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# When a causal assumption is not satisfied by reality: differential brain responses to concessive and causal relations during sentence comprehension

Xiaodong Xu[a], Xiaoming Jiang[b] and Xiaolin Zhou[b,c,d,e]*

[a]*School of Foreign Languages and Cultures, Nanjing Normal University, Nanjing 210097, China;* [b]*Department of Psychology, Center for Brain and Cognitive Sciences, Peking University, Beijing 100871, China;* [c]*Key Laboratory of Machine Perception and Key Laboratory of Computational Linguistics (Ministry of Education), Peking University, Beijing 100871, China;* [d]*Collaborative Innovation Center for Language Competence, Jiangsu Normal University, Xuzhou 221009, China;* [e]*PKU-IDG/McGovern Institute for Brain Research, Peking University, Beijing 100871, China*

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A concessive construction like *Grandma moved from Southern to Northern China although she likes the South, where the winter is warm* implies a causal assumption that is based on one's real world knowledge but is inconsistent with the asserted fact. This study investigated to what extent the processing of a concessive construction differs from the processing of a causal construction with an explicit marker *because*, in which a causal assumption is stated and approved by the fact. The critical word in the subordinate clause was congruent or incongruent with the discourse context. The incongruent word elicited a larger N400 followed by a larger P600 for the causal construction but a larger N400 followed by a larger late negativity for the concessive construction, suggesting that the re-establishment of the conjunctive relations and the underlying brain responses are differentially affected by the conjunction type and by the viability of pragmatic meaning enrichment.

**Keywords:** causal conjunction; concessive conjunction; world knowledge; N400; P600

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To grasp the meaning of a discourse, readers/listeners not only need to understand the propositional contents of each individual sentence but also need to build coherent relations between different clauses/sentences. Understanding the relations between different clauses/sentences is an important step for constructing a coherent discourse representation. Coherent relations are meaningful relations that connect two or more discourse units, examples including consequence-cause (e.g., *I am not going out because it is raining*) and consequence-concession (e.g., *I am going out although it is raining*). These relations can be made explicit by discourse conjunctions like *and*, *because* and *although* (e.g. Sanders & Noordman, 2000). Although previous studies have shown that the presence of an explicit causal marker *because* facilitates the establishment of a discourse representation across two causally related clauses in online sentence comprehension (e.g. Cozijn, Noordman, & Vonk, 2011; Koornneef & Van Berkum, 2006; Van Berkum, Koornneef, Otten, & Nieuwland, 2007; Millis & Just, 1994; Traxler, Bybee, & Pickering, 1997), little is known about how its negative counterpart, i.e., the concessive conjunction *although*, exerts influence on discourse processing. The purpose of this study is to examine to what extent the processing of concessive and causal relations have differential neural manifestations.

Consider the following sentence (1). There is a causal relation between Peter 'exerting himself' and 'passing exams' and this relation is explicitly marked by the conjunction *because*.

(1) Peter passed the exam because he exerted himself.
(2) Peter passed the exam although he did not exert himself.
(3) Peter flunked the exam although he exerted himself.

But in (2) and (3), the causal relation between 'exerting oneself' and 'passing exams' is implicitly assumed (based on real-world knowledge) but is nevertheless negated (König & Siemund, 2000). In other words, a concessive relation with *although* describes a state of affairs (in the main clause) that might have been expected to be ruled out due to another state of affairs described in the subordinate clause but in fact was not. The two states of affairs or two propositions are inherently contradictory. The presence of the concessive marker *although* would help resolve the conflict at the concept level between the two propositions by applying a negation operation to cancel the world-knowledge-based presupposition (e.g., he will pass the exam if he exerted himself) and re-computing a truth value for the discourse. Thus, compared

*Corresponding author. Email: xz104@pku.edu.cn

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with the processing of the causally related construction like (1), processing the concessive construction like (2) or (3) might involve an additional computing process(es), that is, the negation of a presumed, experience-based causal attribution and the reconstruction of the coherence between two conceptually conflicting events (Iten, 1998; Köhne & Demberg, 2012; König & Siemund, 2000; Verhagen, 2000).

(4) * Peter passed the exam although he exerted himself.

On the other hand, if two causally related statements are concessively, rather than causally, connected, as in (4), it would result in a conflict with one's world-knowledge-based presupposition, leading to difficulty in building a coherent discourse representation. In this case, a re-interpretation of the two-clause sentence must take place. Townsend (1983) found that, if a conjunction signals a clear causal relation between propositions, the clauses are readily incorporated into the existing discourse representation; if the conjunction disrupts a clear casual relation, processing is temporarily suspended until more information becomes available. In event-related potentials (ERPs), a pronominal word that is incongruent with the established discourse representation in which the clausal relation is explicitly denoted by a

Table1. Experimental conditions and exemplar sentences with approximate literal translations.

| Conditions | *Examples* |
|---|---|
| *because*-congruent | a. 外婆从哈尔滨迁到了海南, 因为/她/喜欢/那里/暖和/天/舒服。<br>Waipo cong Harbin qiandaole Hainan, yinwei/ta/xihuan/**nali**/dongtian/**nuanhuo**/shufu<br>*Grandma has moved from Harbin to Hainan, because/she/liked/the winter/**there**/being **warm**/and comfortable* |
| *because*-incongruent | b. 外婆从海南迁到了哈尔滨, 因为/她/喜欢/那里/暖和/天/舒服。<br>*Waipo cong Hainan qiandaole Harbin, yinwei/ta/xihuan/**nali**/dongtian/**nuanhuo**/shufu*<br>Grandma has moved from Hainan to Harbin, because/she/liked/the winter/**there**/being **warm**/and comfortable |
| *although*-congruent | c. 外婆从海南迁到了哈尔滨, 尽管/她/喜欢/那里/暖和/天/舒服。<br>Waipo cong Hainan qiandaole Harbin, jin'guan/ta/xihuan/**nali**/dongtian/**nuanhuo**/shufu<br>*Grandma has moved from Hainan to Harbin, although/she/liked/the winter/**there**/being **warm**/and comfortable* |
| *although*-incongruent | d. 外婆从哈尔滨迁到了海南, 尽管/她/喜欢/那里/暖和/天/舒服。<br>Waipo cong Harbin qiandaole Hainan, jin'guan/ta/xihuan/**nali**/dongtian/**nuanhuo**/shufu<br>*Grandma has moved from Harbin to Hainan, although/she/liked/the winter/**there**/being **warm**/and comfortable* |

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(e.g., she likes the warm winter in Harbin) confirmed in the *because* clause or negated in the *although* clause. There are different ways to resolve these conflicts. The first way is to replace the conjunctive word with another conjunctive word. For example, in Condition *d*, the subordinate clause would be congruent with one's world knowledge if the two clauses were causally related. Another way is to reinterpret the intention or reason behind the action by replacing the critical word (e.g., *warm*) with its opposite (e.g., *cold*). A third way is to infer beyond the knowledge-inconsistent event while maintaining the current reference (pragmatic enrichment). For example, in Condition *b*, one can infer 'it is warm indoors in Harbin due to the heating system [there is generally no indoor heating system in southern China]', and the original intention of the action is fulfilled.

Thus, the experiment had a 2*2 factorial design, with *conjunction type* (causal vs. concessive) and *congruency* (congruent vs. incongruent) between information given in the main clause and information conveyed through the critical word as two within-participant factors. Comparing the *because*-incongruent sentences (Condition *b*) with the *because*-congruent sentences (Condition *a*), it is clear that the critical word is *nuanhuo* (*warm*): if it is replaced with a proper word consistent with one's world knowledge about place B (e.g., *cold*), the *because*-incongruent sentence would become acceptable and the *because*-congruent sentence would become unacceptable. Similar manipulations can be applied to sentences in Conditions *c* and *d* to confirm that *nuanhuo* (*warm*) is the critical word for *although*-congruent and *although*-incongruent sentences.

We predicted that the reference of the locative word *nali* can be resolved immediately by the type of conjunctive relation, marked by *because* or *although*. As shown by the pretest, this word is disambiguated by the conjunctions, with *nali* referring to place B in the *because*-clauses and to place A in the *although*-clauses. Previous studies on referential processing have shown a distance effect: P600 responses to the anaphoric word are stronger when its antecedent location is far as opposed to close (e.g. Hammer, Jansma, Lammers, & Münte, 2008; Li & Zhou, 2010; Qiu, Swaab, Chen, & Wang, 2012). We hypothesised that, when comparing ERP responses to the anaphoric word *nali* (there), the locative pronoun would evoke stronger P600 responses in the *although*-clauses than in the *because*-clauses.

We also predicted differential neural responses to the *because*-incongruent and *although*-incongruent sentences. Relative to the *because*-congruent sentence, the critical word in the *because*-incongruent sentence should evoke increased negative responses in the N400 window, reflecting the semantic integration difficulty caused by the incongruence between the input word (e.g., warm) and the expected characteristics of the place referred to by *nali* (Harbin). Moreover, we predicted a late ERP effect for the critical word. To resolve the conflict between the semantics of the input word and the world knowledge concerning place B, a second-pass process may be initiated. As has been established in most previous studies on discourse

processing, a P600 effect was initiated when the cause of an action needs to be reassigned with inference due to a temporary failure in causal attribution (e.g. Van Berkum et al., 2007). A similar positivity effect was found on unexpected sentential continuations, which implied an alternative non-literal interpretation (a so-called 'frame-shifting' positivity), suggesting a pragmatic bridging/inference process (Burkhardt, 2006, 2007; Jiang, Li, & Zhou, 2013b; Kuperberg, Paczynski, & Ditman, 2011; Yang, Perfetti, & Schmalhofer, 2007). As the relation between the two events is straightforward (not involving any operation of negation) in the *because* structure, the strategy of pragmatic enrichment is highly feasible. For example, one can infer 'winter in Harbin can be warm with the indoor heating system [but winter in southern China is cold because there is no indoor heating system]' in order to make sense of the concessive relation in Condition b and maintain a current assignment of the locative reference. Thus, we predicted a P600 effect, following the N400 effect, for the *because*-incongruent condition, relative to the *because*-congruent condition.

Similarly, we predicted an N400 effect for the *although*-incongruent condition, relative to the *although*-congruent condition. For the ERP effect of the second-pass processing, however, the predictions are somewhat complicated. As proposed in the 'causality-by-default' hypothesis, causality is a default, fundamental relationship in cognition (Li, 2009; König & Siemund, 2000; Oudega, 2011; Sanders, 2005), whereas a concessive relationship is the negation of the default mode by linking two mutually exclusive but implicitly related propositions (Izutsu, 2008; Taboada & Gómez-González, 2012). If the processing of the conjunction word *although* establishes a discourse context through the negation of the implicated causality, and this additional operation does not further affect the second-pass processing of the incongruent input word (*warm*), we should expect a P600 effect for this word, similar to the effect for the *because*-incongruent condition. If, however, the negation affects not only the assignment of an antecedent to the anaphoric word *nali* but also the resolution of the conflict between the critical word and the world knowledge, then an inhibition-and-re-interpretation strategy, rather than a pragmatic inference or enrichment strategy, should be initiated. Jiang, Li, and Zhou (2013a) manipulated the pragmatic congruence (i.e., the likelihood of an event) by embedding either a low- (a poor person can afford an expensive house) or high-likelihood event (a rich person can afford an expensive house) in a construction constraining an event of low expectedness (the Chinese *lian…dou…*construction, which is similar to *even…can…* construction in English). The authors observed a larger late negativity following an N400 effect on the *lian…dou* sentence describing a highly likely event (e.g., *Even a rich man can afford such an expensive house)[1] relative to the sentence describing a less likely event (e.g., Even a poor man can afford such an expensive house). The late negativity effect was interpreted as reflecting the inhibition of the critical input word and re-interpretation of the construction-based pragmatic incongruence in the second-pass process. Baggio, Lambalgen, and Hagoort (2008) also observed an increased late negativity on the sentence-final word implying an incomplete goal while the discourse context implied a completed goal. If this strategy is applied to the *although*-incongruent sentences, we expect a late negativity effect on the critical word.

## Methods

### *Participants*

Twenty-four native Chinese speakers from Nanjing Normal University, Nanjing, China (15 females, age ranging from 21 to 28 years with mean age of 24.6 years) were compensated for the participation. All of them were right-handed and had normal or corrected-to-normal vision. None of them had a history of neurological or psychiatric disorder. This study was carried out in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the Department of Psychology, Peking University.

### *Materials*

As shown in Table 1, the main clause stated the fact that a

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Table 2. Percentages of referents for the demonstrative pronoun *nali* to refer to the closer place (place B) in the causal construction and the distant place (place A) in the concessive construction.

| | Percentages of referents | |
|---|---|---|
| | Mean (%) | SD (%) |
| Causal construction – place B | 96.9 | 4.4 |
| Concessive construction – place A | 93.1 | 7.7 |

location unmentioned in the sentence. As can be seen in Table 2, the demonstrative pronoun was interpreted as referring to place B in the causal structure and to place A in the concessive structure. The referential bias is equally strong for the two structures (96.9% vs. 93.1%, $p > 0.5$).

The sentence acceptability ratings examined the acceptability of the discourse coherence/incoherence led by the conjunction and the causally/concessively related statements. Sentences were divided into four versions with a Latin-square procedure. Twenty students who did not participate in the ERP experiment or other pretests were randomly assigned to one of the four versions. They were asked to judge the overall acceptability of each sentence on a 7-point Likert Scale (1 indicating the least acceptable and 7 indicating the most acceptable). As can be seen from Table 3, relative to congruent sentences, the incongruent sentences were rated as less acceptable for both *because* and *although* structures ($p$s $< 0.001$). Moreover, the acceptability was equally unacceptable for *because* and *although* incongruent sentences ($F(1, 19) = 2.1$, $p > 0.16$) but was less acceptable for *although*- than for *because*-congruent sentences ($F(1, 19) = 42.5$, $p < 0.001$).

The cloze probability test examined the degree to which the established context in each experimental condition would predict the truncated critical word. In this test, fragments like *Grandma has moved from Harbin to Hainan, because she liked the winter there…,* in which the critical word (e.g., *warm*) as well as the following constituents were truncated, were divided into four lists with a Latin-square procedure. Twenty-four students who did not participate in the ERP experiment or other pretests were each randomly assigned to one of the four versions and were asked to record the first word that came to their mind and to make the completed sentence as natural as possible. As can be seen in Table 3, the mean cloze probability for the critical words (and words close in meaning to the critical words) used in the ERP experiment was 83.8% for the *because*-congruent condition and 86.0% for the *although*-congruent condition. The difference between them was not significant, $t(127) = 1.42$, $p > 0.2$, suggesting that the expectancy was formed equally strong for the two types of sentences.

Table 3. Results from the acceptability test and the cloze probability test.

| | Acceptability test | | Cloze probability | |
|---|---|---|---|---|
| | Mean | SD | Mean | SD |
| *because*-congruent | 6.46 | 0.31 | 0.838 | 0.26 |
| *because*-incongruent | 1.40 | 0.33 | 0.139 | 0.20 |
| *although*-congruent | 5.71 | 0.70 | 0.860 | 0.23 |
| *although*-incongruent | 1.52 | 0.32 | 0.150 | 0.21 |

In the ERP experiment, each critical sentence in a quartet was assigned to a different testing list with a Latin-square procedure, such that in each list there were 32 sentences per condition. A set of 128 filler sentences were added to each list. To encourage the reader to process the causal and concessive relations, half of the fillers were composed of structures similar to that of the critical sentence except that the subordinate clause had a negative attitude-biased word (32 sentences), e.g., *dislike, hate*, or an unbiased verb or no verb at all (32 sentences). Thus, the referred location of *nali* in the filler sentence could be either place A or place B. The other half were composed of various sentence structures and described situations other than someone moving from one place to another, although they also consisted of two clauses. Among the last half, 24 sentences used conjunctions other than *because* or *although* (e.g., *but, and, therefore*) and 48 sentences had no conjunctions between the clauses. Sentences in each list were pseudo-randomised, with the restriction that no more than three consecutive sentences were of the same condition and no more than three consecutive sentences were congruent or incongruent. Equal numbers of participants were randomly assigned to each of the four lists.

### *Procedures*

Participants were seated in a comfortable chair in a dimly lit room and were instructed to read each sentence attentively. Each trial began with a fixation point ('+') at the centre of the screen for 500 ms, followed by a blank screen for 500 ms. Then the whole main clause was presented on the screen. After finishing reading, the participant pressed the space bar to initiate the second clause, which was presented segment-by-segment at the centre of the screen. Each segment was presented for 400 ms followed by a blank screen for another 400 ms. The final segment of each sentence was followed by a yes/no comprehension question that probed knowledge related to the sentence. The question either probed the content of the individual proposition or probed the relation between the two sentences. The assignment of hand to response type was counterbalanced across participants.

The participant performed a practice block of 16 sentences, which had similar constructions as the stimuli

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in the formal experiment. Sentences in each list of the formal experiment were divided into six blocks with a 3-minute break between the two consecutive blocks. The testing of an average participant lasted about 2 hours.

### *EEG recording and data analysis*

EEG activity was recorded from 64 electrodes in a secured elastic cap (Electro-cap International). Vertical and horizontal electro-oculograms were recorded. The EEGs were referenced online to the tip of nose and re-referenced offline to the algebraic average activity measured in the left and right mastoids (TP9 and TP10). The vertical electrooculogram was monitored from electrodes located above the right eye and the horizontal electrooculogram from electrodes located at the outer canthus of the left eye. Electrode impedances were kept below 5 kΩ. EEG signals were filtered using a bandpass of 0.016–70 Hz, and digitised at a sampling rate of 500 Hz. The ERP epochs were extracted for the locative word *nali*, the critical word determining the discourse congruency, and the word immediately preceding the critical word, with a 200 ms pre-stimulus baseline and the ERP response to the critical words for 800 ms. Trials with EEG maximal amplitude exceeding ±60 μV or with incorrect responses in the comprehension task were eliminated from statistical analysis. The mean number of valid trials for the critical word was 27.4 (85.6%) for the *because*-congruent condition, 26.4 (82.5%) for the *because*-incongruent condition, 26.2 (81.8%) for the *although*-congruent condition and 26.5 (82.8%) for the *although*-incongruent condition. Based on the continuous 50 ms time window analysis and our research hypotheses, two time windows (300–450 ms for the N400 effect and 550–700 ms for the late ERP effect) were selected for the critical word and one window (500–800 ms) was selected for the demonstrative pronoun.

The repeated-measures analysis of variance (ANOVA) was conducted for the critical word with conjunction type (causal vs. concessive), congruency (congruent vs. incongruent), and topographical factors as within-participant variables. For the locative pronoun, we conducted ANOVA with conjunction type and topographical factors as within-participant variables. For the midline analysis, the topographic factor was electrode (three levels): anterior (Fz and FCz), central (Cz and CPz), and posterior (Pz and POz)). For the lateral analysis, the topographic factors were region (three levels: anterior vs. central vs. posterior) and hemisphere (two levels: left vs. right). Thus, six regions of interest were defined: left anterior (F1, F3, F5, FC1, FC3, and FC5), left central (C1, C3, C5, CP1, CP3, and CP5), left posterior (P1, P3, P5, PO3, and PO7), right anterior (F2, F4, F6, FC2, FC4, and FC6), right central (C2, C4, C6, CP2, CP4, and CP6) and right posterior (P2, P4, P6, PO4, and PO8). Mean amplitudes over electrodes in each region of interest were entered into ANOVAs. The Greenhouse–Geisser correction was performed when appropriate.

## Results

### *Behavioural results*

The average comprehension accuracy was 98.4% (Mean = 31.50, SD = 0.66) for *because*-congruent condition, 94.4% (Mean = 30.21, SD = 1.14) for *because*-incongruent condition, 94.7% (Mean = 30.29, SD = 1.20) for *although*-congruent condition and 94.3% (Mean = 30.17, SD = 1.40) for *although*-incongruent condition. ANOVA with conjunction type and congruency as two within-subject factors revealed a main effect of conjunction type, $F(1, 23) = 5.66$, $p < 0.03$, a main effect of congruency, $F(1, 23) = 15.01$, $p < 0.002$, and an interaction between conjunction type and congruency, $F(1, 23) = 6.87$, $p < 0.02$. Further analysis showed that this interaction resulted from the higher accuracy rate in *because*-congruent condition than any of other conditions ($p$s < 0.002). The differences between the other three conditions were not significant, $p$s > 0.1. These findings suggested that the effort of comprehending congruent sentences was more demanding in *although*- than in *because* sentences, consistent with the acceptability rating, while there seemed to be no difference in understanding the incongruent sentences between these two conjunction types.

### *Electrophysiological results*

The grand averaged ERPs, time-locked to the demonstrative pronoun *nali* and to the critical word, are shown in Figures 1 and 2, respectively. As can be seen in Figure 1, the *although* structure elicited a larger late positivity as compared with the *because* structure on *nali*; as can be seen in Figure 2, the incongruent sentences elicited an N400 effect followed by a late positivity effect (for the *because* structure) and a late negativity effect (for the *although* structure) on the critical words. The scalp topographies in Figure 3 depict the differences on the critical words between the incongruent and the congruent conditions for the causal and for the concessive constructions, respectively, and the differences between the *because*-congruent and the *although*-congruent conditions.

### *ERP responses to the demonstrative pronoun nali*

Repeated-measures ANOVA over the mean amplitudes in the 500–800 ms window yielded a significant main effect of conjunction type in the midline analysis, $F(1, 23) =$

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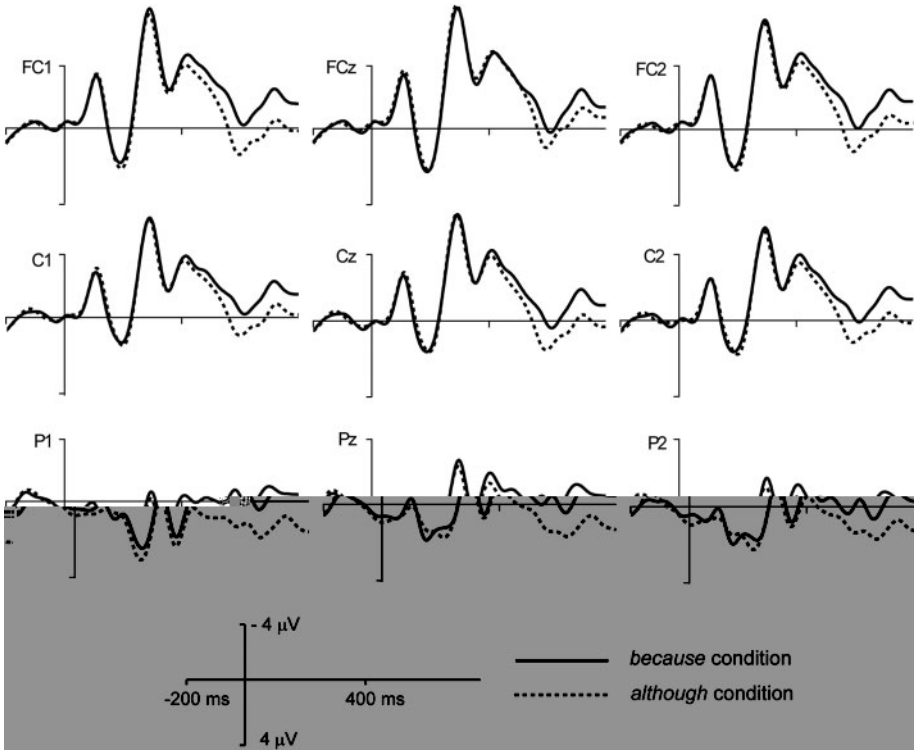


Figure 1. Grand average ERPs time-locked to the locative pronoun *nali* for the *because* conditions and *although* conditions.

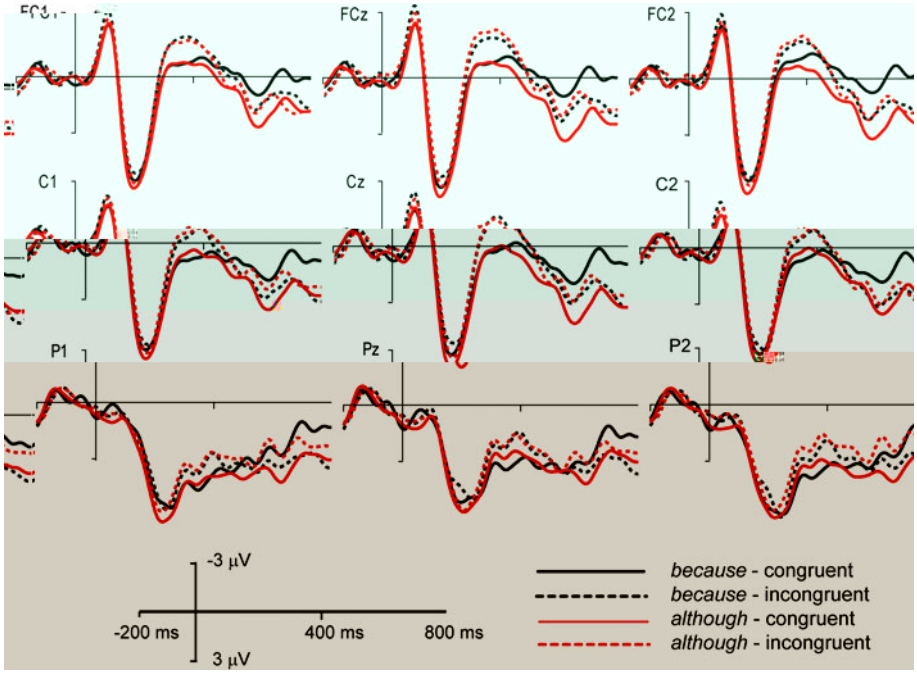


Figure 2. Grand average ERPs time-locked to the critical word (nouns or adjectives) for the *because*-congruent, *because*-incongruent, *although*-congruent and *although*-incongruent conditions, respectively.

7.82, $p < 0.01$, and in the lateral analysis, $F(1, 23) = 10.71$, $p < 0.005$, with *nali* eliciting stronger P600 responses for the *although* conditions than for the *because* conditions. No interaction between conjunction type and region or between conjunction type and hemisphere reached significance in either the midline or the lateral

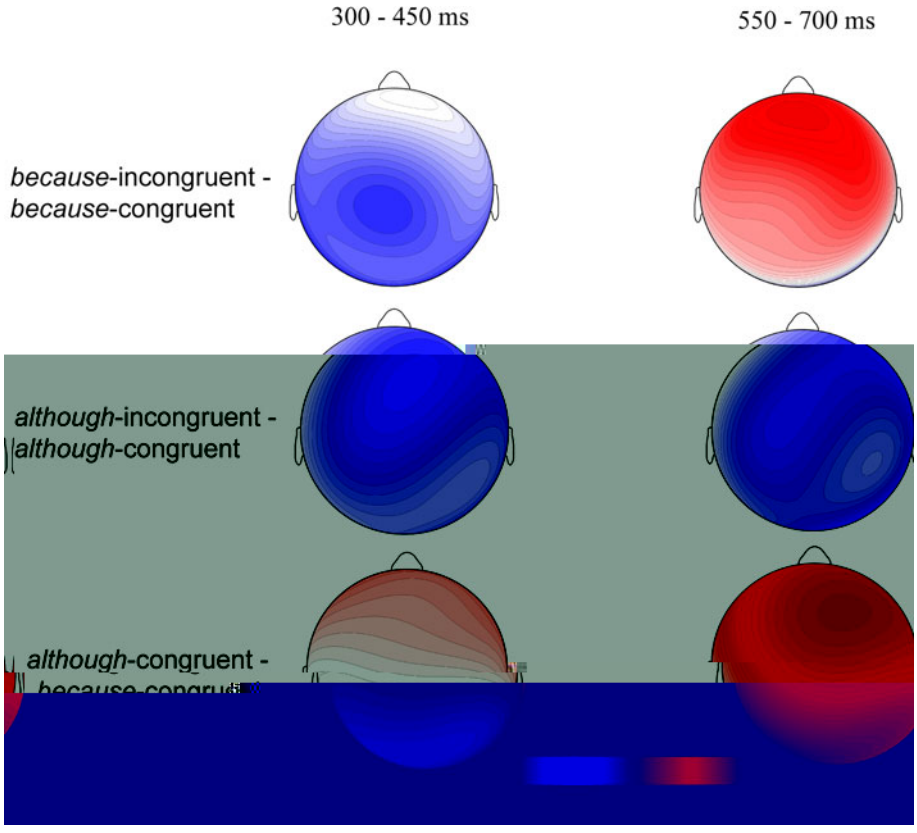


Figure 3. Topographic maps for difference waves on the critical word between the *because*-congruent condition and *because*-incongruent condition, between the *although*-congruent condition and *although*-incongruent condition, and between the two congruent conditions in 300–450 ms window (the left column) and 550–700 ms window (the right column), respectively.

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analysis, $F$s < 1, indicating that the late positivity effect was broadly distributed over scalp (see Figure 3).

### *ERP responses to the critical word*

#### *ERP responses in the 300–450 ms time window*

Repeated-measures ANOVA revealed a significant main effect of congruency in the midline analysis, $F(1, 23) = 13.17$, $p < 0.002$, and in the lateral analysis, $F(1, 23) = 22.11$, $p < 0.001$, indicating that the critical words evoked larger N400 responses in the incongruent sentences than in the congruent sentences. Neither the main effect of conjunction type nor the interaction between conjunction type and congruency was significant, $F$s < 1, indicating that the N400 effects for the *because*-incongruent and *although*-incongruent sentences were essentially of the same size (0.69 μV vs. 0.88 μV in the lateral and 0.80 μV vs. 1.06 μV in the midline).

#### *ERP responses in the 550–700 ms time window*

ANOVA revealed only a significant two-way interaction between conjunction type and congruency in the midline analysis, $F(1, 23) = 6.17$, $p < 0.03$, and in the lateral analysis, $F(1, 23) = 8.69$, $p < 0.01$. The main effect of conjunction type was not significant, $F(1, 23) = 1.79$, $p > 0.1$, in the midline analysis and $F(1, 23) = 2.32$, $p > 0.1$, in the lateral analysis, nor the main effect of congruency, $F$s < 1. Separate analysis for each conjunction type revealed a significant effect of congruency for the *because* sentences, $F(1, 23) = 4.7$, $p < 0.05$, in the midline analysis (1.09 μV) and $F(1, 23) = 7.15$, $p < 0.02$ in the lateral analysis (0.90 μV), with the critical words in the incongruent sentences eliciting increased P600 responses relative to the congruent sentences. In contrast, the *although* sentences also evidence a congruency effect: $F(1, 23) = 3.47$, $p < 0.08$ in the midline analysis (–1.10 μV), and $F(1, 23) = 4.41$, $p < 0.05$ in the lateral analysis (–0.95 μV), but this effect was in the opposite direction, with the critical words in the incongruent sentences eliciting *less positive* responses relative to the congruent sentences. In other words, the incongruence with world knowledge elicited a late negativity effect in the *although* sentences.

Direct comparison between the *although*-congruent and *because*-congruent sentences revealed a significant effect in the midline analysis (1.60 μV), $F(1, 23) = 7.78$, $p < 0.01$, and in the lateral analysis (1.39 μV), $F(1, 23) =$

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10.64, $p < 0.005$, indicating that the critical words in the *although* sentences elicited more positive responses than the words in the *because* sentences in the late time window.

## Discussion

Findings in this study can be summarised as follows. ERP responses to the demonstrative pronoun *nali* (there) were modulated by the type of conjunctive relations, with more positive (P600) responses in the *although* sentences than in the *because* sentences. Compared with the critical words in the *because*-congruent sentences, the same words in the *because*-incongruent sentences elicited an N400 effect followed by a late positivity (P600) effect; compared with the critical words in the *although*-congruent sentences, the same words in the *although*-incongruent sentences elicited an N400 effect followed by a late negativity (N600) effect. The N400 effect was not modulated by the conjunction type. Moreover, the critical words elicited more positive (P600) responses in the *although*-congruent sentences than in the *because*-congruent sentences. These findings suggest that although the increased effort of integrating the critical word, which was caused by semantic/pragmatic incongruence between the implicated or actual causal relation and the real-world knowledge, is independent of the type of conjunction, the re-establishment of the conjunctive relations is subserved by differential neural mechanisms. In the following paragraphs, we concentrate on the functions of the neural dissociations underlying the processing of concessive and casual relations.

We found a modulation of conjunction type on P600 responses on the locative pronoun *nali* (there), with stronger P600 in the *although* construction than in the *because* construction (see Figure 1). One may link this positivity effect to the difference in the offline comprehension acceptability rating, since *although*-congruent sentences were rated less acceptable than the *because*-congruent sentences (Table 1). Although we do not deny the potential association between the offline acceptability rating (for the whole sentence) and the online processing difficulty reflected by ERP activities (on the critical word), we believe that this association has no direct impact upon the observed P600 effect. If the P600 effect on *nali* were directly associated with the offline acceptability rating, then both incongruent conditions would also evoke increased P600 responses compared with the congruent sentences on the following critical word given that the incongruent sentences were less acceptable than the congruent ones. However, only the incongruent *because* sentences showed a P600 effect, whereas the incongruent *although* sentences showed a reversed pattern on this word.

Instead, the P600 difference on *nali* between *although* vs. *because* construction was more likely to be associated with the distance difference between the pronoun *nali* and its referent. As shown in the forced choice pretest, *nali* is strongly preferred to link with the closer referent (place B) in the *because* construction but with the distant referent (place B) in the *although* construction. It is possible that to link *nali* with place A, the system needs to overcome the interference from place B, which could have higher activation and higher likelihood to link with place B due to its recency. This effortful, conceptual shifting process (i.e., linking *nali* to place A) is reflected in the P600 responses (e.g. Hammer et al., 2008; Li & Zhou, 2010; Qiu et al., 2012) and might affect the acceptability rating for the whole sentence. Likewise, the larger P600 response evoked by critical words (e.g., *warm*) in *although*-congruent sentences relative to *because*-congruent sentences (Table 1) may also be associated with the distance difference between *nali* and its actual referent, since its congruence status was determined by the characteristics of the place being referred to by *nali*. According to its preceding context, *nali* should be interpreted as referring to *Hainan* (place A) in the *although*-congruent sentences. The successful integration of the following critical word *warm* with its preceding context, including the preceding word *winter*, depends on access to semantic/pragmatic characteristics of the actual referent (i.e., Hainan, which is famous for its warmth during winter). Thus, in the process of establishing a coherent event representation, linking the feature of the critical word *warm* to a long-distance referent (place A) in *although*-congruent sentences would be more demanding than linking it to a short-distance referent (place B) in the *because*-congruent sentences, resulting in increased P600 responses. Note that the feature *warm* had to be updated with respect to a particular place in the discourse or event representation. If the input were neutral with respect to place A or place B, no P600 effect would be observed. Indeed, when we examined the ERP responses to the words between *nali* and the critical words (e.g., *dongtian*/*winter* in Table 1), we found no difference between conditions (data not shown here). Taken together, the modulation of the P600 responses to *nali* by conjunction type and the clear dissociation of location assignment (closer referent for the *because* sentence vs. further referent for the *although* sentence) in the forced-choice referent test demonstrated that the reader can effectively utilise conjunction information during sentence reading.

For the incongruence between world knowledge and the critical word referring to the feature of place B (for the *because* sentences) or place A (for the *although* sentences), we observed N400 effects on the critical word, irrespective of the type of conjunction, reflecting the incongruence between the input word (e.g., *warm*) and the real-world knowledge about the place (Harbin is cold in winter). This finding replicated earlier studies on pragmatic-based inconsistence during sentence comprehension

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(e.g. Hald, Steenbeek-Planting, & Hagoort, 2007; Hagoort, Hald, Bastiaansen, & Petersson, 2004; Jiang et al., 2013a; Nieuwland & Van Berkum, 2006; Otten & Van Berkum, 2007). Given that the conjunction type has modulated ERP responses to the preceding demonstrative pronoun *nali*, it is interesting to see that the conjunction type did not modulate the N400 responses to the critical words, a pattern consistent with the indistinguishable cloze probability for predicting the critical words in the two structures.

Although the conjunction type exerted no modulation on the initial semantic/pragmatic integration, it did modulate the discourse-level integration. While world knowledge inconsistence evoked a late positivity effect in the causal construction, this inconsistence evoked a late negative, rather than positive, effect in the concessive construction. The dissociation in neural responses in the late time window suggests that different reprocessing strategies were adopted to resolve the inconsistency between the input and the world knowledge. When the asserted causal relation is inconsistent with the reader's real-world knowledge, the reader may attempt to infer beyond literal interpretation of the input to rationalise the sentence. For example, although Harbin is very cold outside in the winter, the highly accessible indoor heating system may lead an individual to want to live in Harbin in the winter (as opposed to Southern China where the winters are milder but heating systems are rare, resulting in a potentially colder winter). Thus, the meaning enrichment of the statement, as in many previous studies (e.g. Burkhardt, 2006; Jiang et al., 2013b; Kuperberg et al., 2011; Yang et al., 2007), would elicit a late positivity, which can be interpreted as reflecting the employment of pragmatic inference to realise a non-literal interpretation and to rebuild a new mental representation (see similar interpretations in Brouwer, Fitz, & Hoeks, 2012; Jiang et al., 2013b).

In the concessive construction, however, upon encountering a pragmatic-based inconsistency, the strategy of making a pragmatic inference to rationalise the input was unviable, given that the negation of a presupposed causal assumption was already highly cognitively demanding. Moreover, the two propositional contents in the main and subordinate clauses were closely related and easily formed a consequence-causal relation; under such a circumstance, the reader may prefer an easier and more straightforward approach (i.e., inhibition-and-re-interpretation strategy), for example, by replacing the inappropriate conjunction *although* with the appropriate conjunction *because* or by directly omitting the conjunction word. Indeed, in a post-experiment error correction test, when 24 new participants were asked to correct potential errors in each incorrect sentence in the way that first came into mind, most changes (68.8%) were made by replacing *although* with *because* for the *although*-incongruent sentences; in contrast, only 31.3% of changes were made by replacing *because* with *although* for the *because*-incongruent sentences. [Most changes for *because*-incongruent sentences were made either by exchanging the positions of the two places (39.6%) or by changing other sentential content (29.2%), e.g., replacing the attitude-biased word *like* with *dislike*, or the critical word *warm* with *cold*]. This strategy is consistent with the argument that causality is a default and fundamental relationship in cognition (e.g., the causality-by-default hypothesis; Li, 2009; König & Siemund, 2000; Oudega, 2011; Sanders, 2005). The processing system is more likely to appeal to the default mode when it attempts to make coherent connections between propositions.

This interpretation of P600 and the late negativity for processing incoherent causal vs. concessive relations is consistent with Jiang et al. (2013b) in which the misuse of an over-respectful pronoun (e.g., a person of higher social status talking to a person of lower status by using a respectful second-person pronoun *nin*/you) evoked a late positivity, whereas the misuse of a less-respectful pronoun (e.g., a person of lower status talking to a person of higher status by using a less-respectful pronoun *ni*/you) evoked a late negativity. The late positivity reflected the involvement of pragmatic inference (i.e., a non-literal interpretation of the second personal pronoun *nin* as making a joking or sarcastic remark), whereas the late negativity was interpreted as reflecting the re-interpretation of an initially built mental representation (i.e., the recovering the correct use of the pronoun *nin* from the its 'incorrect' form *ni* to rebuild the utterance representation). Consistent with this interpretation, in the current study, upon encountering the critical word in the *although*-incongruent sentence, the reader may adopt a re-interpretation strategy, namely, using the appropriate alternative *because* to replace the inappropriate conjunction *although*, to resolve the inconsistence between the implicated causality and the world knowledge and to build a coherent discourse representation. However, it should be noted that the lack of a P600 effect in the concessive incongruent condition does not exclude the possibility that pragmatic enrichment can happen for the concessive structure under specific circumstances. Further studies should look at how the accessibility of pragmatic inference affects the late ERP effect in understanding concessive sentences.

## Conclusions

To conclude, by comparing the congruency effect (incongruent vs. congruent) in the causal construction with that in the concessive construction, we found that the critical word in incongruent sentences elicited a larger N400 followed by a larger P600 for the causal construction but a larger N400 followed by a late negativity for the concessive construction. Moreover, a larger P600 was observed for the congruent concessive sentences than for the

congruent causal sentences. These findings suggest that although the increased integration effort, caused by the semantic/pragmatic incongruence between the implicated or stated causal relation and the world knowledge, is independent of the type of conjunction, the exact way of re-establishing a coherent discourse representation can vary depending on whether or not viable pragmatic enrichment is highly accessible.

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## Note

1. This construction has similar functions as a concessive conjunction, since it encodes anti-prediction statement.

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