the basis of examples from English (cf. example 3). Note that here and in the following, we will use the labels introduced by Comrie (1978) as a theory-neutral means of identifying particular arguments: S (the sole argument of an intransitive relation; e.g., *Peter* in 3a/*the boys* in 3b); A (the more agent-like argument of a transitive relation; e.g., *Peter* in 3c/*The boys* in 3d); P (the more patient-like argument of a transitive relation; e.g., *the dogs* in 3c/3d).

- (3) a. Peter is sleeping.
 b. The boys are sleeping
 c. Peter was washing the dogs.
 d. The boys were washing the dogs.
 e. The dogs were being washed (by Peter).

The examples in (3) show that, in English, the argument left-adjacent to the auxiliary agrees with it in number (and person). This is the case in both intransitive (3a/b) and transitive (3c/d) sentences, thus showing that S and A arguments are systematically treated alike in English in terms of both position and agreement (and also case marking if we were to use pronouns instead of non-pronominal noun phrases). Crucially, as shown by the comparison of the active sentence 3c and its passive counterpart 3e, this

similar treatment of S and A arguments cannot be reduced to semantic factors such as the thematic role borne by the initial argument. Hence, it provides evidence for a grammatical relation {S,A}, i.e., ‘subject’ in traditional terms. The relevance of the notion ‘subject’ for English is substantiated by further phenomena, e.g., conjunction reduction as in (4).

- (4) a. Peter_i greeted Bill_k and ____{i/*k} went home.
 b. Bill_k was greeted by Peter_i and ____{*i/k} went home.
 c. Peter went home and ___ greeted Bill.
 d. *Peter went home and Bill greeted ___.

The examples in (4) show that, when two clauses are conjoined and an argument is omitted from the second clause, two conditions must be fulfilled: the omitted argument must (a) be co-referent with the subject (S or A argument) of the first conjunct, and (b) be the subject (S or A argument) of the second conjunct.

The preceding discussion served to summarise some of the arguments for the importance of the grammatical relation ‘subject’ in English. A similar line of argumentation also holds for the other languages in which a subject preference has been observed during online processing (e.g., German, Dutch, Italian, Turkish). Hence, for all of these languages, the existence of a subject category is relatively uncontroversial. For Mandarin Chinese, by contrast, the existence of grammatical relations has been hotly debated. Consider the following examples (from LaPolla, 1993).

- (5) a. Nei ge ren ba xigua diao zai dishang, sui le.
 that CL person BA watermelon drop LOC ground broke-to-pieces ASP
 ‘That man dropped the watermelon on the ground, (and it) burst.’
 b. Nei ge ren ba xigua diao zai dishang, huang le.
 that CL person BA watermelon drop LOC ground get-flustered ASP
 ‘That man dropped the watermelon on the ground, (and he) got flustered.’

The Chinese sentences in (5) stand in stark contrast to the English examples in (4). They illustrate that (in contrast to English and the other languages discussed so far) there are no grammatical restrictions on coreference in conjoined clauses in Chinese, i.e., the omitted argument in the second clause can either be coreferent with the P argument (5a) or the A argument (5b) of the first conjunct. Hence, conjunction reduction does not provide evidence for a distinction between ‘subjects’ and ‘objects’ in Chinese. Furthermore, since Chinese has neither case marking nor agreement, these phenomena also cannot serve to identify subjects. Finally, since word order is considerably

freer in Chinese than in English, a position-based definition of subjecthood is not feasible either.

On the basis of these and further observations, LaPolla (1993) argued that there is no evidence for a subject/object asymmetry in Chinese. In a similar vein, Li and Thompson (1976) proposed that many of the phenomena that can be explained with reference to grammatical relations such as subject in other languages (e.g., English) are rather derivable via the notion of 'topic' in Chinese. While other researchers have argued for somewhat less extreme positions, noting that subject/object asymmetries can in fact be observed in Chinese under certain conditions (for discussion, see Bisang, 2006), it appears undisputable that the evidence for the grammatical relation 'subject' is much thinner in Chinese as opposed to the languages in which a subject preference has been observed to date. In view of this observation, the question of whether Chinese also shows a 'subject-preference' (i.e., a preference for an S or A reading of an initial ambiguous argument) is of high theoretical interest for models of language comprehension. Should Chinese show a subject-preference, this would attest to the cross-linguistic stability of this processing strategy. However, given the controversial status of the subject category in Chinese, such a finding would also call for a reinterpretation of the representations that engender this preference across languages. By contrast, if Chinese failed to show a subject-preference, this would provide a first indication that a preference of this type might be confined to languages in which the subject-object distinction is straightforwardly defined. Note that, here and in the following, we continue to use the term 'subject-preference' as a convenient label for an {S/A}-preference in spite of the controversial status of the grammatical relation 'subject' in Chinese.¹

Chinese and the subject-preference: Previous findings

As briefly mentioned above, the term 'subject-preference' has a twofold meaning in the psycholinguistic literature, i.e., it is used to refer to the preferred analysis of ambiguous arguments in simple sentences, but also to the preference for subject- vs. object-extracted relative clauses. Previous empirical studies of the subject-preference in Chinese have exclusively concerned themselves with the second of these two senses, i.e., with the processing preferences obtaining in Chinese relative clause constructions.

¹ Note that, since the notion of an {S/A} correspondence is theory-neutral and, in principle, independent of all of the properties that are usually used as diagnostics for subjecthood (e.g., case marking, agreement, structural position, control properties, etc.), it is not a contradiction in terms to assume that a language without such subject properties (like Chinese) might show a preference for an S/A reading of an initial ambiguous argument during online language comprehension.

However, the overall pattern of results is currently somewhat contradictory. Whereas Hsiao and Gibson (2003) originally reported a reading time advantage for object over subject RCs, other researchers observed a preference for subject RCs in experiments using self-paced reading (Lin & Bever, 2006) and event-related brain potentials, ERPs (Packard, Ye, & Zhou, 2006). The status of the subject-preference in relative clause constructions in Chinese has thus not yet been fully resolved.

Yet the question of whether a language shows a subject-preference in relative clause constructions overlaps only in part with the cross-linguistic issues raised above. In addition to the question of how a subject-preference might be engendered by possible subject-object asymmetries, relative clauses introduce a range of additional influences that could potentially impact upon the way in which these constructions are processed (e.g., the relation between the role of the head noun in the main clause and in the relative clause). Furthermore, the typologically exceptional status of relative clauses in Chinese (i.e., prenominal relative clauses in a verb-object language) could also impact upon the processing choices in relative clause constructions in this language in some way. In view of all of these potentially confounding influences, a more straightforward approach to the question of whether Chinese shows a subject-preference in spite of the controversial status of grammatical relations appears to lie in the examination of simple sentences. Hence, the present ERP studies examined whether a subject-preference can be observed in simple declarative clauses in Mandarin Chinese.

EXPERIMENT 1

The aim of Experiment 1 was to examine whether Mandarin Chinese shows a subject-preference for an initial argument in simple declarative sentences. As described above, this question is rendered particularly interesting by several unique features of this language. Firstly, Chinese is often described as a ‘topic-prominent’ language. This means that pragmatic or discourse-related criteria – rather than structural or thematic role-related constraints – serve to determine which argument occupies the sentence-initial position (Li & Thompson, 1976). For this reason, object-initial word orders are also possible in addition to the basic SVO order.² Secondly, like Italian and Turkish, Chinese permits subject-drop. Because of these specific features, a

² Besides the basic word order SVO (Sun & Givón, 1985), OSV, SOV, and VOS are also found in spoken Chinese. However, these three word orders are pragmatically marked. Object-initial sentences – as used in the present study – highlight the topichood of the object (i.e., are used when the object conveys information that is available to both speaker and hearer). For a detailed discussion of the other two marked word orders, see Li (1990), Sun (1991), Li and Thompson (1981) on SOV and Lu (1980) on VOS.

simple NP-V sequence as in (6) is readily interpreted as a sentence with a topicalised object ('novel') and a dropped subject, i.e., the first person ('I') or someone in a discourse. Since Chinese has no case marking or subject-verb agreement, disambiguation is effected via an animacy restriction (i.e., the verb *read* requires an animate subject while the first NP is inanimate).

- (6) 小说 阅读了。
 xiaoshuo yuedu-le
 novel read-ASP
 'I (somebody) read the novel.'

If Mandarin Chinese – like all of the languages previously examined – shows a subject preference in simple sentences (i.e., a preference to interpret an initial argument as an S or A argument), we should be able to observe reanalysis effects at the position of the verb in sentences such as (6). To examine this question, the present study presented critical sentences such as those in Table 1.

In all of the sentence conditions shown in Table 1, the initial NP is ambiguous between a subject and an object reading. In accordance with the aims of the present study, the condition of primary interest is IO. Here, 'novel' is disambiguated as the object of the sentence when the verb 'read' is encountered. As mentioned above, this disambiguation was effected via an animacy restriction. In the IO condition, verbs always required an animate subject, while the initial NP was inanimate. Recall from the discussion of example (6) above that, at the position of the verb, a string such as 'novel read' can be interpreted as a sentence with a topicalised object and a dropped

TABLE 1

Example sentences for each of the three critical conditions in Experiment 1. Conditions are abbreviated as follows: IO (inanimate object-initial condition), AS (animate subject-initial condition), IS (inanimate subject-initial condition).

Condition	Example	
	NP1	Verb NP2
a. IO	*小说	阅读了演员。
	*xiaoshuo	yuedu-le yanyuan
	novel	read-ASP actor
		'The actor read the novel.'
b. AS	演员	阅读了小说。
	yanyuan	yuedu-le xiaoshuo
	actor	read-ASP novel
		'The actor read the novel.'
c. IS	小说	教育了演员。
	xiaoshuo	jiaoyu-le yanyuan
	novel	educate-ASP actor
		'The novel educated the actor.'

subject. As the dropped subject is usually the first person ('I') or someone in the discourse, the post-verbal animate NP, which can only be analysed as the subject of the verb, results in a highly dispreferred word order (OVS). Note that, in spite of the inacceptability of OVS word orders in Chinese, previous behavioural findings suggest that NP-V-NP sentences with an inanimate first NP and an animate second NP (as in our IO condition) are preferentially interpreted as OVS (e.g., Li, Bates, & MacWhinney, 1993; Miao, Chen, & Ying, 1986).

Because of the impossibility of grammatically based word order disambiguation in Chinese (see above), it was not possible to construct a subject-initial control condition which differs from the critical condition in only a single feature (e.g., agreement or case). Therefore, two subject-initial control conditions (AS/IS) were chosen, each of which controlled for different stimulus parameters. AS has the same meaning as IO, but a canonical SVO word order, and IS begins with the same inanimate NP as IO but disambiguates this NP towards a subject reading. Furthermore, AS includes identical verbs to IO and therefore allows for a comparison of identical lexical items at the position of the verb. By contrast, IS provides a lexically identical control for IO at the position of NP2. Our hypotheses for these two critical positions are as follows:

- a. Verb: At this position, contrasting IO with AS allows for a comparison of lexically identical materials (the verb *read*, disambiguating either towards an object- or a subject-initial reading). By contrast, the comparison between IO and IS ensures that the ambiguous region (*novel*) is kept constant across conditions. If the initial ambiguous NP is analysed as the subject of the sentence, a reanalysis effect should be observable for IO in comparison with both control conditions (AS/IS). Previous investigations of subject-object reanalyses in other languages have revealed several ERP correlates of this type of reanalysis depending on the language and construction type under examination (e.g., late and early positivities, but also N400 effects; see Bornkessel & Schlesewsky, 2006, for discussion). Hence, as this is the first ERP investigation of the subject-preference in simple sentences in Chinese, it is virtually impossible to predict a particular type of ERP effect for the verb position.
- b. NP2: At this position, the comparison between IO and AS contrasts sentences with an identical meaning, whereas IO vs. IS involves a comparison across lexically identical materials. Here, we expect to observe an ERP response to a dispreferred word order (OVS), which should again be observable for IO in comparison with both control conditions (IS/AS). Previous findings suggest that the ill-formedness of the IO condition should be reflected in a late positive ERP effect (P600;

e.g., Hagoort, Brown, & Groothusen, 1993; Osterhout & Holcomb, 1992).

Materials and methods

Participants. Twenty-eight monolingually raised native speakers of Mandarin Chinese (Beijing dialect) participated in the experiment after giving informed consent (15 female; mean age 27.0 years; age range 23–34 years). At the time of the experiment, all participants were residing in Berlin, Germany. Participants were right handed (as assessed by an adapted Chinese version of the Edinburgh handedness inventory; Oldfield, 1971) and had normal or corrected-to-normal vision. Three participants were subsequently excluded from the final data analysis on the basis of excessive EEG artifacts and/or too many errors in the behavioural control task.

Materials. As shown in Table 1, three critical conditions were examined in this experiment. Each of the critical sentences contained two nouns and a verb in a string of NP1-verb-NP2. The specific nouns and verbs used in the experiment are listed in the Appendix. Within each of the three conditions, the total number of characters in each sentence was held constant: only two-character nouns and verbs were used for all sentences. As Mandarin Chinese lacks overt inflections to distinguish between a set of ‘words’ and a ‘sentence’, the aspect marker 了(‘le’) was included after the verb to ensure that the sequence NP1-verb-le-NP2 would be interpreted as a sentence expressing a completed event.

Forty sets of the three conditions in Table 1 were constructed. In order to ensure that all individual verbs would be repeated equally often in the critical sentences, only 20 verbs were used in the inanimate subject-initial condition (IS) and repeated twice across the 40 sets, while 40 verbs were used to construct the IO and AS conditions. The 120 critical sentences (40 in each condition) were interspersed with 120 filler sentences, which included O/S-V-Adv structures such as 小说阅读了一会儿 (lit: ‘Novel read for a while’; i.e., ‘I/somebody read the novel for a while’) and 小说流行了大半年 (lit: ‘Novel was popular for over half a year’; i.e., ‘The novel was popular for over half a year’). Overall, the filler sentences ensured an equal probability of an initial inanimate noun being disambiguated as the subject or the object of the sentence.

The 240 sentences in the experiment (120 critical sentences and 120 fillers) were presented to participants in two different randomised presentation orders.

Procedure. Sentences were presented visually in the centre of a computer screen in a word-by-word manner with a presentation time of

650 ms per word and an inter-stimulus interval (ISI) of 100 ms. Each trial began with the presentation of an asterisk (800 ms stimulus onset asynchrony; SOA) and ended with a 600 ms pause. Subsequently, participants were required to complete a comprehension task by answering a yes/no question based on the content of the preceding experimental sentence. Comprehension questions were constructed by rephrasing the preceding experimental sentence as a canonically ordered active sentence (SVO) or as a passive sentence (O 被 (bèi) S V) with a question particle ‘吗’ (ma) at the end. Comprehension questions were presented in both active and passive form in order to ensure that participants could not simply answer the question by means of a visual match between the experimental sentence and the question. Questions to be answered with ‘yes’ (50% of all questions) were consistent with the proposition of the preceding sentence. Examples of correct active and passive questions are shown in (7b) and (7c), respectively. Questions to be answered with ‘no’ were constructed in the same way but included a substituted subject, object, or verb (e.g., ‘magazine’ instead of ‘book’ or ‘read loudly’ instead of ‘read’). Comprehension questions were presented on the screen as a whole and without spaces between the words.

(7) a. Sample experimental sentence for condition IO

小说 阅读了 演员
xiaoshuo yuedu-le yanyuan
novel read-ASP actor
*‘The actor read the novel.’

b. Corresponding correct active question

演员 阅读了 小说 吗?
yanyuan yuedu-le xiaoshuo ma
actor read-ASP novel MA
‘Did the actor read the novel?’

c. Corresponding correct passive question

小说 被 演员 阅读了 吗?
xiaoshuo bei yanyuan yuedu-le ma
novel BEI actor read-ASP MA
‘Was the novel read by the actor?’

The comprehension task required the answer ‘yes’ equally as often as the answer ‘no’ in each of the experimental conditions. The assignment of the left and right buttons to the answers yes and no for the comprehension task was counterbalanced across participants.

Participants were asked to avoid movements and to only blink their eyes between their response to the comprehension task and the presentation of the next sentence. The experimental session began with a short training

session followed by six experimental blocks comprising 40 sentences each, between which the participants took short breaks. The entire experiment (including electrode preparation) lasted approximately 2 hours.

EEG recording. The EEG was recorded via 25 AgAgCl-electrodes fixed at the scalp by means of an elastic cap (ElectroCap International, Eaton, OH). The ground electrode was positioned at AFZ. Recordings were referenced to the left mastoid, but re-referenced to linked mastoids off-line. The electro-oculogram (EOG) was monitored by means of electrodes placed at the outer canthus of each eye for the horizontal EOG and above and below the participant's right eye for the vertical EOG. Electrode impedances were kept below $5k\Omega$. All EEG and EOG channels were amplified using a Twente Medical Systems DC amplifier (Enschede, The Netherlands) and recorded with a digitisation rate of 250Hz. The EEG data were filtered with 0.3–20 Hz band pass off-line to exclude slow signal drifts.

Average ERPs were calculated per condition per participant from the onset of the critical stimulus items (i.e., the verb and NP2) to 1000 ms post onset, before grand-averages were computed over all participants. Trials for which the comprehension task was not performed correctly were excluded from the averaging procedure, as were trials containing ocular, amplifier-saturation or other artifacts (the EOG rejection criterion was $40\ \mu\text{V}$). Less than 10% of all trials were excluded in this manner (8.4% for the position of the verb and 9.7% for the position of NP2) and exclusion rates did not differ significantly across conditions.

Data analysis. For the behavioural data, the mean accuracy rates and reaction times were calculated for each condition. Incorrectly answered trials were excluded from the reaction time analysis. We computed a repeated-measures analysis of variance (ANOVA) involving the within-participants factor CONDITION (IO vs. AS vs. IS) and the random factors participants (F_1) and items (F_2). In the case of a significant result, post-hoc pair-wise comparisons of the three levels of the factor CONDITION were computed. For these multiple comparisons, the critical alpha level was adjusted according to a modified Bonferroni procedure (Keppel, 1991). In these cases, we report unadjusted p -values for all comparisons reaching significance at the corrected alpha level of .033 (with a corrected alpha level of .046 amounting to a marginally significant effect).

For the statistical analysis of the ERP data, repeated measures ANOVAs involving the factor CONDITION (IO vs. AS vs. IS) were calculated for mean amplitude values per time window per condition. Analyses additionally involved the topographical factor 'region of interest' (ROI). Lateral regions of interest were defined as follows: left-anterior (F3, F7, FC1, FC5); left-posterior (CP1, CP5, P3, P7); right-anterior (F4, F8, FC2, FC6); and

right-posterior (CP2, CP6, P4, P8). For midline sites, each electrode was defined as a ROI of its own: FZ, FCZ, CZ, CPZ, PZ, POZ. As for the behavioural data, significant effects of CONDITION were followed up by means of Bonferroni-adjusted pairwise comparisons between the critical conditions. Time windows were chosen on the basis of visual inspection of the data.

The statistical analysis was carried out in a hierarchical manner, i.e., only significant effects ($p \leq .05$) were resolved. To avoid excessive type 1 errors due to violations of sphericity, we applied the correction of Huynh and Feldt (1970) when the analysis involved factors with more than one degree of freedom in the numerator.

Results

Behavioural data. Table 2 shows the mean accuracy rates and reaction times for the three critical conditions. Standard deviations are given in parentheses. As is apparent from the table, participants were generally very accurate in interpreting the sentences, with all conditions showing an accuracy of over 90%.

The results in Table 2 suggest that participants were less likely to interpret the OVS word order in condition IO correctly in comparison with the subject-initial control conditions (AS/IS). This descriptive impression was confirmed by the statistical analysis of the accuracy rates. Here, a repeated measures ANOVA revealed a main effect of CONDITION, $F_1(2, 48) = 4.02$, $p < .03$; $F_2(2, 78) = 6.07$, $p < .01$. Subsequent pair-wise comparisons revealed a significant difference (marginal in the analysis by participants) between IO and AS, $F_1(1, 24) = 4.54$, $p < .05$; $F_2(1, 39) = 15.80$, $p < .001$, and a marginally significant difference between IO and IS only in the analysis by items, $F_1(1, 24) = 3.34$, $p < .09$; $F_2(1, 39) = 4.27$, $p < .05$. The two subject-initial conditions (AS/IS) also differed marginally from one another in the analysis by participants, $F_1(1, 24) = 4.81$, $p < .04$; $F_2 < 1$.

For the reaction times, the analysis revealed a main effect of CONDITION, $F_1(2, 48) = 11.28$, $p < .001$; $F_2(2, 78) = 6.31$, $p < .01$. Pair-wise comparisons showed a significant difference between IO and IS, $F_1(1,$

TABLE 2
Mean accuracy rates and reaction times for the comprehension task
in Experiment 1. Standard deviations are given in parentheses.

Condition	Accuracy (%)	RT (ms)
a. IO	92.0 (12.8)	1266.9 (292.5)
b. AS	97.9 (2.2)	1252.1 (267.5)
c. IS	96.6 (2.9)	1338.0 (296.0)

24) = 8.32, $p < .01$; $F_2(1, 39) = 6.02$, $p < .02$, and AS and IS, $F_1(1, 24) = 40.23$, $p < .001$; $F_2(1, 39) = 9.74$, $p < .01$, but not between IO and AS, $F_1 < 1$; $F_2(1, 39) = 1.23$, $p > .27$. Thus, reaction times were higher for the condition with an inanimate initial subject (IS) in comparison with the other two conditions.

In summary, though performance accuracy was generally very high, participants were most likely to assign a correct interpretation to sentences in condition AS and least likely to interpret sentences in condition IO correctly. Accuracy rates for condition IS were intermediary between those for the other two conditions, with the additional difficulty in this condition likely stemming from the presence of an inanimate subject/Actor. This assumption is supported by the reaction times, which were longer for condition IS in comparison with both AS and IO.

ERP data. In the analysis of the ERP data, the two positions of interest in our critical sentences – namely the verb and the second NP – were considered in turn.

Verb. Grand average ERPs at the position of the verb are shown in Figure 1.

As is apparent from Figure 1, the ERPs at the position of the verb revealed no signs of reanalysis-related processing difficulty for the object-initial condition (IO). There was, however, a centro-parietal negativity between approximately 300 and 550 ms (N400) for both subject-initial control conditions (IS/AS) in comparison with IO (Figure 1A: AS vs. IO; Figure 1B: IS vs. IO). The time window 300–550 ms was therefore chosen for the statistical analysis of the verb.

In this time window (300–550 ms), a repeated measures ANOVA revealed interactions of CONDITION \times ROI for both lateral, $F(3, 72) = 9.03$, $p < .001$, and midline, $F(5, 120) = 6.16$, $p < .001$, electrode sites. Resolving these interactions by ROI showed significant effects of CONDITION in both posterior regions for the lateral electrodes: left, $F(1, 24) = 4.18$, $p < .03$; right, $F(1, 24) = 5.66$, $p < .01$, and at the midline electrodes CPZ, $F(1, 24) = 4.37$, $p < .03$, PZ, $F(1, 24) = 5.88$, $p < .01$, and POZ, $F(1, 24) = 7.50$, $p < .01$.

Subsequent pair-wise comparisons within the ROIs showing an effect of CONDITION revealed a significant difference between IS and IO within all of these regions, all $F_s(1, 24) > 7.40$, all $p_s < .02$, due to a larger N400 in the IS condition. By contrast, the comparison between AS and IO did not reach significance in any region. Finally, IS also showed a slightly larger N400 in comparison with AS, as reflected in a marginally significant difference between the two conditions in the right-posterior region, $F(1, 24) = 4.34$, $p < .05$, and a significant difference at POZ, $F(1, 24) = 6.07$, $p < .03$.

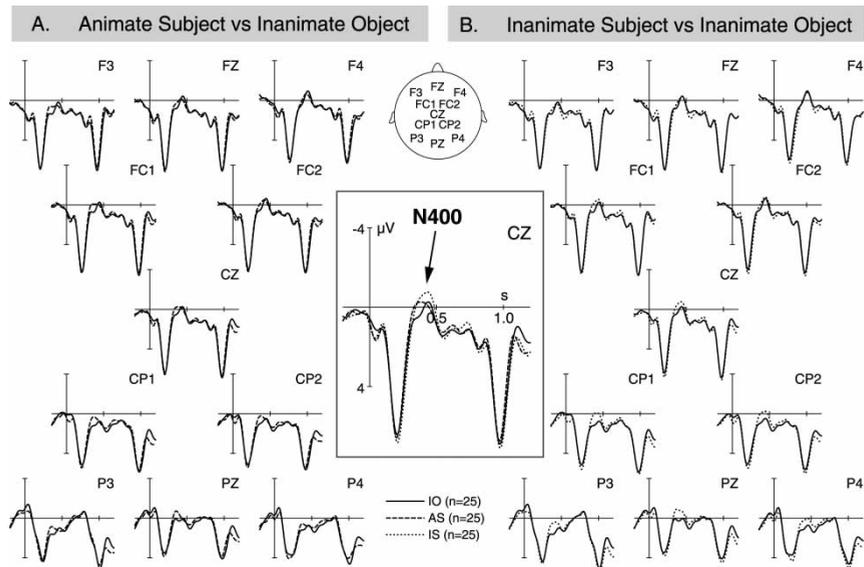


Figure 1. Grand average ERPs ($n = 25$) time-locked to the verb (onset at the vertical bar) in the three critical conditions in Experiment 1. Pair-wise comparisons of the critical object-initial condition (IO) and the animate (AS) and inanimate subject-initial (IS) controls are shown in Panels A and B, respectively. The enlarged centre panel shows a direct comparison of all three conditions at one electrode. Negativity is plotted upwards.

While the N400 effect for AS vs. IO did not reach significance within the time window from 300 to 550 ms, visual inspection of Figure 1 suggests that effect was confined to a smaller time window. This impression was confirmed by a subsequent analysis in a time window between 300 and 400 ms. In this time window, AS differed significantly from IO in all of the regions that showed a main effect of condition within the overall time window, all $F_s(1, 24) > 5.20$, all $p_s < .03$.

To summarise, at the position of the verb, both subject-initial control conditions (IS/AS) showed an N400 in comparison with the critical object-initial condition (IO). This effect was somewhat more pronounced in the IS as opposed to the AS condition.

NP2. Figure 2 shows grand average ERPs at the position of NP2.

Figure 2 shows that, in contrast to the pattern of results observed at the verb, ERPs time-locked to the onset of NP2 are indicative of increased processing costs in condition IO. At this position, IO engendered a biphasic N400 – late positivity pattern in comparison with both control conditions (Figure 2A: IO vs. AS; Figure 2B: IO vs. IS). Two time-windows were chosen

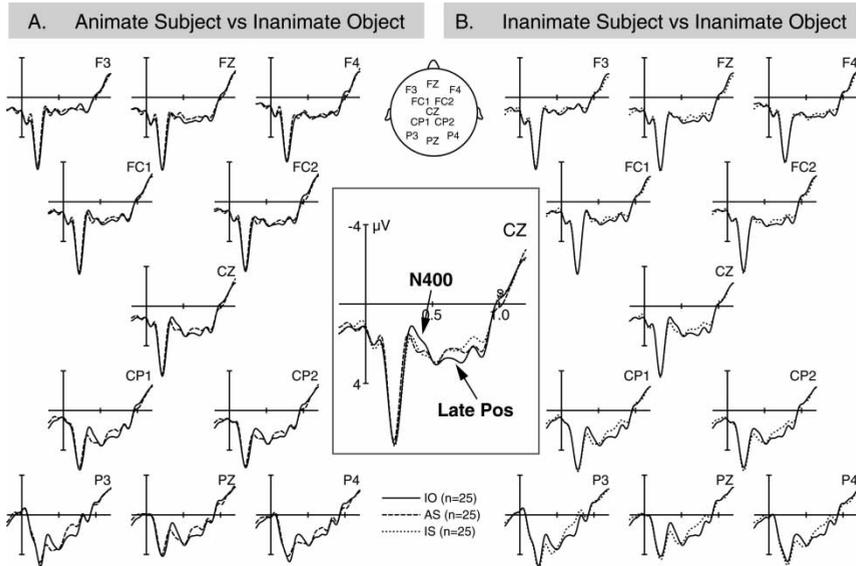


Figure 2. Grand average ERPs ($n=25$) time-locked to NP2 (onset at the vertical bar) in the three critical conditions in Experiment 1. Pair-wise comparisons of the critical object-initial condition (IO) and the animate (AS) and inanimate subject-initial (IS) controls are shown in Panels A and B, respectively. The enlarged centre panel shows a direct comparison of all three conditions at one electrode. Negativity is plotted upwards.

for the statistical analysis of the ERP data at NP2: 300–450 ms for the N400 and 550–750 ms for the late positivity.

In the earlier time window (300–450 ms), the statistical analysis revealed interactions $CONDITION \times ROI$: lateral, $F(3, 72) = 4.09$, $p < .01$; midline, $F(5, 120) = 3.90$, $p < .01$. Separate analyses per ROI showed significant effects of $CONDITION$ in the left-posterior region, $F(1, 24) = 7.89$, $p < .01$, and at PZ, $F(1, 24) = 4.95$, $p < .02$. In addition, the effect of $CONDITION$ reached marginal significance in the right-posterior region, $F(1, 24) = 3.29$, $p < .06$) as well as at CPZ, $F(1, 24) = 3.18$, $p < .07$, and POZ, $F(1, 24) = 3.41$, $p < .06$.

Pair-wise comparisons in the ROIs showing an effect of $CONDITION$ revealed a significant difference between IO and IS in all of these regions (all $F_s > 5.60$, all $p_s < .03$), while the difference between IO and AS only reached significance in the left-posterior region ($F(1, 24) = 6.80$, $p < .02$). In all cases, the effects were due to a negativity in condition IO as compared to IS/AS. By contrast, the two subject-initial conditions (IS/AS) did not differ from one another in any region.

The analysis of the later time window (550–750 ms) showed the following results. For the lateral electrodes, we observed an interaction

CONDITION \times ROI, $F(3, 72) = 4.42$, $p < .001$, which resulted from significant effects of CONDITION in the two posterior regions: left, $F(1, 24) = 9.40$, $p < .001$; right, $F(1, 24) = 4.46$, $p < .02$. Pair-wise comparisons between individual conditions within these regions revealed a significant difference between IO and IS in both ROIs: left, $F(1, 24) = 18.26$, $p < .001$; right, $F(1, 24) = 10.98$, $p < .01$, while the difference between IO and AS only reached significance in the left-posterior region, $F(1, 24) = 12.80$, $p < .01$. In all cases, effects were due to a positivity for IO in comparison with IS/AS. The two subject-initial conditions (IS/AS) did not differ from one another in any region.

The analysis of the midline electrodes showed a main effect of CONDITION, $F(2, 48) = 3.54$, $p < .04$. Subsequent pair-wise comparisons only revealed a difference between conditions IO and IS, $F(1, 24) = 8.39$, $p < .01$, which was due to more positive-going ERPs for condition IO.

In summary, the analysis of the ERPs at the position of NP2 showed a biphasic N400 – late positivity pattern for IO in comparison with both subject-initial control conditions (IS/AS). These effects, both of which showed a clear posterior maximum, were somewhat more pronounced in the comparison with the lexically identical control condition IS.

Relatedness questionnaire

The most surprising result of the present study was that both subject-initial control conditions (AS/IS) engendered N400 effects in comparison with the critical object-initial condition (IO) at the position of the verb. This finding might be attributable to differences in lexical-semantic relatedness between NP1 and the verb (for a review, see Kutas & Federmeier, 2000). That is, the verb ‘read’ in condition IO is closely related to the meaning of the first NP ‘novel’, while the verbs ‘read’ in AS and ‘educated’ in IS are less expected from the meaning of the first NP. To examine whether our critical conditions indeed differed in terms of lexical-semantic relatedness, we conducted an additional questionnaire study.

Participants. Twenty-four native speakers of Mandarin Chinese residing in mainland China at the time of the study took part in the questionnaire study (15 females; mean age: 28.2 years, range: 18–52 years). None of them had ever lived outside of China.

Materials. The 120 critical NP1 – verb pairs used in our ERP study were randomly interspersed with 240 filler pairs. Fillers were constructed so as to display varying degrees of relatedness.

TABLE 3
 Mean relatedness ratings between NP1 and the verb for the critical conditions in Experiment 1. Standard deviations are given in parentheses.

<i>Condition</i>	<i>Relatedness (SD)</i>
a. IO	1.26 (0.27)
b. AS	2.82 (0.50)
c. IS	2.72 (0.49)

Procedure. Participants judged the relatedness of the word pairs on a 4-point scale (1 = 'closely related'; 4 = 'not at all related').

Results. The mean relatedness ratings obtained in the questionnaire study are shown in Table 3.

The ratings in Table 3 suggest that the NP1-verb pairs in the object-initial condition (IO) were judged to be more closely related to each other than those in the subject-initial conditions (AS/IS). This impression was confirmed by the statistical analysis, which revealed a significant main effect of CONDITION, $F_1(2, 46) = 168.23, p < .001$; $F_2(2, 78) = 71.44, p < .001$. Subsequent pair-wise comparisons showed significant differences between the object-initial condition and both subject-initial conditions: IO vs. AS, $F_1(1, 23) = 246.63, p < .001$; $F_2(2, 78) = 197.21, p < .001$; IO vs. IS, $F_1(1, 23) = 191.76, p < .001$; $F_2(2, 78) = 112.02, p < .001$. By contrast, the two subject-initial conditions did not differ significantly in relatedness: AS vs. IS, $F_1(1, 23) = 1.612, p > .2$; $F_2 < 1$.

In summary, the findings of the questionnaire suggest that the lexical-semantic relatedness between NP1 and the verb was indeed higher in the IO condition than in conditions AS and IS.

Discussion

Experiment 1 investigated whether Mandarin Chinese shows a subject-preference (i.e., a preference for an S/A reading of an initial argument) in simple sentences. To examine this question, we compared the processing of OVS and SVO sentences in a visual ERP study. At the position of the verb, which disambiguated the initial argument towards an object reading in the critical object-initial condition, we observed no signs of reanalysis-related processing difficulty for this condition. Rather, both subject-initial controls showed an N400 in comparison with the critical object-initial condition at this position. At the post-verbal NP, by contrast, the object-initial condition showed a biphasic N400-late positivity pattern in comparison with both controls. This finding, which is corroborated by higher error rates for the

OVS condition on the behavioural task, suggests that the dispreferred OVS order engendered higher processing costs when the post-verbal subject was encountered. In the following, we will discuss the effects observed at the position of the verb and at the position of NP2 in turn.

At the position of the verb, we observed a graded N400 response, with the inanimate subject-initial control condition (IS) showing the largest N400 and the critical object-initial condition (IO) showing the smallest N400. The animate subject-initial condition (AS) elicited an intermediary N400 response. Most generally, the results of the relatedness questionnaire suggest that the finding of an N400 effect for the subject-initial conditions in comparison with the object-initial condition can be accounted for in terms of differences in the lexical-semantic relatedness between NP1 and the verb. Whereas these two constituents were closely related/associated in the IO condition, they were judged to be significantly less closely related in the AS/IS conditions. However, as the two subject-initial conditions did not differ in the questionnaire study, the overall pattern of results at the position of the verb – in which condition IS also engendered a more pronounced N400 than condition AS – cannot be accounted for in terms of relatedness alone. Perhaps, the additional N400 difference between IS and AS is due to differences in the lexical frequency of the verbs used in the two conditions: a preliminary analysis of the individual verb frequencies in the *Modern Chinese Frequency Dictionary* (1986) suggests that the verbs in condition IS were indeed somewhat less frequent than the verbs in conditions AS/IO. However, this analysis is not fully conclusive as a number of the verbs that were used in our materials were not listed in the dictionary (IS: 5 verbs; AS/IO: 14 verbs). Nonetheless, the findings at the position of the verb appear to be parsimoniously accounted for in terms of lexical differences. Hence, it is not clear whether a possible subject-preference might have been obscured by these potentially confounding factors.

In contrast to the somewhat inconclusive findings for the verb position, the effects observed at the position of NP2 attest to the fact that an object-verb-subject order is clearly dispreferred in Chinese. Thus, the critical IO condition engendered an N400-late positivity response in comparison with both control conditions. However, based on the findings of Experiment 1 alone, it is difficult to go beyond the rather global interpretation that condition IO engendered increased processing costs relative to AS/IS, as a more precise functional interpretation of the ERP pattern at NP2 crucially depends on the question of which processing choices were undertaken at the position of the verb. This requires a clarification of the relative role of lexical factors in engendering the graded N400 pattern observed in the present study.

In order to disentangle the relative contribution of lexical and non-lexical factors in eliciting the ERP pattern observed in Experiment 1, we conducted

a second ERP experiment that controlled for the relatedness between NP1 and the verb across conditions.

EXPERIMENT 2

Experiment 2 aimed to examine whether the results of Experiment 1 could be replicated when the degree of relatedness between NP1 and the verb is controlled for. To this end, we constructed new experimental materials by replacing the verbs used in conditions IO/AS in Experiment 1 with verbs showing a 'looser' semantic relationship with their objects (i.e., with NP1 in condition IO). The critical conditions thus resulting are exemplified in Table 4.

By examining sentences of the type in Table 4, Experiment 2 explored whether a reanalysis-related effect can be observed at the verb position for the critical object-initial condition (IO) when differences in lexical-semantic relatedness between the first NP and the verb are ruled out. Furthermore, we aimed to replicate the N400 – late positivity pattern for IO vs. IS/AS at the position of the post-verbal NP.

Relatedness pre-test

In order to ensure that the relatedness between NP1 and the verb was indeed equated across conditions in Experiment 2, we conducted a second relatedness questionnaire for the new materials.

TABLE 4

Example sentences for each of the three critical conditions in Experiment 2. Conditions are abbreviated as for Experiment 1. Note that the materials only differed from those of Experiment 1 in the use of different verbs for conditions IO and AS. Condition IS was identical to Experiment 1.

<i>Example</i>		
<i>Condition</i>	<i>NP1 Verb NP2</i>	<i>Translation</i>
a. IO	*小说理解了演员。	*xiaoshuo lijie-le yanyuan novel understand-ASP actor 'The actor understood the novel.'
b. AS	演员理解了小说。	yanyuan lijie-le xiaoshuo actor understand-ASP novel 'The actor understood the novel.'
c. IS	小说教育了演员。	xiaoshuo jiaoyu-le yanyuan novel educate-ASP actor 'The novel educated the actor.'

Participants. Twenty-four native speakers of Mandarin Chinese residing in Germany took part in the questionnaire study (14 females; mean age: 23.7 years, range: 20–31 years). Participants were students of the Universities of Leipzig and Marburg and the vast majority of them (19) had only been in Germany for approximately one month.

Materials. The 120 critical NP1 – verb pairs used in Experiment 2 were randomly interspersed with 280 filler pairs. The fillers were constructed so as to display varying degrees of relatedness.

Procedure. As for the first questionnaire study, participants judged the relatedness of the word pairs on a 4-point scale (1 = ‘closely related’; 4 = ‘not at all related’).

Results. The mean relatedness ratings obtained for the materials of Experiment 2 are shown in Table 5.

From Table 5, it is apparent that the relatedness between NP1 and the verb was very similar across conditions in the new materials. This impression was confirmed by the statistical analysis, which revealed that the object-initial condition IO did not differ from the two subject-initial conditions (AS/IS). By contrast, the relatedness ratings for the two subject-initial conditions proved to differ marginally. Specifically, the statistical analysis revealed that the main effect of CONDITION only reached significance in the analysis by participants, $F_1(2, 46) = 3.60, p < .04$; $F_2(2, 78) = 1.93, p > .15$. Subsequent pair-wise comparisons showed that condition IO did not differ from the two subject-initial conditions: IO vs. AS, $F_1(1, 23) = 1.25, p > .27$; $F_2(1, 39) < 1$; IO vs. IS, $F_1(1, 23) = 3.19, p > .09$; $F_2(1, 39) = 1.23, p > .27$. However, the relatedness ratings for IS were lower than those for AS, though this difference was only marginal in the analysis by items, $F_1(1, 23) = 5.35, p < .03$; $F_2(1, 39) = 3.24, p < .08$.

TABLE 5
Mean relatedness ratings between NP1 and the verb for the critical conditions in Experiment 2. Standard deviations are given in parentheses.

<i>Condition</i>	<i>Relatedness (SD)</i>
a. IO	2.53 (0.49)
b. AS	2.43 (0.55)
c. IS	2.70 (0.57)

In summary, the relatedness questionnaire revealed that, with the materials used in Experiment 2, condition IO was comparable to the two subject-initial conditions (AS/IS) in terms of lexical-semantic relatedness.

Method

Participants. Twenty-eight monolingually raised native speakers of Mandarin Chinese (Beijing dialect) participated in the experiment after giving informed consent (14 female; mean age 26.1 years; age range 20–34 years). None had participated in Experiment 1. At the time of the experiment, all participants were residing in Leipzig, Germany. Participants were right handed (as assessed by an adapted Chinese version of the Edinburgh handedness inventory; Oldfield, 1971) and had normal or corrected-to-normal vision. Six participants were subsequently excluded from the final data analysis on the basis of excessive EEG artifacts and/or too many errors in the behavioural control task.

Materials. The materials for Experiment 2 were identical to those used in Experiment 1, with the exception that the verbs in conditions IO and AS were replaced (see above for a motivation and Appendix 5 for a list of the verbs). Thus, there were again 120 critical sentences, which were interspersed with 140 fillers.

As for Experiment 1, the verbs in condition IS were again somewhat less frequent than the verbs in conditions AS/IO (IS: 0.00639, IO/AS: 0.02035) according to the *Modern Chinese Frequency Dictionary* (1986). However, the frequency analysis was again not fully conclusive as a number of the verbs that were used in our materials were not listed in the dictionary (IS: 5 verbs; AS/IO: 3 verbs).

Procedure. The experimental procedure, task, and EEG recording parameters were identical to Experiment 1 with the exception that the EEG was amplified by a Neuroscan synamps amplifier (DC-50 Hz) in this experiment.

Data analysis. The behavioural data and the ERP data were analysed as for Experiment 1. As in Experiment 1, less than 10% of all trials were excluded from the ERP analysis due to artifacts or errors in the behavioural task (9.0% for the position of the verb and 8.4% for the position of NP2) and exclusion rates did not differ significantly across conditions.

TABLE 6
 Mean accuracy rates and reaction times for the comprehension task
 in Experiment 2. Standard deviations are given in parentheses.

Condition	Accuracy (%)	RT (ms)
a. IO	95.0 (3.5)	1495.5 (277.7)
b. AS	97.2 (3.8)	1444.3 (257.9)
c. IS	94.5 (5.3)	1521.4 (294.6)

Results

Behavioural data. Table 6 shows the mean accuracy rates and reaction times for the three critical conditions. Standard deviations are given in parentheses.

As in Experiment 1, participants' performance on the comprehension task was very accurate, thus indicating that they processed the sentences attentively and understood them. The statistical analysis of the accuracy rates revealed that the main effect of CONDITION only reached significance in the analysis by participants, $F_1(2, 42) = 3.22$, $p < .05$; $F_2(2, 78) = 1.31$, $p > .27$. Subsequent pair-wise comparisons showed a marginally significant difference between IO and AS in the analysis by participants only, $F_1(1, 21) = 4.63$, $p < .05$; $F_2(1, 39) = 1.28$, $p > .26$, while the difference between IS and AS was significant by participants and marginal by items, $F_1(1, 21) = 7.79$, $p < .02$; $F_2(1, 39) = 4.14$, $p < .05$. There was no difference between conditions IO and IS ($F_1 < 1$; $F_2 < 1$). Thus, participants were more accurate in answering the comprehension task for the animate subject-initial condition AS as opposed to the other two conditions (IO/IS).

For the reaction times, the analysis revealed a main effect of CONDITION, which again only reached significance in the analysis by participants, $F_1(2, 42) = 5.39$, $p < .01$; $F_2(2, 78) = 2.56$, $p < .09$. Pair-wise comparisons showed a significant difference between the two subject-initial control conditions IS and AS, $F_1(1, 21) = 10.71$, $p < .01$; $F_2(1, 39) = 4.55$, $p < .04$, whereas the difference between IO and AS only reached significance in the analysis by participants, $F_1(1, 21) = 5.63$, $p < .03$; $F_2(1, 39) = 2.67$, $p > .11$. There was no difference between IO and IS ($F_1 < 1$; $F_2 < 1$). The reaction times thus showed a very similar pattern to the accuracy rates in that conditions IO and IS engendered slower responses in comparison with condition AS.

ERP data. In the analysis of the ERP data, the two positions of interest in our critical sentences – namely the verb and the second NP – were considered in turn. Statistical analyses were computed in identical time windows to those used in Experiment 1.

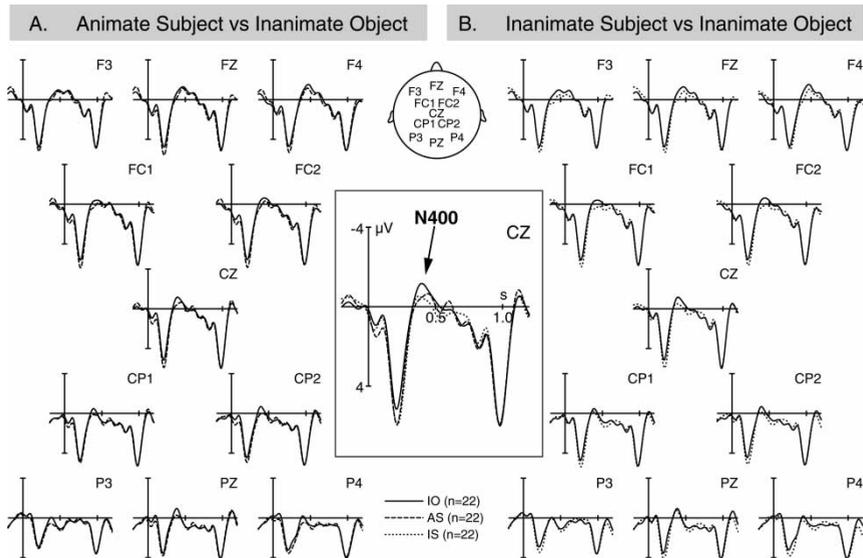


Figure 3. Grand average ERPs ($n=22$) time-locked to the verb (onset at the vertical bar) in the three critical conditions in Experiment 2. Pair-wise comparisons of the critical object-initial condition (IO) and the animate (AS) and inanimate subject-initial (IS) controls are shown in Panels A and B, respectively. The enlarged centre panel shows a direct comparison of all three conditions at one electrode. Negativity is plotted upwards.

Verb

Grand average ERPs at the position of the verb are shown in Figure 3.

As is apparent from Figure 3, condition IO engendered an N400 in comparison with both subject-initial control conditions. In addition, visual inspection suggests that the animate subject-initial condition AS also elicited a small negativity as opposed to the inanimate subject-initial condition IS.

In the 300–550 ms time window, a repeated measures ANOVA revealed interactions of $\text{CONDITION} \times \text{ROI}$ for the lateral, $F(3, 63) = 3.22, p < .02$, and midline electrodes, $F(5, 105) = 3.29, p < .02$. Resolving these interactions by region showed significant effects of CONDITION in both anterior ROIs: left-anterior, $F(1, 21) = 5.65, p < .01$; right-anterior, $F(1, 21) = 4.19, p < .03$, and a marginal effect of CONDITION in the right-posterior region, $F(1, 21) = 2.91, p < .07$. For midline sites, we observed significant effects of CONDITION at FZ, $F(1, 21) = 3.72, p < .04$, and FCZ, $F(1, 21) = 4.37, p < .03$.

Subsequent pair-wise comparisons within the ROIs showing an effect of CONDITION revealed a significant difference between IO and IS within both anterior ROIs: left-anterior, $F(1, 21) = 11.03, p < .01$; right-anterior:

$F(1, 21) = 6.85, p < .02$; and at the midline electrodes: FZ, $F(1, 21) = 6.21, p < .03$, FCZ, $F(1, 21) = 10.55, p < .01$, and CZ, $F(1, 21) = 6.51, p < .02$. By contrast, the difference between IO and AS only reached significance in the right-posterior region, $F(1, 21) = 7.29, p < .02$. Finally, we observed a marginally significant difference between IS and AS in the left-anterior ROI, $F(1, 21) = 5.35, p < .04$.

To summarise, at the position of the verb, the inanimate object-initial condition (IO) engendered significantly more negative ERP deflections than both subject-initial control conditions. Whereas the negativity for IO vs. AS showed a classic N400 distribution (right-posterior), the effect for IO vs. IS was more frontally distributed. In addition, condition AS also showed a marginally significant negativity in comparison with IS in the left-anterior region.

NP2

Figure 4 shows grand average ERPs at the position of NP2.

Visual inspection of Figure 4 suggests that the biphasic N400-late positivity pattern observed for IO in Experiment 1 was replicated in Experiment 2. However, while the late positivity was again observable in comparison with both subject-initial control conditions (AS/IS), condition

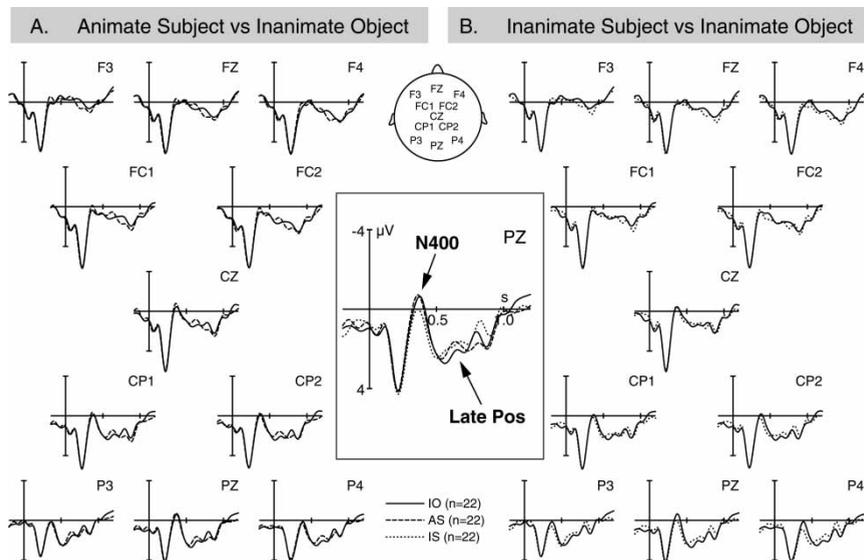


Figure 4. Grand average ERPs ($n = 22$) time-locked to NP2 (onset at the vertical bar) in the three critical conditions in Experiment 2. Pair-wise comparisons of the critical object-initial condition (IO) and the animate (AS) and inanimate subject-initial (IS) controls are shown in Panels A and B, respectively. The enlarged centre panel shows a direct comparison of all three conditions at one electrode. Negativity is plotted upwards.

IO did not differ from condition AS with respect to the N400 in this study. Rather, it appears as though both IO and AS engendered an increased N400 in comparison with IS. Furthermore, it appears that condition IS engendered a very late negativity in comparison with IO and AS.

In the N400 time window (300–450 ms), the statistical analysis revealed interactions $\text{CONDITION} \times \text{ROI}$ for lateral, $F(3, 63) = 4.80, p < .01$, and midline, $F(5, 105) = 3.41, p < .02$, sites. Resolving these interactions by ROI showed significant effects of CONDITION in the right-posterior ROI, $F(1, 21) = 6.26, p < .01$, as well as at the midline electrodes PZ, $F(1, 21) = 5.27, p < .04$, and POZ, $F(1, 21) = 4.38, p < .02$. Pair-wise comparisons in the ROIs showing an effect of CONDITION revealed a significant difference between IO and IS in the right-posterior ROI and at POZ ($F_s > 6.19, p_s < .03$) and a marginal difference between these conditions at PZ, $F(1, 21) = 5.27, p < .04$. In all cases, IO showed a negativity in comparison with IS. The two subject-initial conditions (IS/AS) only differed from one another in right-posterior electrodes, $F(1, 21) = 8.20, p < .01$, with AS more negative than IS. Finally, there was no difference between IO and AS in any region.

The analysis of the late positivity time window (550–750 ms) showed the following results. We observed an interaction $\text{CONDITION} \times \text{ROI}$ for lateral, $F(3, 63) = 3.18, p < .02$, and midline electrodes. For the lateral electrodes, the interaction was due to a marginally significant effect of CONDITION in the right-posterior region, $F(1, 21) = 3.23, p < .08$. With respect to the midline electrodes, we observed a marginal effect of CONDITION at the electrode POZ, $F(1, 21) = 2.78, p < .08$. Pair-wise comparisons between individual conditions within these regions revealed a significant difference between IO and IS in all regions, all $F_s(1, 21) > 5.74, p_s < .03$, while the difference between IO and AS only reached marginal significance in the right-posterior region, $F(1, 21) = 4.34, p < .05$. In all cases, effects were due to a positivity for IO in comparison with IS/AS. The two subject-initial conditions (IS/AS) did not differ from one another in any region.

Finally, for the analysis of the very late negativity, we chose a time window from 750–900 ms. In this time window, the statistical analysis revealed interactions of $\text{CONDITION} \times \text{ROI}$ for both lateral, $F(3, 63) = 3.62, p < .01$, and midline, $F(5, 105) = 4.04, p < .02$, electrode sites. Resolving these interactions by ROI showed significant effects of CONDITION in the right-posterior region, $F(1, 21) = 5.22, p < .01$, and at the midline electrodes PZ, $F(1, 21) = 5.19, p < .01$, and POZ, $F(1, 21) = 5.41, p < .01$. In addition, we observed a marginally significant effect of CONDITION at CPZ, $F(1, 21) = 2.85, p < .07$. Pair-wise comparisons in the ROIs showing an effect of CONDITION revealed a significant difference between AS and IS in all of these regions (all $F_s > 6.15, p < .03$). The difference between IO and IS reached significance at POZ, $F(1, 21) = 4.92, p < .04$, and marginal

significance in the right-posterior region, $F(1, 21) = 3.92$, $p < .07$, while AS and IO did not differ from one another in any region.

In summary, the comparison of IO and IS replicated the findings of Experiment 1, in that IO showed an N400-late positivity pattern in comparison with IS. In comparison with condition AS, by contrast, IO only elicited a late positivity in Experiment 2. In addition to the biphasic pattern that was expected from Experiment 1, Experiment 2 revealed a late posterior negativity for condition IS as opposed to IO and AS.

Discussion

At the position of the verb, which disambiguated our critical conditions towards a subject- or an object-initial order, Experiment 2 revealed an N400 for the object-initial condition (IO) in comparison with both subject-initial control conditions (AS/IS). The difference between IO and AS is particularly revealing as these two conditions employed identical verbs, thereby ruling out lexical differences as a possible source of the effect. We therefore interpret the finding of an N400 for IO vs. AS as a correlate of a reanalysis towards an object-initial reading. This effect, which was obscured by differences in the relatedness between NP1 and the verb in Experiment 1, suggests that Mandarin Chinese shows a subject-preference (i.e., a preference for an S/A reading of the first argument) in simple sentences.

At the position of NP2, we replicated the basic N400 – late positivity pattern for condition IO that had already been observed in Experiment 1. However, in contrast to Experiment 1, the biphasic pattern was only fully observable for the comparison between IO and IS, whereas IO and AS only differed with respect to the late positivity. Thus, both IO and AS engendered an N400 in comparison with IS in Experiment 2. Yet a closer consideration of the statistical analyses reveals that the N400 for AS vs. IS was somewhat less pronounced than that for IO vs. IS, as the latter comparison reached significance in more regions and showed higher F-values. Hence, the N400 response at the position of NP2 was graded in the following manner: IO > AS > IS. This pattern in fact mirrors that observed for the N400 response in Experiment 1: there, the N400 difference between IO and IS reached significance in both posterior ROIs and at several midlines sites, whereas the N400 difference between IO and AS was only observable in the left-posterior region. Thus, in spite of the fact that condition AS generally clustered with condition IO in the N400 time window for NP2 in Experiment 2 and with condition IS in Experiment 1, the overall graded N400 pattern is quite comparable across the two studies. Possible functional interpretations of these results will be discussed in the General Discussion section.

Finally, at the position of NP2, Experiment 2 revealed a late negativity (750–900 ms) for condition IS in comparison with the other two critical

conditions. To determine whether this effect was also present in our first study, in which it had not been as strongly apparent from visual inspection, we reanalysed the ERPs from Experiment 1 within the 750–900 ms time window relative to the onset of NP2. However, while this analysis did reveal an increased negativity for IS, this effect only reached significance between 750 and 800 ms. Thus, the late negativity is only partially consistent across the two experiments. Furthermore, as late negativities of this type are not typically reported in ERP studies of language processing, it is not entirely clear how this effect should be interpreted. Speculatively, it might be related to the processing of a sentence with an inanimate Actor acting upon an animate Undergoer. Indeed, condition IS engendered higher error rates and slower reaction times than condition AS, its subject-initial counterpart with an animate Actor and an inanimate Undergoer. In addition, Demiral (2007) observed an increased N400 effect at the position of the second NP for sentences with an inanimate Actor and an animate Undergoer in Turkish. In view of all of these observations, it appears quite plausible that condition IS should have engendered increased processing costs at NP2 in comparison with the other two critical conditions. However, given that the effect observed here (a late posterior negativity) is not consistent with previous findings (Demiral, 2007) and that it was not fully reliable across both of the present studies, it clearly requires further investigation in future studies. We will therefore refrain from further speculations with respect to possible functional interpretations of this result.

GENERAL DISCUSSION

The present study aimed to examine whether a subject-preference (i.e., a preference for an S/A reading of an ambiguous argument) can be observed in Mandarin Chinese in spite of the controversial status of grammatical relations (e.g., ‘subject’ and ‘object’) in this language. As we wished to avoid the additional influences on processing that might be introduced by the use of complex constructions (e.g., relative clauses), we examined this question using simple NP-V-NP structures. Event-related potentials (ERPs) served as the dependent variable.

In Experiment 1, we observed an N400 response for both subject-initial control conditions (AS/IS) as opposed to our critical object-initial condition (IO) at the position of the disambiguating verb. At the position of NP2, by contrast, the object-initial condition (IO) engendered a biphasic N400-late positivity pattern in comparison with the two subject-initial conditions. Experiment 2 showed that the pattern of results at the verb changes fundamentally when effects of lexical-semantic relatedness between NP1 and the verb are controlled for. Thus, at the verb position, this study revealed

N400 effects for the condition in which NP1 was disambiguated towards an object reading (IO) in comparison with both control conditions (AS/IS). At the position of NP2, Experiment 2 replicated the basic N400-late positivity pattern for condition IO. However, in contrast to Experiment 1, condition AS clustered with IO as opposed to IS in the N400 time window.

In the following, we discuss these two main results (N400 at the verb, biphasic pattern at NP2) in turn, before addressing the consequences of these findings for the characterisation of the subject-preference.

Effects at the position of the verb: Evidence for a subject-preference

When lexical-semantic relatedness between NP1 and the verb was controlled for, the disambiguation towards an object (P) reading of the pre-verbal argument engendered an N400 at the position of the verb. The finding of an N400 for the critical object-initial condition IO as opposed to the animate subject-initial condition AS is particularly conclusive as these two conditions used identical verbs. This comparison therefore serves to exclude a lexically based interpretation of the N400. Hence, we interpret the N400 effect for IO as a correlate of the reanalysis towards an object reading of the initial argument and, thereby, as evidence for the existence of a subject-preference in Chinese (i.e., as evidence for an S/A preference for an initial ambiguous argument). This result of course raises the intriguing question of why a language in which there is no strong evidence for a subject category (i.e., a syntactic correspondence of S and A arguments) might display such a preference. Before turning to this issue, we will discuss the ERP evidence for a subject-preference in a little more detail.

Readers familiar with the ERP literature on sentence comprehension may wonder why a subject-object reanalysis should be reflected in an N400 rather than in a late positivity (P600). However, while syntactic reanalyses were traditionally associated with P600 effects (e.g., Osterhout & Holcomb, 1992, 1993; for a recent review, see Kutas, Van Petten, & Kluender, 2006), subject-object reanalyses have in fact been shown to correlate with N400 effects in a number of recent ERP studies (German: Bornkessel et al., 2004; Haupt, Schlesewsky, Roehm, Friederici, & Bornkessel-Schlesewsky, 2008; Leuckefeld, 2005; Schlesewsky & Bornkessel, 2006; Japanese: Wolff, Schlesewsky, & Bornkessel, 2007). In contrast to the present experiments, all of these previous studies employed grammatical means of disambiguation (e.g., via subject-verb agreement or via case marking), thereby suggesting that the N400 observed here did not simply result from the animacy-based means of disambiguation employed. Furthermore, it appears unlikely that the N400 simply reflected a perceived implausibility: according to our questionnaire pre-test, the verb was equally expected given NP1 in conditions IO and AS in

Experiment 2. Furthermore, given that object topicalisation is a frequent option in Chinese and that the inclusion of fillers ensured that, at the position of the verb, the IO sentences could still plausibly be analysed as a highly acceptable O-V structure, participants should not have adopted an implausible S-V analysis at this point. Indeed, findings from comparable structures in English suggest that, had such an implausible inanimate subject analysis been adopted (e.g., in the sense of ‘The novel was understanding...’), this animacy violation should have been reflected in a P600 effect (e.g., Kuperberg, Kreher, Sitnikova, Caplan, & Holcomb, 2007). In view of all of these observations, we believe that we are justified in interpreting the N400 as a correlate of the reanalysis towards an object-initial reading.

But which properties of the first NP required a revision when the verb was reached? After all, the verb in condition IO not only disambiguated the initial argument to an object reading, but also to a Patient/Theme interpretation. However, it appears unlikely that the effect observed at the position of the verb should be interpreted in terms of a thematically based processing strategy, which assigns the Actor role to the first argument encountered (i.e., a strategy leading to an interpretation of the first argument as the argument primarily responsible for the state of affairs being described). Firstly, the initial arguments in our critical IO condition were inanimate and thereby non-prototypical Actors. Secondly, the results of a recent ERP study (Philipp, Bornkessel-Schlesewsky, Bisang, & Schlewsky, 2008) suggest that there is no principled Actor or Undergoer preference for initial arguments in Mandarin Chinese. This was demonstrated by using *bǎ*- and *bèi*-constructions, which allow for unmarked verb-final orders via the insertion of the coverbs *bǎ* and *bèi* between NP1 and NP2. Crucially, the interpretation of the arguments is determined by the choice of coverb. Whereas the *bǎ*-construction instantiates an Actor-Undergoer-Verb order, the *bèi*-construction is often described as a ‘passive’ in that the first argument is interpreted as the Undergoer of the event, while the second argument is the Actor (Li & Thompson, 1981). In addition to *bǎ* vs. *bèi*, Philipp and colleagues manipulated the animacy of NP1 and NP2. By means of this experimental design, they investigated whether an initial argument is preferentially interpreted as an Actor in Chinese, in which case a reanalysis effect should be observable when the coverb *bèi* is encountered. Alternatively, if the interpretation of an initial NP is determined by its animacy (such that an animate NP is preferentially interpreted as an Actor, while an inanimate NP is preferentially analysed as an Undergoer), an interaction of animacy of NP1 and type of coverb should be observable. However, Philipp et al.’s data did not support either of these scenarios. Rather, they suggested that, independently of animacy, an initial argument in Mandarin Chinese is interpreted neither as an Actor nor as an Undergoer. Preferences with respect to Actor- and Undergoerhood only become observable at the

position of NP2, when the two arguments must be related to one another. These findings therefore support the claim that the N400 observed for condition IO at the position of the verb does not reflect a thematic revision.

Given that thematically based processing preferences don't seem to account for our findings, how do other accounts of the subject-preference fare? Assuming that the base position of an object is indeed behind the verb in Chinese, de Vincenzi's (1991) Minimal Chain Principle (MCP) can derive the finding of a subject-preference in our data. An analysis of the initial NP as a subject (with a base position in front of the verb) rather than as a topicalised object serves to create a more minimal chain. However, since many scholars have questioned the idea of structural asymmetries between subjects and objects in Chinese (see the introduction), an MCP-based analysis of our results would require an additional justification of this crucial representational assumption.

An alternative explanation is offered by the minimal event account (Bornkessel & Schlesewsky, 2006; Demiral et al., 2008). From this perspective, an initial ambiguous NP is preferentially analysed as the sole argument of an intransitive relation. When the verb in our critical IO condition is subsequently reached, a reanalysis towards a transitive reading is required. Moreover, within this transitive relation, the preverbal NP must be associated with the argument that does not correspond to the sole argument in an intransitive relation (i.e., it corresponds to the more Patient-like argument of the transitive event). However, similarly to the additional structural assumptions required by an MCP-based explanation, a minimal event-based derivation of the Chinese findings would need to account for the fact that a revision/extension from an S reading (i.e., an analysis as the only argument of a minimal event) to an A reading (i.e., an analysis as the more Agent-like argument of a transitive event) is less costly than the revision/extension to a P reading (i.e., an analysis as the more Patient-like argument of a transitive event).

Thus, both the MCP and the minimal event approach are, in principle, capable of deriving our findings, though additional assumptions are required in both cases. We shall return to a more detailed discussion of these two explanations in the section on consequences for the characterisation of the subject-preference below.

Effects at the position of NP2: Evidence for a structural preference against OVS

At the position of NP2, the critical IO condition engendered a biphasic N400-late positivity pattern in comparison with the (lexically identical) IS condition in both experiments. The late positivity was also observable in both studies when IO was compared with AS (i.e., to the control condition with an identical meaning). With regard to the N400, however, AS clustered

with IS in the first experiment and with IO in the second, though both studies revealed the following overall trend with regard to N400 amplitude: IO > AS > IS. In the following, we first discuss possible functional interpretations for the biphasic pattern for the critical object-initial condition IO, before turning to the question of why condition AS showed a different pattern of results across the two experiments.³

Firstly, the observation of a late positivity in condition IO appears relatively straightforward. Late positive ERP effects ('P600s') are typically observed in response to dispreferred disambiguations, syntactically complex or ill-formed structures (Friederici, Mecklinger, Spencer, Steinhauer, & Donchin, 2001; Hagoort et al., 1993; Kaan, Harris, Gibson, & Holcomb, 2000; Osterhout & Holcomb, 1992; Osterhout, Holcomb, & Swinney, 1994). The P600 has also been linked to a more general sense of 'conflict monitoring' during language processing (Kolk, Chwilla, van Herten, & Oor, 2003; Vissers, Chwilla, & Kolk, 2006). From this perspective, the observation of a late positivity at NP2 is not at all surprising, as this is the position that renders the sentences in condition IO unacceptable.

Though P600 effects have recently also been observed for the processing of semantically implausible sentences (Hoeks, Stowe, & Doedens, 2004; Kim & Osterhout, 2005; Kolk et al., 2003; Kuperberg, Sitnikova, Caplan, & Holcomb, 2003), a 'semantic P600' interpretation does not appear to lend itself to the present findings. Notably, our participants' performance on the comprehension task indicates that they did not assign an implausible SVO interpretation to the sentences in condition IO: accuracy rates were over 90% for this condition in both experiments. As the comprehension task included questions in both active and passive form, this high accuracy rate could not have resulted from a simple linear matching strategy between the constituents of the experimental sentence and those of the comprehension question. Rather, participants must have understood the sentences in order to perform the comprehension task correctly (and only trials for which the task was performed correctly entered the data analysis). In this way, our results stand in contrast to those of the studies reporting 'semantic P600' effects, in which the critical sentences were judged to be implausible.

In view of these observations, we interpret the late positivity observed at NP2 in condition IO as a correlate of *ill-formedness* detection (see also Bornkessel & Schlewsky, 2006).

³ Note that, since NP2 was also the sentence-final constituent in both experiments, it cannot be excluded that the ERP effects observed at this position were partly influenced by processes of sentence wrap-up. However, sentence wrap-up in and of itself clearly cannot explain the more fine-grained modulations of the overall component pattern between Experiment 1 and Experiment 2.

Turning now to the N400 for condition IO at NP2, this additional finding appears somewhat less expected from the perspective of standard processing accounts. As already outlined with respect to the late positivity, an implausibility based explanation of this effect appears unlikely in view of the fact that our participants understood the sentences correctly. We would thus like to propose an alternative interpretation based on previous observations in other languages. Consider the following examples from German, which Bornkessel, Fiebach, & Friederici (2004) examined in an ERP study.

- (8) Herbert fragte sich, ...
 Herbert wondered ...
- a. ... welcher Autor ... den Senator kritisierte.
 ... [which author]_{NOM} ... [the senator]_{ACC} criticised
 '... which author criticised the senator.'
- b. ... welchen Autor ... der Senator kritisierte.
 ... [which author]_{ACC} ... [the senator]_{NOM} criticised
 '... which senator criticised the author.'

At the position of the second argument in sentences such as (8a/b), Bornkessel et al. (2004) observed increased processing costs in the form of an N400 for (8a) vs. (8b), i.e., for the *canonical* subject-before-object order in comparison with the object-initial order. This facilitation for the object-initial structure can be interpreted as a consequence of differences in the predictability of the second argument: an initial nominative is compatible with both an intransitive and a transitive continuation but, via least-effort considerations, is analysed as the sole argument of an intransitive event (Bornkessel & Schleewsky, 2006; Gibson, 1998; Schleewsky & Friederici, 2003). An initial accusative, by contrast, unambiguously calls for a transitive interpretation and, thereby, for a second argument. Thus, the second argument is predicted in the accusative-initial sentence (8b) and its processing is thereby facilitated in comparison with the second argument in the nominative-initial sentence (8a).

A similar line of argumentation can be applied to the present findings. In condition IO, the processing system does not expect to encounter an additional argument after the verb, since this would render the structure ungrammatical. Thus, when a second argument is encountered post-verbally, the processing system must revise its assumption that only one of the two arguments in the transitive relation is overtly expressed. From this perspective, the N400 at the position of NP2 might either reflect the increased effort required to process an unpredicted argument or costs of the additional referential specification of a subject that was previously thought to be unexpressed.

These ideas also provide a possible avenue of explanation for the pattern of results in the animate subject-initial condition AS. Recall that, while this

condition essentially showed an intermediary N400 effect between those in conditions IO and IS in both experiments, it clustered more strongly with IS in Experiment 1 and with IO in Experiment 2. Why should the preferred subject-initial condition with an animate subject and an inanimate object have shown an N400 in Experiment 2? Assuming, as argued above, that the N400 at this position reflects the degree of expectedness of the second argument, the data suggest that the object argument was less expected in Experiment 2 than in Experiment 1 for condition AS. This very likely resulted from the critical change in materials between the two studies: recall that, in order to equate the lexical-semantic relatedness between NP1 and the verb in conditions AS and IO, we loosened the relationship between the object and the verb when constructing the sentence materials for Experiment 2. Thus, by this very fact, the post-verbal object in condition AS was less expected in Experiment 2. In the same way as for condition IO, this relatively general line of explanation could be specified further in at least two different ways: either, the processing system did not predict an object at all in condition AS in Experiment 2, or there was simply no expectation for a *particular* object or class of objects (in contrast to Experiment 1). However, these two possibilities cannot be teased apart on the basis of the present materials.

Most generally, the observation of a similar N400 effect in conditions IO and AS lends further support to the assumption that the N400 observed for IO does not reflect the processing of an ill-formed or implausible structure. If this were the case, it would be very difficult to explain why this type of effect was also observed for the highly preferred animate subject-initial condition AS. As indicated above, the different proposals for a more fine-grained functional interpretation of the N400 effects observed here will need to be contrasted in future studies. However, we presently favour the explanation based on the idea of reference specification, as this provides a coherent explanation for the N400 effects in both critical conditions. Neither IO nor AS allows for a clear specification of the post-verbal NP before this constituent is actually encountered in the input. In IO, this is the case because the processing system assumes a structure with a dropped subject. In AS, by contrast, it results from the fact that the verb is not closely associated with a particular object. In this way, we can derive a coherent explanation for the N400 across both experiments: the second NP always calls for an additional referential specification in IO, but for AS this depends on how strongly the verb predicts a particular object.

Consequences for the characterisation of the subject-preference

The present findings from Chinese add a further important piece to the cross-linguistic puzzle concerning the subject-preference, i.e., the preference

for an S or A reading of an initial ambiguous argument. Assuming that the observations of a subject-preference in different languages all reflect a similar underlying processing strategy – which would appear to be the most parsimonious interpretation – the consequences of the present findings can be described as follows. Firstly, recall from the introduction that filler-gap-based approaches do not provide a cross-linguistically adequate explanation of the subject-preference. This was demonstrated on the basis of Turkish (Demiral et al., 2008), in which an initial ambiguous argument can be in its base position (i.e., require a zero chain) under both a subject and an object analysis. Findings from Japanese (Wolff et al., 2007) attest to the cross-linguistic stability of this result. In view of the problems faced by a filler-gap approach in languages such as Turkish and Japanese, the most plausible remaining account of the subject-preference across languages appears to be constituted by the minimal event-based explanation (Bornkessel & Schlewsky, 2006; Demiral et al., 2008). From this perspective, an initial argument is preferentially analysed as the sole argument in an intransitive relation (for converging support from language typology, see DuBois' Preferred Argument Structure principle; DuBois, 1987; DuBois, Kumpf, & Ashby, 2003). A revision of this intransitivity assumption is costly (see the discussion of example 8 for converging evidence), with processing costs increasing even further when the role of the ambiguous argument in the transitive relation is not the one corresponding to the sole argument in an intransitive relation in the language under consideration. Hence, disambiguation towards an object reading (i.e., towards a P argument) is costly in Germanic and Romance languages, Turkish, and Japanese, because these all involve an {S,A} correspondence (see the Introduction).

In this context, the findings from Chinese become highly relevant. As outlined in the introduction, the correspondence between S and A arguments is not nearly as strong in Chinese as in the other languages referred to above, as correspondences between S and P arguments are also allowed under many circumstances (e.g., in coordinations). Nevertheless, like the languages examined previously, Chinese shows a subject-preference for an initial ambiguous argument in a simple sentence. This finding suggests that the correspondence between S and A arguments *does* play an important role during online processing in Chinese, in spite of the fact that it is not dominant when the descriptive facts of the language are considered. (Note again that, while a filler-gap-based explanation like the Minimal Chain Principle could also account for the existence of a subject-preference in Chinese – at least under the assumption that subjects and objects can be distinguished structurally in this language – we do not favour this type of account because it encounters problems in other languages, e.g., Turkish, Japanese.)

Yet why should Chinese favour a correspondence between S and A arguments *only* during online processing? In other words: Why should the

processing behaviour of Chinese be more conservative than the descriptive facts of the language? There appear to be two possible explanations for this observation. Firstly, recall from the introduction that several authors have argued for a correspondence between S and A arguments (i.e., for the relevance of a 'subject' category) in several limited domains in Chinese. Thus, this remaining correspondence between the sole argument of an intransitive clause and the more Agent-like argument of a transitive clause might serve to drive comprehension.

Alternatively, it might be the case that the possibility of overriding the {S,A} correspondence (e.g., via pragmatic influences) is a relatively 'late' process. From this perspective, the processing system would first apply a relatively simple, cross-linguistically applicable processing strategy, namely the preference for minimal events (together with the assumption that, in case an extension to a transitive reading is required, the S argument corresponds to the A argument in the transitive clause). However, in contrast to the other languages examined with respect to the subject-preference to date, Chinese allows for this initial preference to be overridden by additional information.⁴ The predictions of such an account could be tested by examining the subject-preference in further structures in Chinese. Thus, if this explanation is correct, we should also expect to find an initial preference for an {S,A} vs. {S,P} correspondence in conjoined clauses during online processing (i.e., an initial preference for 5b over 5a), though this is then overridden by very strong pragmatic preferences at a later point. Though speculative at present, the scenario that Chinese might not differ from other languages with respect to its initial processing choices, while liberally allowing these to be overturned by semantic or pragmatic preferences, constitutes an intriguing new scenario for the derivation of cross-linguistic differences.

To summarise, the finding of a subject-preference in Mandarin Chinese provides further converging support for the assumption that the subject-preference might be a universal strategy of ambiguity resolution during online language comprehension. Based on all available cross-linguistic facts, however, we have argued that the preference for a 'subject' reading of an initial ambiguous argument arises as an epiphenomenon of the tendency to assume minimal (i.e., intransitive) events and, if an extension to a transitive event is required, to assume a correspondence between the sole argument of the previously assumed intransitive event and the more Agent-like argument of the transitive event. Thus, in contrast to what we have previously assumed, the processing system appears to prefer an {S/A}-correspondence when

⁴ This would, in fact, appear to make for a relatively efficient overall processing strategy: minimal event-based processing decisions can be made locally (i.e. when no information is available beyond the ambiguous argument itself), whereas pragmatically-based processing choices will typically require further intra-sentential information.

extending from an intransitive to a transitive event even when the surface behaviour of the language under consideration provides only very little evidence for such a correspondence. Future research will need to determine whether this processing strategy results from the small number of phenomena that arguably display a subject/object asymmetry in Chinese or whether it should rather be viewed as a true universal of online language processing.⁵

CONCLUSIONS

The present ERP results suggest that Chinese shows a subject-preference for a single initial argument in simple sentences. As suggested by previous empirical findings, this preference cannot be reduced to a thematic interpretation strategy (Philipp et al., 2008). We have therefore argued that, cross-linguistically, the subject-preference is best accounted for in terms of a tendency to analyse an initial argument as the sole participant in an intransitive event. A revision of this preferred analysis towards a transitive reading is always costly, but even more so when the ambiguous argument must be assigned an argument role that does not correspond to that of the single argument in an intransitive event. Strikingly, during online processing, Chinese also shows this tendency for a preferred correspondence between the sole argument of an intransitive event (S) and the more Agent-like argument of a transitive event (A) in spite of the fact that correspondences with the more Patient-like argument (P) are also possible in the language. We have speculated that this overall data pattern might be accounted for by the early (local) application of a universal {S,A}-preference, which, in Chinese, may be overridden by more global pragmatic considerations at a later point in time. Most generally, the present findings suggest that the subject-preference may indeed constitute a universal strategy of ambiguity resolution in language comprehension. However, rather than assigning any 'subject'-specific properties, this strategy is best described as an epiphenomenon of relatively general, economy-based processing considerations.

⁵ The seemingly radical claim that the language processing system might universally show an initial (early/local) {S/A}-preference appears to receive some support from typological patterns of language change. Thus, it has been observed that there is a higher likelihood for an ergative {S/P} pattern to change into an accusative {S/A} pattern than vice versa (e.g., Nichols, 1993, 2003). This tentatively suggests that there may be a 'deeper' basis to the {S/A}-preference.

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APPENDIX

1. Initial NPs in conditions IO/IS (Experiments 1 and 2)

小说(xiaoshuo, novel)	电影(dianying, film)	西装(xizhuang, suit)
雕像(diaoxiang, statue)	考分(kaofen, score)	故障(guzhang, problem)
电脑(diannaο, computer)	报纸(baozhi, paper)	手机(shouji, mobile phone)
股票(gupiao, stock)	化石(huashi, fossil)	设备(shebei, equipment)
婚礼(hunli, wedding)	档案(dang'an, document)	房屋(fangwu, house)
剧本(juben, script)	美金(meijin, dollar)	垃圾(laji, rubbish)
宫殿(gongdian, palace)	灰尘(huichen, dust)	诗词(shici, poem)
首饰(shoushi, jewelry)	石头(shitou, stone)	头发(toufa, hair)
会议(huiyi, meeting)	邮件(youjian, mail)	照片(zhaopian, photo)
炸药(zhayao, bomb)	毒酒(dujiu, poison wine)	肿瘤(zhongliu, tumor)
汽车(qiche, car)	摩托(motuo, motor)	军舰(junjian, warship)
政策(zhengce, policy)	蛋糕(dangao, cake)	财产(caichan, property)
飞机(feiji, plane)	日历(rili, calendar)	闹钟(naozhong, alarm clock)
中药(zhongyao, chinese medicine)		

2. Initial NPs in condition AS (Experiments 1 and 2)

演员(yanyuan, actor)	同学(tongxue, classmate)	学生(xuesheng, student)
秘书(mishu, secretary)	男孩(nanhai, boy)	局长(juzhang, general director)
专家(zhuangjia, expert)	教授(jiaoshou, professor)	保镖(baobiao, bodyguard)
大款(dakuan, Millionaire)	农民(nongmin, farmer)	厂长(changzhang, director)
朋友(pengyou, friend)	律师(lüshi, lawyer)	师傅(shifu, instructor)
诗人(shiren, poet)	老板(laoban, boss)	司机(siji, driver)
皇帝(huangdi, emperor)	公主(gongzhu, princess)	老人(laoren, old man)
太太(taitai, Madam)	学者(xuezhe, scholar)	模特(mote, model)
经理(jingli, manager)	疯子(fengzi, loony)	记者(jizhe, journalist)
会计(kuaiji, accountant)	作家(zuojia, writer)	店主(dianzhu, shop owner)
球迷(qiumi, football fan)	保姆(baomu, nanny)	将军(jiangjun, general)
校长(xiaozhang, headmaster)	孤儿(gu'er, orphan)	凶手(xiongshou, murderer)
爷爷(yeye, grandfather)	队员(duiyuan, member)	警察(jingcha, police)
园丁(yuanding, gardener)		

3. Verbs in condition IS (Experiments 1 and 2)

教育了(jiaoyu-LE, educated)	逗乐了(doule-LE, amused)
打击了(daji-LE, upset)	鼓励了(jili-LE, encouraged)
愚弄了(yunong-LE, fooled)	吸引了(xiying-LE, attracted)
伤害了(shanghai-LE, hurt)	启发了(qifa-LE, inspired)
困扰了(kunrao-LE, troubled)	激怒了(jinu-LE, exasperated)
安慰了(anwei-LE, comforted)	惊吓了(jingxia-LE, surprised)
警告了(jinggao-LE, alarmed)	恐吓了(konghe-LE, threatened)
折磨了(zhemo-LE, tortured)	撞伤了(zhuangshang-LE, injured)
支持了(zhichi-LE, supported)	引诱了(yingyou-LE, charmed)
帮助了(bangzhu-LE, helped)	提醒了(tixing-LE, reminded)

4. Verbs in conditions IO/AS in Experiment 1

阅读了 (yuedu-LE, read)	观看了(guankan-LE, watched)
试穿了(shichuan-LE, tried on)	摆放了 (baifang-LE, placed)
计算了(jisuan-LE, graded)	检查了(jiancha-LE, examined)
安装了(anzhuang-LE, installed)	订阅了(dingyue-LE, subscribed)
购买了(goumai-LE, bought)	抛售了(paoshou-LE, sold)
发现了(faxian, discovered)	采购了(caigou-LE, purchased)
筹备了(choubei-LE, prepared)	查看了(chakan-LE, looked up)
装修了(zhuangxiu-LE, decorated)	修改了(xiugai-LE, modified)
积攒了 (jizan-LE, saved)	搬运了(banyun-LE, moved)
建造了(jianzao-LE, built)	清扫了(qingsao-LE, cleared)
背诵了 (beisong-LE, recited)	设计了(sheji-LE, designed)
收藏了(shoucang-LE, collected)	挑染了(tiaoran-LE, colored)
参加了(canjia-LE, attend)	编写了(bianxie-LE, edited)
携带了(xiedai-LE, brought)	冲洗了(chongxi-LE, developed (a film))
调制了(tiaozhi-LE, mixed)	切除了(qichu-LE, cut away)
擦洗了(caxi-LE, cleaned)	修理了(xiuli-LE, repaired)
调遣了(diaoxian-LE, assigned)	制定了(zhiding-LE, made (policy,law))
品尝了(pinchang-LE, tasted)	霸占了(bazhan -LE,occupied)
服用了(fuyong-LE, drank)	驾驶了(jiashi-LE, drove)
撕破了(sipo-LE, tore something up)	设置了 (shezhi, set up)

5. Verbs in conditions IO/AS in Experiment 2

理解了(lijie-LE, understood)	思考了(sikao-LE, thought about)
偷窃了(touqie-LE, stole)	观察了(guancha-LE, observed)
质疑了(zihyi-LE, doubted)	总结了(zongjie-LE, summarized)
介绍了(jieshao-LE, introduced)	期待了(qidai-LE, looked forward to)
寻找了(xunzhao-LE, searched)	提供了(tigong-LE, provided)
测量了(celiang-LE, measured)	询问了(xunwen-LE, questioned)
反对了(fandui-LE, objected to)	得到了(dedao-LE, gained)
比较了(bijiao-LE, compared)	携带了(xiedai-LE, brought)
准备了(zhunbei-LE, prepared)	隐藏了(yincang-LE, hid)
眺望了(tiaowang-LE, looked over)	发现了(faxian-LE, discovered)
了解了(liaojie-LE, knew about)	打听了(dating-LE, sounded)
出售了(chushou-LE, sold)	炫耀了(xuanyao-LE, flaunted)
知道了(zhidaole-LE, knew)	朗读了(langdu-LE, read loudly)
相信了(xiangxin-LE, believed)	分类了(fenlei-LE, grouped)
包装了(baozhuang-LE, packaged)	否认了(fouren-LE, denied)
谈论了(tanluan-LE, talk about)	辨认了(bianren-LE, identified)
购买了(goumai-LE, bought)	忽视了(hushi-LE, ignored)
接受了(jieshou-LE, accepted)	听说了(tingshuo-LE, heard about)
放弃了(fangqi-LE, gave up)	尝试了(changshi-LE, tried)
注意了(zhuyi-LE, noticed)	摆弄了(bainong-LE, played)