

Structural position affects topic transition

An eye-tracking study

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In an eye-tracking study, we used Chinese double-subject construction [NP_a NP_b PREDICATE] (e.g., [nage jiezhì]_{NP_a} [sheji]_{NP_b} [hèn tiē]_{PREDICATE} ‘that ring design very special’) in a concessive construction like *suiran...dan...* ‘although...but...’ to investigate how the syntactic position of the topic NP (i.e., *that ring*) affects the comprehension of topic transition in the subsequent clause. We contrasted topics located at a higher pre-connective topic position (e.g., *that ring although*) and those located at a post-connective subject position (e.g., *although that ring*). Topic transition was manipulated as either using a subtopic (e.g., *workmanship of that ring*) or a new topic (e.g., *the wedding dress*) in the second clause of concession. We found a main effect of topic transition in a batch of eye-movement measures showing that subtopic transition was preferred over new-topic transition. More importantly, we found interactions on total reading time and total fixations at the topic-*suiran* region and on total fixations at the post-critical region, with post hoc tests revealing a larger cost of topic transition in the high-topic condition than in the low-topic condition. The results suggest that when a topic NP is located at a higher topic position (i.e., above the connective), it binds the topics of both clauses and induces greater cost when the topics do not form a consistent chain. When the topic NP is located at a local (i.e., post-connective) position, the processing of topic shift or resolution of topic conflict in the second clause is less costly because the second topic is not syntactically bound by the higher topic. Together, the results support a prominent status of the before-connective position in Chinese discourse. Furthermore, they indicate that syntactically induced topicality constrains the processing of topic transition in the subsequent discourse.

Keywords: topicality, topic shift, concession, double-subject construction

1. Introduction

Effective communication relies on the systematic organization and successful transfer of information. One important notion associated with information processing is topic, the most salient discourse element that indicates what an utterance is about (Chafe 1976; Reinhart 1981; Gundel 1988).

During discourse comprehension, changes in topic can trigger comprehenders to shift and build a new mental representation (O'Brien et al. 1986; Binder & Morris 1995; Gernsbacher 1995, 1997). Studies have shown that when processing expository texts—a genre that requires readers to represent the major topics of the text and their relationships—increased reading time is spent on sentences that introduce a new topic than those that continue the topic of preceding sentences (Robert F. Lorch et al. 1985, 1987; Elizabeth P. Lorch et al. 1987; Hyönä 1994, 1995). A similar topic shift effect is observed in narrative texts where sentences at episode boundaries are allocated more reading time than the within-episode sentences (Haberlandt 1980; Haberlandt et al. 1980). More recently, event-related potential (ERP) studies have consistently reported a late positivity effect on topic-shift conditions, reflecting discourse updating due to the introduction of a new topic (Hirotani & Schumacher 2011; Hung & Schumacher 2012, 2014; Wang & Schumacher 2013; Xiaohong Yang et al. 2013). It is therefore suggested that processing topic shift is more costly than topic continuation, as additional cognitive resources need to be spent to encode a new topic (or episode) and to activate a new “substructure” in which the subsequent information is to be organized (e.g., Hyönä 1994, 1995; Gernsbacher 1995, 1997; Hyönä et al. 2003).

Being a central element for presenting information in discourse, topic can be established by context such as questions as well as being marked by linguistic devices such as discourse markers. Contextually induced topicality affects the processing of subsequent discourse. For instance, a topic context like “what about X” in (1a) facilitates the comprehension of stories containing non-canonical word order in German that involves topicalization like (1b) (Burmester et al. 2014), and a topic-inducing structure like the *wh* question in (2a) facilitates the resolution of the initial ambiguity at *photographer* in coordinated structures like (2b) (Hoeks et al. 2002).

- (1) a. Topic context
 “The owl and the hedgehog have set up an easel in the park. What about the owl?”
- b. Critical sentence with an OS (non-canonical) word order
 “The owl, the hedgehog paints in the park.” (Burmester et al. 2014)

- (2) a. Topic context
 “What did the model and the photographer do?”
 b. Critical sentence with an initial ambiguity at *photographer*
 “The model embraced the designer and the photographer...”
 (Hoeks et al. 2002)

Similarly, Hung & Schumacher (2012) use *wh*-questions like “what about X” to set up X as the topic in Chinese. When a topic is set up in the context like (3a), ERP responses at the topic position in the target sentence (i.e., *Zhangsan* in (3b)) in the topic-shift condition (i.e., *Lisi* being set up as the topic in (3a)) showed a larger late positivity effect in addition to a pronounced negativity (N400) than the topic-continued condition (i.e., *Zhangsan* being set up as the topic in (3a)). However, when no topic is set up in the context as in (4a), the initial name in the target sentence (i.e., *Zhangsan* in (4b)) introduces a novel topic and elicits only an N400 effect but no late positivity effect, which suggests a different late-stage integration of a novel topic (eliciting only an N400 effect) from that of a shifted topic (eliciting an N400 effect followed by late positivity).

- (3) a. Topic context
 張三_{Topic} / 李四_{Topic} 怎麼 了?
Zhangsan / Lisi zenme le?
 Zhangsan/Lisi what PAR
 ‘What about Zhangsan/Lisi?’
 b. Target sentence
 張三_{Topic} 李四 毆打了。
Zhangsan Lisi ouda le.
 Zhangsan Lisi beat PAR
 ‘Lisi beat Zhangsan.’
- (4) a. Non-topic context
 怎麼 了?
zenme le?
 What PAR
 ‘What happened?’
 b. Target sentence
 張三_{Topic} 李四 毆打了。
Zhangsan Lisi ouda le.
 Zhangsan Lisi beat PAR
 ‘Lisi beat Zhangsan.’

(Hung & Schumacher 2012)

Chinese, being a topic-prominent language (Li & Thompson 1976; 1981), uses several devices to identify topics. Topics can be indicated by “pause particles” like *-a* (*-ya*), *-ne*, *-me*, *-ba* as in (5) (Li & Thompson 1976; 1981; Tsao 1979; Shyu 2014), as well as special word orders transposing a lower NP leftward to a periph-

eral position as in (6) (Huang et al. 2009). As illustrated below, the topic in (5), i.e., *Laowang*, is marked by a particle *-a*, and *jiaoxiangyue* ‘symphony’ in (6) is a topic derived by movement and associated with an empty category (e.g., a gap) in the comment clause.

- (5) 老王 啊，他很 善良。
Laowang a ta hen shanliang.
 Laowang TOP he very kind-hearted
 ‘Laowang, he is kind-hearted.’
- (6) 交響樂_i， 我很 喜歡 *e_i*。
jiaoxiangyue wo hen xihuan e.
 symphony I very like
 ‘I like symphony.’

Additionally, in a double-subject construction [$NP_a NP_b$ PREDICATE], as Li & Thompson (1976; 1981) point out, NP_a serves a topic that holds a part-whole relation with NP_b . For example, in (7), *nage jiezhi* ‘that ring’ (i.e., NP_a) is the topic of the sentence, and the second NP *sheji* ‘design’ holds a possessive part-whole relation with the topic NP of the sentence. The possessor argument is indicated as X in (7). The whole sentence is about the ring, and the comment clause, made of NP_b (*sheji* ‘design’) and a predicate, describes one of its features. Together, NP_b and the predicate form the comment of the topic. Aligned with Chafe (1976), Li & Thompson (1976; 1981) suggest a “framework-setting” function of topics such that a topic like *nage jiezhi* ‘that ring’ in (7) sets a framework to indicate what the sentence is about.

- (7) 那個戒指_i(NP_a) [設計(x_i) $_{NP_b}$ 很特別 $_{predicate}$]comment。
nagejiezhi sheji hentebie.
 that ring_i design(x_i) very special
 ‘That ring, its design is very special.’

When multiple clauses are conjoined by connectives, integrating the subtopics inside each clause into a more general discourse model is necessary for achieving a global understanding of the discourse information. An ERP study on Chinese found that when an NP is syntactically topicalized to the position before the connective *yinwei* ‘because’, it constrains pronoun resolution in the discourse to a greater extent than when the NP appears after the connective (Xu & Zhou 2016). See (8) for a topic structure where *Wangyu* is the topic above the connective *yinwei* ‘because’ and (9) for a non-topic structure where *Wangyu* serves a subject and appears after the connective. In either sentence, *Wangyu* is a male name and *Liwei* a female name. The pronoun in the second clause indicates either a continuous topic using *he* or a shifted topic using *she*.

- (8) 王宇 因為 擔心 李薇，所以 他/她 堅持 二十四 小時
Wangyu yinwei danxin Liwei, suoyi ta/ta jianchi ershisi xiaoshi
 Wangyu because worry Liwei so he/she insist twenty four hours
 開機。
kaiji.
 keep phone on
 ‘Because Wangyu worries about Liwei, (so) he/she keeps a 24-h phone access.’
- (9) 因為 王宇 擔心 李薇，所以 他/她 堅持 二十四 小時
yinwei Wangyu danxin Liwei, suoyi ta/ta jianchi ershisi xiaoshi
 because Wangyu worry Liwei so he/she insist twenty four hours
 開機。
kaiji.
 keep phone on
 ‘Because Wangyu worries about Liwei, (so) he/she keeps a twenty-four hour
 phone access.’ (Xu & Zhou 2016)

Xu & Zhou (2016), using ERPs, found stronger and earlier late positivity for the topic-shifting female pronoun than the topic-continuing male pronoun in (8), but almost indistinguishable late positivity between the subject-shifting female pronoun and subject-continuing male pronoun in (9). In addition, a direct comparison between the topic-shift condition (i.e., the female pronoun in (8)) and the subject-shift condition (i.e., the female pronoun in (9)) showed larger late positivity responses in the former case. They suggest that a pre-connective topic has a privileged cognitive status and provides a referential framework with respect to which the predication is evaluated. In this case, a pronoun referring to a non-topic object NP disrupts the sentence comprehension process and causes processing difficulty. A subject, in contrast, only controls the local selectional relation with the verb, which exerts less influence on the processing of the subsequent discourse.

While Xu & Zhou (2016) have suggested a prominent status of the pre-connective topic in *causal* relations using *yinwei* ‘because’, whether it can be extended to other discourse relations remains to be investigated. For example, different from a causal relation that describes a cause-consequence relation between events, a concessive relation indicates a conflict between events described in the two clauses (Xing 2001). Like the causal clause, the concessive clause in general precedes the main clause, as in (10) and (11) (Pan & Paul 2018). The concessive relation in (10) describes a negated/canceled causal relation between being tall (cause) and being good at playing basketball (consequence) (König 1991). On the other hand, the example in (11) illustrates an “indirect” concessive relation in which the two clauses form a contrastive relation (Lakoff 1971; Azar 1997; Izutsu 2008), which involves a transition of topics in discourse.

- (10) 雖然 他很高，但不擅長打籃球。
suiran ta hen gao, dan bu shanchang da lanqiu.
 although he very tall but not good at play basketball
 'Although he is tall, he is not good at playing basketball.'
- (11) 雖然 他很高，但弟弟很矮。
suiran ta hen gao, dan didi hen ai.
 although he very tall but brother very short
 'Although he is tall, his brother is short.'

When a double-subject construction is embedded in a concessive clause as in (12), the NP2 in the *dan* 'but' clause can involve topic shifting that is contrastive to either the general topic (e.g., *that ring*) or the sub-topic in the topic chain (e.g., *its design*). That is, NP2 can be either a completely new topic, e.g., *the wedding dress*, contrasting with the topic NP of Clause 1, or a new sub-topic that subsumes under the same general topic, e.g., (*that ring's*) *workmanship*. As illustrated in Figure 1, when the topic NP appears after the connective *suiran* 'although' and thus being structurally below the connective, each of the two clauses can establish structures that are parallel to each other. We see two possible positions for NP2, one being subsumed under the same topic NP (*pro*, which is coreferential with *that ring*), the other taking the topic NP position in Clause 2 thus incurring a shift of the general topic.

- (12) 雖然 那個戒指_{topic NP} 設計_{NP1} 很特別，但 NP2...
suiran nagejiezhi sheji hentebie, dan NP2...
 although that ring design very special but NP2
 'Although for that ring, its design is very special, ...'

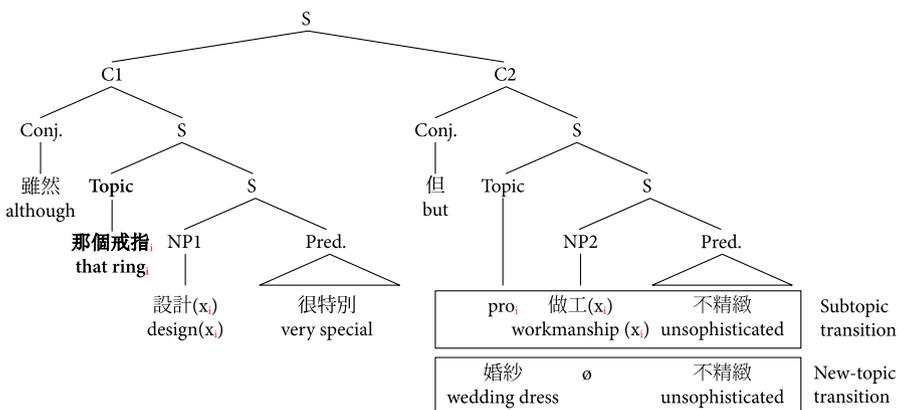


Figure 1. Sentence structure of low-topic conditions

Alternatively, the topic NP can also appear before the connective *suiran*, thus being at a higher topic position that binds the topics of both clauses as in (13) and Figure 2. In this case, the introduction of a new topic in Clause 2 is restricted to the lower level (e.g., at NP2, *workmanship*). The transition to a completely new topic (e.g., *the wedding dress*) would conflict with the general topic already established in the discourse model; structurally, the topic NP in Clause 2 is already occupied by a sub-topic *pro* and bound by the sentence-initial topic NP.

- (13) 那個戒指_{topic NP} 雖然 設計_{NP1} 很特別, 但 NP2...
nagejiezhi *suiran* *sheji* *hentebie*, *dan* NP2...
 that ring although design very special but NP2
 ‘That ring, although its design is very special, ...’

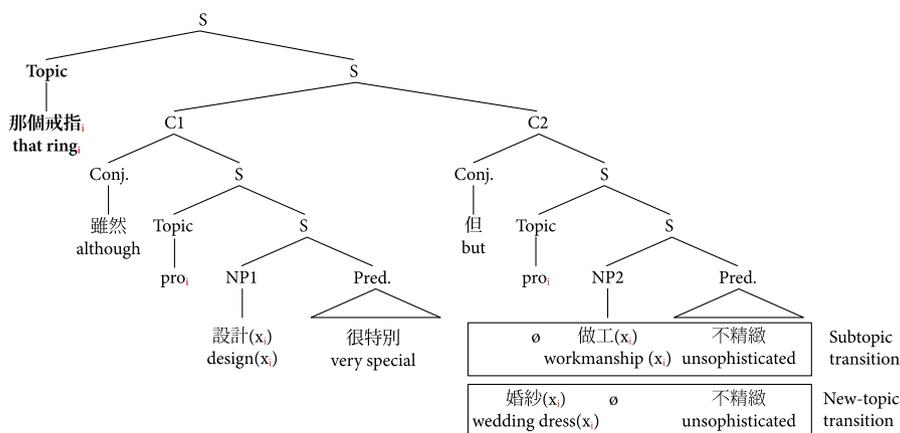


Figure 2. Sentence structure of high-topic conditions

The different structural positions of the topic NP thus have different constraints on the interpretation of subsequent topic NPs and subject NPs. The position above the initial connective has a prominent status and sets up a discourse model that affects the topic interpretation of both the concessive and the subsequent contrastive clauses. The updating of the discourse representation in the second clause to a completely new topic is unlicensed, and therefore its integration with the discourse model set up by the initial topic NP should bring about greater processing difficulty. The low-topic position, on the other hand, sets up a local discourse model only for the first clause and does not enforce a binding of the topic in the subsequent discourse. In this case, the discourse updating to a completely new topic is less costly than in the high-topic condition.

While it is evident in the literature that topic transition causes processing difficulty, how the cost of processing a new NP is modulated by the structural cue

in the context remains under-explored. Previously, Xu & Zhou (2016) have examined the role of the pre-connective position of a causal relation by manipulating the pronoun in the second clause as either a continuous topic or a shifted topic. In the present study, we embed a double-subject construction in a concessive relation, which allows us to examine topic transition at different levels of the syntactic structure. What status the pre-connective position has during discourse comprehension and how this syntactic position constrains the real-time processing of different levels of topic transition in the subsequent discourse are what the present study aims to explore.

In an eye-tracking experiment, we adopted a 2×2 design in which topic position (high topic vs. low topic) and topic transition (subtopic vs. new topic) were manipulated. We embedded a double-subject construction [$NP_a NP_b$ PREDICATE] in the first clause of a canonical Chinese concessive relation *suiran...dan...* ‘although...but...’ and manipulated the position of the topic NP (i.e., NP_a) as either before (i.e., high-topic position, see (13)) or after (i.e., low-topic position, see (12)) the connective *suiran*. The shifting of topic was manipulated by either providing a subtopic or a new topic in the adversative clause introduced by *dan* ‘but.’

It has long been known that semantic and pragmatic anomalies have effects on eye movements during reading (Ferguson & Sanford 2008; Ferguson & Jayes 2018). When participants notice the inconsistency in the texts they read, they show longer fixations and more regressions to the relevant regions of the sentence to read, re-read, and repair their initial hypotheses (Hyönä et al. 2003). In the present study, a batch of eye-movement measures will be selected to capture the initial and integrative stages for resolving the inconsistency of the sentence (Rayner 1998). As an early-stage measure, first-pass reading time is the sum of all fixations made upon first entering a region of text until an eye movement exits the region to either the left or the right, indicating the difficulty experienced when participants initially process a region of text. Regression-in count is the number of times an interest area was entered from the interest area(s) to its right, reflecting the processing difficulty and reprocessing of the sentence. Total reading time is the sum duration of all fixations made within a region, and total fixation count is the total number of fixations falling in the interest area, both indicating the overall amount of cognitive efforts spent in processing text in that region.

Previous studies have found a delayed effect of implausibility in sentences like *John used an axe/knife to chop the large carrots for dinner* where the implausibility effect was not observed on the first-pass reading times of the critical word *carrots* (Rayner et al. 2004), but on more regressions into the pre-critical region of inconsistent sentences like *If cats are hungry... families could [feed their cat a bowl of]_{pre-critical region} [carrots]_{critical region}* than that of consistent sentences like *If*

*cats are hungry... families could [feed their cat a bowl of]*_{pre-critical region} [*fish*]_{critical region} (Ferguson & Sanford 2008). In light of these studies, and in view of the syntactic positions of the higher and lower topics that have been introduced, we make the following predictions. First, in both high-topic and low-topic conditions, we expect to find a main effect of topic transition on both the early and integrative (later) eye-movement measures. This topic transition effect, however, may be observed in the post-critical region if it is slightly delayed and may bring about more regressions into the pre-critical region of the new-topic condition than that of the subtopic condition. Second, and more importantly, if the structural position of the initial topic does influence the interpretation scope of the discourse model constructed, we expect the effect of topic inconsistency to be greater in the high-topic condition than in the low-topic condition (i.e., interaction between topic transition and topic position), as a higher syntactic position would bind the topics of the two clauses in concession and thus impair the processing of topic transition in the subsequent discourse. We expect this modulation effect of topic position, which is at a higher discourse level, to be observed at a later integrative stage, which is more likely to be reflected in measures like the total reading time and total fixation count.

2. Methods

2.1 Participants

Forty native speakers of Mandarin Chinese (11 males, 29 females; mean age = 26 years, range 21–40 years) were paid to participate in this experiment. All participants had a normal or correct-to-normal vision and gave their informed consent.

2.2 Materials

Twenty-four sets of experimental items were created. The materials consisted of two sentences, i.e., a context sentence and a target sentence. The context sentence described a background situation where four objects were mentioned, e.g., *the ring, the wedding dress, the earring, and the bracelet*. The target sentence showed a concessive relation expressed by *suiran... dan...* ‘although...but...’ where the initial *suiran* clause contained a double-subject construction like (7). One of the four objects in the context sentence was chosen as the topic NP for the *suiran* clause, e.g., *that ring*, together with a description of one of its features (NP1), e.g., *its design is very special*. The topic NP was placed either before or after the concessive connective *suiran*, resulting in the high-topic and low-topic conditions, respec-

tively. The subsequent *but* clause introduced a transition of the topic at NP2 (the critical region), which was either a subtopic of the primary topic NP, e.g., *workmanship (of the ring)*, or another object mentioned in the context sentence, e.g., *the wedding dress*, resulting in the subtopic condition and the new-topic condition, respectively.

The *suiran...dan...* structure was always preceded by a phrase like *ta faxian* ‘she found that’ to avoid possible sentence-initial skipping effect and followed by two additional commentary clauses to form a continuous and complete discourse. An example of a context sentence is shown in (14). Example critical sentences in each condition are shown in (15), where square brackets indicate the regions of interest for eye-movement analyses.¹

(14) Context sentence

小美 在店裡 選購 結婚用品， 看了 戒指、婚紗、
Xiaomei zaidianli xuangou jiehunyongpin, kanle jiezhi hunsha
 Xiaomei in store shop for wedding stuff browse ring wedding dress
 耳環 和 手鐲。

erhuan he shouzhuo.

earring and bracelet

‘Xiaomei was shopping for her wedding. She browsed for the ring, the wedding dress, the earring, and the bracelet.’

(15) a. High-subtopic condition

她 發現 [那個戒指_{topic NP} 雖然]_{Region1} 設計_{NP1} 很特別， 但
ta faxian nagejiezhi suiran sheji hentebie, dan
 she found that ring although design very special but
 [做工_{NP2}]_{Region2} [不精緻，]_{Region3} 看著 很粗糙， 真是的。
zuogong bujingzhi, kanzhe hencucao, zhenshide.

workmanship not sophisticated looks very coarse such a pity

‘She found out that in terms of that ring, although its design is very special, its workmanship is not sophisticated. It looked coarse. What a pity.’

b. High-new condition

她 發現 [那個戒指_{topic NP} 雖然]_{Region1} 設計_{NP1} 很特別， 但
ta faxian nagejiezhi suiran sheji hentebie, dan
 she found that ring although design very special but
 [婚紗_{NP2}]_{Region2} [不精緻，]_{Region3} 看著 很粗糙， 真是的。
hunsha bujingzhi, kanzhe hencucao, zhenshide.

wedding dress not sophisticated looks very coarse such a pity

‘She found out that in terms of that ring, although its design is very special, the wedding dress is not sophisticated. It looked coarse. What a pity.’

1. Simplified Chinese characters were used in the experiment.

c. Low-subtopic condition

她發現 [雖然 那個戒指^{topic NP}_{Region1} 設計^{NP1} 很特別， 但
ta faxian suiran nagejiezhi *sheji hentebie, dan*
 she found although that ring design very special but
 [做工^{NP2}]_{Region2} [不精緻，]_{Region3} 看著 很粗糙， 真是的。
zuogong bujingzhi, kanzhe hencucao, zhenshide.
 workmanship not sophisticated looks very coarse such a pity
 ‘She found out that in terms of that ring, although its design is very special, its workmanship is not sophisticated. It looked coarse. What a pity.’

d. Low-new condition

她發現 [雖然 那個戒指^{topic NP}_{Region1} 設計^{NP1} 很特別， 但
ta faxian suiran nagejiezhi *sheji hentebie, dan*
 she found although that ring design very special but
 [婚紗^{NP2}]_{Region2} [不精緻，]_{Region3} 看著 很粗糙， 真是的。
hunsha bujingzhi, kanzhe hencucao, zhenshide.
 wedding dress not sophisticated looks very coarse such a pity
 ‘She found out that in terms of that ring, although its design is very special, the wedding dress is not sophisticated. It looked coarse. What a pity.’

The twenty-four sets of experimental items, each containing four conditions, were divided into four lists in a Latin square design. Twenty-six filler items in the same two-sentence format (i.e., consisting of a context sentence and a target sentence) but with a number of syntactic variations were added. Altogether, fifty items were presented to each participant in a pseudo-random order. Yes/No comprehension questions followed each trial to ensure participants understood the sentences. To keep consistency across conditions, half of the questions were targeted at the content of the context sentence and the other half at the feature of NP1 in the critical sentence or inference from it.

2.3 Apparatus

Eye movements of the left eye were recorded with an SR Research EyeLink 1000 Plus eye tracker (SE Research Ltd., Ottawa, Ontario, Canada) at a sampling rate of 1000 Hz. Stimuli were presented on a 19-inch LCD monitor with a resolution of 1024 × 768 pixels. All stimuli were written in Simplified Chinese characters (font type SimSun, font size 24) in black font on a light gray background (RGB 211, 211, 211). The stimuli were presented by EyeLink Experiment Builder 2.1.140, and the eye-movement data was pre-processed by EyeLink Data Viewer 3.1.97.

2.4 Procedure

Participants sat at 70 cm from the monitor with their heads on a chin rest to avoid head movements. The task started with a 13-point calibration. Once the calibration check was completed (<0.50 degrees of error), the experimenter advanced the screen to display two practice trials in the same format as the experimental item.

Each trial consisted of two separate pages, i.e., the context page and the target page. Before each trial, participants were instructed to fixate on a dot located at the position where the first character of the sentence would be subsequently displayed to enable drift correction. After reading the context sentence, participants pressed the spacebar to proceed to the next page where the target sentence was displayed.² Participants were instructed to read at their normal rate. Their eye movements were recorded only when they read the target sentence.

After each trial, participants pressed the spacebar to begin the presentation of a Yes/No question. Yes/No answers were equally distributed among all trials. Participants responded by pressing $\langle F \rangle$ for Yes and $\langle J \rangle$ for No on the keyboard. The whole process took around 25 minutes.

3. Results

Linear mixed-effects models were fit to the comprehension accuracy and a batch of eye-movement measures in each region of interest using lme4 package version 1.1–31 (Bates et al. 2015) in R version 4.2.2 (R Core Team 2022). Topic transition (subtopic vs. new topic) and topic position (high vs. low) were included as fixed effects and subjects and items as random intercepts. All fixed effects were manually coded using sum contrast so that the intercept is the grand mean (i.e., the mean of all the group means) and the main effect of one factor is tested as the average across levels of the other (Clopper 2013; Schad et al. 2020). Any significant interaction was followed by further tests on the effect of topic transition in the high-topic condition and low-topic condition, respectively, using emmeans package version 1.8.7 (Lenth 2021) and Bonferroni correction.

Reading time measures were log-transformed to stabilize variance and achieve approximately normal residuals (Box & Cox 1964). Comprehension accuracy was treated as binomial dependent variables and analyzed using generalized

2. We acknowledge that no drift correction was conducted on the second page where the target sentence was presented, which may have added some noise to the regression data. However, given that the noise occurred rather randomly, it should not have affected the observed effects.

linear mixed effects models with a binomial link function. The lmerTest package version 3.1–3 (Kuznetsova et al. 2017) was used to demonstrate the significance level.

3.1 Comprehension accuracy

We excluded three out of twenty-four questions that asked for participants' subjective inference (e.g., 'Will you buy the ring if you were Xiaomei?'), as these questions reflected participants' personal judgments and there was no correct or wrong answer. The overall accuracy of the remaining experimental trials was 82.6% ($SD=0.38$). The accuracy was 81.4% ($SD=0.39$) for the high-subtopic condition, 85.2% ($SD=0.36$) for the high-new condition, 80.5% ($SD=0.40$) for the low-subtopic condition, and 83.3% ($SD=0.37$) for the low-new condition, respectively. Generalized linear mixed-effects models showed no main effects of topic transition or topic position, nor their interaction ($ps > .10$), suggesting that in general, participants understood all sentences equally well.

3.2 Eye-movement data

The regions of interest, as indicated in (15), included (i) topic-*suiran* (Region 1), e.g., *nage jiezhi suiran* 'that ring although' for the high-topic condition and *suiran nage jiezhi* 'although that ring' for the low-topic condition; (ii) NP2 (Region 2), which was the critical region; and (iii) NP2+1 (Region 3), which was the post-critical region.

Eye-movement measures included first-pass reading time (FP), regression-in count (RIC), total reading time (TR), and total fixation count (TF) (Rayner 1998). Fixations shorter than 80 ms or longer than 1200 ms were excluded from data analysis (Drieghe et al. 2008; White 2008). Trials where the critical region (Region 2) or the post-critical region (Region 3) had zero first-pass reading times were removed, altogether accounting for 2.3% of the total experimental trials.

The results of different eye-movement measures in each region of interest are presented in Table 1 and Figure 3. Statistical results are shown in Table 2.

Table 1. Mean values of log-FP, RIC, log-TR, and TF in each region of interest. Standard deviations are in parentheses

	Region 1 topic- <i>suiran</i>	Region 2 NP2	Region 3 NP2+1
FP			
High-subtopic	5.80 (0.56)	5.57 (0.43)	5.46 (0.44)
High-new	5.78 (0.60)	5.60 (0.44)	5.54 (0.48)
Low-subtopic	5.75 (0.56)	5.59 (0.45)	5.40 (0.45)
Low-new	5.76 (0.56)	5.61 (0.45)	5.47 (0.43)
RIC			
High-subtopic	0.16 (0.39)	0.38 (0.68)	–
High-new	0.26 (0.53)	0.42 (0.68)	–
Low-subtopic	0.16 (0.38)	0.35 (0.63)	–
Low-new	0.18 (0.44)	0.39 (0.63)	–
TR			
High-subtopic	6.57 (0.55)	5.88 (0.57)	5.81 (0.68)
High-new	6.72 (0.64)	6.05 (0.65)	6.07 (0.74)
Low-subtopic	6.52 (0.64)	5.92 (0.59)	5.78 (0.63)
Low-new	6.52 (0.63)	6.03 (0.59)	5.93 (0.68)
TF			
High-subtopic	3.74 (2.12)	1.53 (1.03)	1.59 (1.53)
High-new	4.41 (2.73)	2.00 (1.57)	2.32 (1.89)
Low-subtopic	3.67 (2.22)	1.62 (1.26)	1.55 (1.29)
Low-new	3.57 (2.24)	1.86 (1.24)	1.89 (1.60)

In Region 1, we found a main effect of topic transition on RIC and TF showing more regressions-in and more total fixations in the new-topic condition than the subtopic condition, and a main effect of topic position on TR and TF showing longer total reading time and more total fixations in the high-topic condition than the low-topic condition. There was an interaction between topic transition and topic position on both TR and TF. Further tests showed a significant effect of topic transition in the high-topic condition, with new-topic transitions inducing greater processing costs than subtopic transitions (TR: $\beta = -0.20$, $t = -4.23$, $p < .001$, $p_{bon} < .001$; TF: $\beta = -0.81$, $t = -4.44$, $p < .001$, $p_{bon} < .001$), but no such effect was found in the low-topic condition ($ps > .30$).

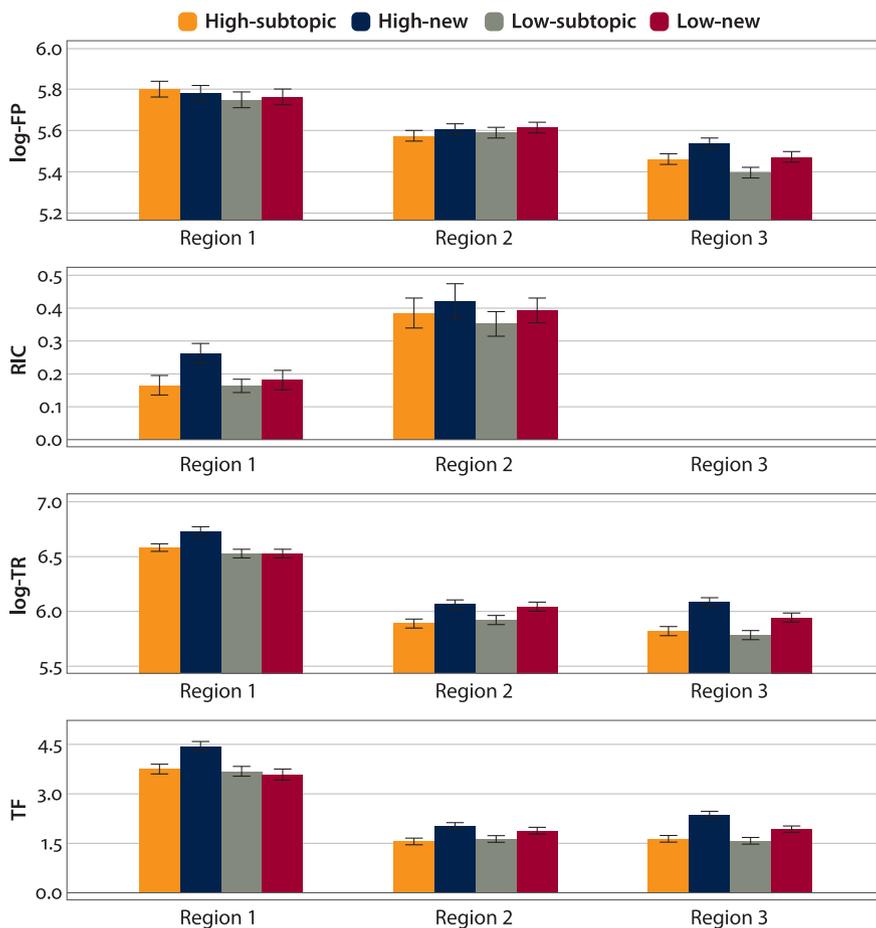


Figure 3. Mean values of each eye-movement measure in each region of interest. Error bars represent one standard error

In Region 2, we found a main effect of topic transition on TR and TF, showing greater difficulty in processing the new-topic condition than the subtopic condition. No other effects reached significance.

In Region 3, we found a main effect of topic transition on FP, TR, and TF showing greater processing difficulty in the new-topic condition than the subtopic condition, and a main effect of topic position on FP and TF showing greater processing costs in the high-topic condition than the low-topic condition. There was an interaction between topic transition and topic position on TF. Further tests revealed a significant effect of topic transition in the high-topic condition, with new-topic transitions inducing greater processing costs than subtopic transitions ($\beta = -0.43$, $t = -3.39$, $p < .001$, $p_{bon} = .001$), but no such effect was found in the low-topic condition ($p > .70$).

Table 2. Main effects of topic transition and topic position and their interaction by region of interest. The dependent variables are log-FP, RIC, log-TR, and TF

	Region 1			Region 2			Region 3		
	Coef.	SE	<i>t</i> -value	Coef.	SE	<i>t</i> -value	Coef.	SE	<i>t</i> -value
FP									
A	-0.01	0.03	-0.29	0.02	0.03	0.85	0.07	0.03	2.61**
B	0.04	0.03	1.09	-0.02	0.03	-0.57	0.06	0.03	2.18*
A×B ^a	-0.02	0.07	-0.28	0.01	0.05	0.24	0.00	0.06	0.08
RIC									
A	0.06	0.03	2.09 ^{+b}	0.03	0.04	0.92	-	-	-
B	0.04	0.03	1.40	0.04	0.04	1.04	-	-	-
A×B	0.08	0.06	1.40	-0.01	0.07	-0.12	-	-	-
TR									
A	0.06	0.03	1.92	0.14	0.04	3.92***	0.23	0.04	5.51***
B	0.12	0.03	3.61***	0.00	0.04	0.00	0.08	0.04	1.93
A×B	0.16	0.07	2.38 ⁺	0.07	0.07	0.90	0.14	0.08	1.72
TF									
A	0.26	0.13	2.05 ⁺	0.35	0.08	4.56***	0.52	0.09	5.86***
B	0.44	0.13	3.38***	0.02	0.08	0.30	0.24	0.09	2.65**
A×B	0.75	0.26	2.91**	0.22	0.15	1.47	0.39	0.18	2.15 ⁺

a. A: topic transition (subtopic was the reference level); B: topic position (low-topic was the reference level);

b. *** $p < .001$, ** $p < .01$, * $p < .05$

4. Discussion

This study sought to investigate how the syntactic position of a topic NP affects the processing of topic transition in the subsequent discourse. In an eye-tracking experiment, we used the Chinese concessive structure *suiran...dan...* where *suiran* clause contained a double-subject construction $[[NP_a]_{Topic} [NP_b \text{ PREDICATE}]_{Comment}]$ and *dan* clause introduced a shift of topic. The topic NP in *suiran* clause (i.e., NP_a) was located at either a higher pre-connective position (i.e., topicalized) or a lower post-connective position, and the topic transition in *dan* clause was manipulated as either a subtopic under the topic NP or a completely new topic. We found a main effect of topic transition on a batch of selected eye-movement measures (i.e., first-pass duration, regression-in count, total reading

time, and total fixation count), showing that processing new-topic transitions was more costly than processing subtopic transitions where topic continuity was retained. Importantly, we found interactions between topic position and topic transition on total reading time and total fixations at Region 1 (i.e., topic-*suiran*) and on total fixations at Region 3 (i.e., post-critical region), with post-hoc tests showing a significant effect of topic transition in the high-topic condition but not in the low-topic condition. Taken together, the results suggest a prominent status of the position before the connective, which binds the topic of both clauses of a concessive structure and affects the processing of topic transition in the second clause.

The present study corroborated the previous finding that a shift of topic in discourse induces greater processing difficulty than topic continuation (Haberlandt 1980; Haberlandt et al. 1980; Robert F. Lorch et al. 1985; Elizabeth P. Lorch et al. 1987; Hyönä 1994, 1995). We found a main effect of topic transition on a variety of eye-movement measures, suggesting that regardless of the position of the topic NP, a subtopic transition is easier to process than the transition to a new topic. During the comprehension of a double-subject construction *that ring_{topic NP} design_{NP1} very special*, the topic NP sets up a topic model for interpretation in the discourse. The transition to a completely new topic in the subsequent clause triggers the establishment of a new “substructure” (Gernsbacher 1995; 1997) or discourse model for interpretation, which requires greater processing effort. When the topic of the second clause occurs within the established topic frame (e.g., a subtopic like *workmanship of the ring*), however, this subtopic can be subsumed under the same discourse model, which is less costly. It should be noted that the early effect of topic transition based on first-pass reading time showed up at the post-critical region rather than immediately at the critical region. We suggest this is because it is not until participants reached the predicate of the second clause, e.g., *not sophisticated*, that they fully comprehended the contrastive event and established the interclausal relation.

We found interactions on total reading time and total fixations in the topic-*suiran* region and on total fixations in the post-critical region, all showing a significant effect of topic transition in the high-topic condition but not in the low-topic condition. The interactions in the topic-*suiran* region indicate participants’ (re)confirmation of the discourse topic. When an inconsistency occurred in the high-topic condition (as opposed to the low-topic condition), readers encountered greater difficulty and needed to go back to the initial topic and re-confirm what the sentence was about, which induces longer total reading time and more total fixations in the region of the topic NP. The interactions in the post-critical region again suggest that it is not until participants have established a new substructure of the contrastive event that they showed sensitivity to the interclausal

inconsistency. In both regions, the topic shift effect was observed only when the binding topic is located at a higher (i.e., more salient) syntactic position, suggesting a strong topic-binding effect by the topic-initial structure.

A direct comparison between the high-new and low-new conditions further showed longer total reading times on the former in the topic-*suiran* region and more fixations on the former in both the topic-*suiran* region and the post-critical region, suggesting that processing a new topic is impaired when the topic NP is placed in a higher structural position (i.e., above the connective). Though both are relatively “incompatible”, the new-topic transition in the low-topic sentences was still better than that in the high-topic condition. We suggest this is because the higher topic position enforces a stronger binding of NP2 to the topic, making it difficult to rescue an inconsistent topic chain. However, when the topic NP is located at a local (i.e., post-connective) position, the processing of topic shifting or resolution of topic chain conflicts in the second clause is less costly since the second topic is not syntactically bound by a higher topic.

While the structural topicality effect was observed in the processing of a completely new topic, it does not affect the subtopic transitions. That is, we found no structural effect between the high-subtopic and low-subtopic conditions. This result was consistent with Xu & Zhou (2016), where the ERPs on the topic-continuation pronoun (e.g., *he*) in the second clause showed no differences between the topic condition (e.g., *Wangyu*_(male) *because...*, *he...*) and the non-topic condition (e.g., *Because Wangyu*_(male)*...*, *he...*). Xu & Zhou (2016) suggest that in non-topic structures, the subject (e.g., *Wangyu*) is still the first-mentioned NP in the sentence and has higher accessibility than the object NP, which leads to easy access to the subject during later pronoun resolution. Consistent with their results, we suggest that the initial topic NP in both our high-topic and low-topic conditions is the most prominent entity in the discourse, regardless of whether it is syntactically topicalized or not. In both (12) and (13), for example, the topic NP in the double-subject construction (e.g., *that ring*) is the first-mentioned entity in discourse and thus has the most prominent topic status (Gernsbacher & Hargreaves 1988). The transition to a subtopic within this topic frame is highly acceptable in both cases, and it is this ceiling effect that has led to the absence of difference between the high-subtopic and low-subtopic conditions.

Together with Xu & Zhou (2016), our study suggests a prominent status of the above-connective position for binding topic interpretations across clauses in Chinese discourse. Chinese complex sentences are typically expressed by paired connectives, e.g., *suiran... dan(shi)...* ‘although...but...’ and *yinwei...suoyi...* ‘because...so...’. The position before *suiran* and *yinwei* is a salient structural position that sets up the discourse topic, the scope of which extends to the second clause of the concessive or causal sentences. For example, in our high-topic condi-

tion like (13), as illustrated in Figure 2, *that ring* is syntactically topicalized above the connective *suiran*. This topic sets up an interpretation scope for both the *suiran* and *dan* structures in the subsequent discourse, which makes topic transitions in the second clause more challenging.

The present study has implications for the role of syntactic structures in processing Chinese discourse relations. Connectives, including those used to introduce adverbial clauses like *yinwei* ‘because’ and *suiran* ‘although’ ($C_{\text{adverbial}}$) and those that introduce main clauses like *suoyi* ‘so’ and *dan(shi)* ‘but’ (C_{main}), are important cues in establishing a coherent discourse representation (e.g., Xu et al. 2018; Lyu et al. 2020). We suggest that during the processing of a paired-connective relation like $C_{\text{adverbial}} \dots C_{\text{main}} \dots$, the position of the first entity (e.g., an NP) relative to $C_{\text{adverbial}}$ is a crucial cue that determines the scope of the sentence topic (i.e., what the sentence is about), and it brings about different degrees of constraints to the processing of the subsequent discourse, as illustrated in (16).

(16) $\text{NP}_{\text{topic}} [C_{\text{adverbial}} \dots C_{\text{main}} \dots] > [C_{\text{adverbial}} \text{NP}_{\text{topic}} \dots] [C_{\text{main}} \dots]$

As shown in (16), when the topic NP is above the sub-clauses, it sets up a framework within which the following clause is to be interpreted. During online comprehension, immediately after encountering $\text{NP}_{\text{topic}} - C_{\text{adverbial}}$ (e.g., *Zhangsan yinwei* ‘Zhangsan because’, *Nage jiezhi suiran* ‘That ring although’), participants can establish the mental representation of the topic NP and construct the discourse relation (e.g., a cause-consequence relation) about this particular topic. An NP structurally above a connective thus has a higher binding strength on the processing of the subsequent discourse relation (the current study; Xu & Zhou 2016).

In a connective-initial sentence, on the other hand, the two clauses stand in their own independent discourse frames. The topic NP in the first clause does not bind the topic interpretation in the second clause. When processing such sentences, after encountering $C_{\text{adverbial}} - \text{NP}_{\text{topic}}$ (e.g., *Yinwei Zhangsan* ‘Because Zhangsan’, *Suiran nage jiezhi* ‘Although that ring’), participants can still adjust the interpretation of the topic NP in forming the topic chains of the subsequent clause.

Our study also has broader implications for the overall prominence of structurally higher positions (such as subjects and topics; see also Lin 2018) for binding interpretations of NPs, pronouns, and traces. Previous studies have suggested that dependent NPs located at higher positions (e.g., the subject position) bear greater discourse prominence in the working memory and are easier to retrieve (e.g., Keenan & Comrie 1977; Hawkins 2004; Friederici et al. 2011; Lin 2018). For instance, when processing Chinese possessive relative clauses where the head noun is associated with a dependent noun phrase in the embedded clause, retriev-

ing a dependent NP at the subject position is less costly than retrieving dependent NPs at lower syntactic positions (e.g., the object position) (Lin 2018). In anaphor resolution, the subject NP of a sentence is the most favored pronoun referent in the following sentence (Chin Lung Yang et al. 2003; Kaiser & Trueswell 2008). Topic, being what an utterance is about, receives greater attention and is more salient and accessible in discourse (Lin 2019). The present study manipulates the syntactic position of the topic NP, and consistent with the subject-prominence view, we suggest that a structurally higher topic NP (e.g., before the connective) holds a prominent status and places a greater binding constraint on topic interpretation in the subsequent discourse.

We conclude by suggesting that the topic position above the connective (i.e., $NP_{\text{topic}}-C_{\text{adverbial}}$) applies to a variety of Chinese discourse relations, including not only concession and causality that have been studied (the present study; Xu & Zhou 2016), but also other relations like *budan...erqie...* ‘not only... but also...’ and *jishi...ye...* ‘even if... still...’ etc. Further studies can look at the salient status of the pre-connective position and its constraints on the processing of different types of discourse relations.

5. Conclusion

In this study, we investigated two aspects of topic interpretation in Chinese discourse (i.e., the syntactic position of topicality and its scope, and topic transition in forming a topic chain). We found that shifting to a subtopic of the primary topic NP is easier than transitioning to a new topic. More importantly, we found that this effect is modulated by the syntactic position of the topic. When the topic NP is located in a higher structural position (i.e., before the connective), it places a stronger binding constraint on the processing of topics in the subsequent discourse. Our results suggest a salient status of the pre-connective topic position in processing Chinese discourse relations. The salient position sets up a topic frame that scopes over the subsequent clause and limits the transitioning of topics in discourse.

Acknowledgements

The first author thanks Prof. Xuping Li for discussing the syntactic literature.

Abbreviations

FP	first-pass reading time
RIC	regression-in count
TR	total reading time
TF	total fixation count

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Publication history

Date received: 8 March 2021
Date accepted: 8 February 2022
Published online: 2 January 2024