

Understanding Counterfactuals in Transparent and Nontransparent Context: An Event-Related Potential Investigation

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Counterfactuals describe imagined alternatives to reality that people know to be false. Successful counterfactual comprehension therefore requires people to keep in mind both an imagined hypothetical world and the presupposed real world. *Counterfactual transparency*, that is, the degree to which a context makes it easy to determine counterfactuality, might affect semantic processing. This might especially be the case for languages like Chinese which lack dedicated counterfactual markers and therefore are more context-dependent. Using event-related potentials, this study investigates the role of counterfactual transparency on the comprehension of Chinese counterfactuals. For transparent contexts (e.g., “If everything in the world could go back in time . . .”), in which the information needed to identify counterfactuality is highly accessible, discourse incongruent words elicited P600 effects. In contrast, for nontransparent contexts (e.g., “If better preparations were made at that time . . .”) in which readers must attend to specific discourse context and engage pragmatic information to arrive at the counterfactual interpretation, discourse incongruencies gave rise to N400 effects. These findings suggest that (a) provided a constraining context, semantic processing is not disrupted by the dual nature of counterfactuality (i.e., readers can rapidly make contextually appropriate inferences to interpret subsequent narratives) and (b) the degree of transparency of the counterfactual can affect the nature of subsequent semantic processing. Our findings support the usage-based view that Chinese counterfactual comprehension is highly context-dependent and pragmatics-driven.

Keywords: counterfactuals, counterfactual transparency, semantic anomaly, N400, P600

Counterfactuals are statements describing situations or events that are counter-to-fact (e.g., “If John had gotten up earlier this morning, he wouldn’t have been late for class”). Successful comprehension of counterfactuals requires not only the mental simulation of an imagined possible alternative (e.g., “John got up earlier and was not late for class”) but also an evaluative comparison between the alternative and its corresponding current reality (e.g., “John did not get up early and was late for class”) to work out the difference of the two states (e.g., Markman & McMullen, 2003; see also the mental model theory of Johnson-Laird and Byrne, 1991, 2002 and the mental space framework of Fauconnier, 1994, 1997). Therefore, in the cognitive view of counterfactuals, people simultaneously draw upon both fact and fiction, while having to

resolve the conflict between the real-world knowledge and the imagined alternative. Maintaining these dual representations might lead to an (initial, brief) disruption of online comprehension. Exploring the processing mechanism underlying counterfactuals will make important contributions to our understanding of how people coordinate the real-world knowledge and the hypothetical world knowledge in real-time language processing. A number of recent studies have investigated the cognitive process of counterfactual comprehension (Black et al., 2018; de Vega & Urrutia, 2012; Ferguson & Cane, 2015; Ferguson & Sanford, 2008; Nieuwland, 2013; Nieuwland & Martin, 2012). It is, however, still unclear what the impact is of competing representations on incremental discourse processing, and how one can explain the differences observed in the time course of processing across the different experiments.

The dual representation hypothesis, as well as the idea that maintaining incompatible representations during counterfactual processing is cognitively costly, have been supported by a number of previous studies employing diverse methods, including self-paced reading, eye-tracking, event-related potentials (ERPs), and fMRI (Ferguson, 2012; Ferguson et al., 2019; Ferguson & Cane, 2015; Ferguson & Sanford, 2008; Ferguson et al., 2008; Kulakova et al., 2013; Kulakova et al., 2014; Kulakova & Nieuwland, 2016; Santamaría et al., 2005; Urrutia et al., 2012). For example, in an eye-tracking experiment (Ferguson, 2012), people read short narratives in which a context sentence set up a counterfactual world (e.g., “If Joanne had remembered her umbrella, she would have

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avoided the rain”), followed by a critical sentence that was either consistent or inconsistent with the preceding context information (e.g., “Joanne’s hair was dry/wet”). A real-world context narrative was included as a baseline of normal contextual integration (e.g., “Because Joanne remembered her umbrella . . . Joanne’s hair was dry/wet”). Results showed longer reading times for inconsistent conditions relative to consistent conditions in the real-world context. In the counterfactual context, however, initial reading times were as long for the consistent word as for the inconsistent word, with both showing longer reading times than the real-world consistent baseline. Thus, the initial processing of the critical word was associated with increased processing cost for both consistent and inconsistent conditions in counterfactual contexts. This suggests that upon encountering the critical words, readers had mental representations of both factual and counterfactual worlds. These representations compete in memory and interfere with early semantic processing. Similar results were observed in ERP experiments (e.g., Ferguson & Cane, 2015) in which N400 effects were elicited by inconsistent versus consistent words in real-world factual context, whereas null or even reversed effects were elicited in counterfactual context.

However, other studies failed to find evidence that maintaining both counterfactual and real-world representations disrupts discourse processing (Nieuwland, 2013; Nieuwland & Martin, 2012). Nieuwland and Martin (2012) observed comparable brain responses to semantic anomalies in real-world context (e.g., “Because NASA developed its Apollo Project, the first country to land on the moon was Russia_{inconsistent}/America_{consistent}”) and counterfactual context (e.g., “If NASA had not developed its Apollo Project, the first country to land on the moon would have been Russia_{consistent}/America_{inconsistent}”). In both contexts, an N400 was elicited by words that were inconsistent versus consistent with the intended representation. This N400 effect was indistinguishable between the counterfactual and the real-world contexts. The discrepancy in findings between studies can be accounted for in several ways. First, it might be due to methodological differences. The techniques employed (e.g., eye-tracking vs. ERPs) might influence how stimuli are presented and further influence how language comprehension progresses. More importantly, the difference could also be related to differences in the counterfactual contexts (i.e., counterfactuals set in realistic and everyday situations vs. counterfactuals depicting surreal events). In a recent eye-tracking study, Black and colleagues (2018) examined the processing pattern of different counterfactual structures. They used stimuli modified from Ferguson (2012) and from Nieuwland and Martin (2012), with counterfactuals describing everyday events and nonrealistic events, respectively. Results showed that anomaly detection effects appeared one word position earlier in nonrealistic counterfactuals which depicted scenarios contradicting encyclopedic world knowledge, than in the counterfactuals describing realistic everyday situations. It is argued that in nonrealistic contexts, the factual-counterfactual representations are more clearly distinct, and comprehension is grounded in our well-entrenched world knowledge which can be easily retrieved from long-term memory. As for counterfactuals depicting specific everyday events, anomaly detection is mainly based on local discourse constraints, thus readers must generate specific new representations of the factual and counterfactual worlds, which could compete with each other in

working memory and consequently delay the time course of inconsistency effects.

A closer look at the two types of counterfactuals suggests that a fundamental difference between them lies in the immediacy and accessibility of the information that is needed for detecting counterfactuality, in other words, the degree to which a context makes it easy to determine counterfactuality, which we will refer to as COUNTERFACTUAL TRANSPARENCY in the current study (see also Yeh & Gentner, 2005). In the field of semantics, the term transparency refers to the extent to which an expression’s meaning can be derived from the literal meaning of its constituents (Keysar & Bly, 1995; Ullmann, 1962). For instance, if the meaning of an expression can be directly inferred from a literal analysis of its composing words, it is transparent; if the meaning is nondecomposable and not directly retrieved from its constituents, it is non-transparent. For counterfactual processing, transparency might facilitate discourse comprehension. Counterfactual contexts that depict nonrealistic situations contradicting our general world knowledge (e.g., “If NASA had not developed its Apollo Project . . .”) can be treated as transparent, as the information needed for detecting counterfactuality is highly accessible and immediate for inference. On the other hand, for counterfactuals set in everyday realistic contexts (e.g., “If Joanne had remembered her umbrella . . .”), the counterfactual meaning is not transparently expressed as the situation described cannot directly or unambiguously establish a counterfactual interpretation without linguistic cues (e.g., past tense and subjunctive mood) or further background information. Counterfactuality can be easily canceled if a subsequent sentence does not refer to a past event, so counterfactual meaning is usually achieved at a global discourse level when all the information is integrated. Especially in languages that have no dedicated formal markers, readers must attend to specific discourse context and engage pragmatic reasoning to arrive at the counterfactual interpretation of an assertion (Wang, 2016; Yeh & Gentner, 2005; Yuan, 2015). Recent studies on counterfactual processing have begun to look into the processing difference among different counterfactual constructions (Black et al., 2018; Ferguson et al., 2019), and the findings on this issue are mainly obtained in a between-item, between-subjects fashion. In the present study, we attempted to directly manipulate counterfactual transparency as a within-item, within-participant factor, exploring whether and how it modulates competition between contextual information and real-world representation in real-time language comprehension.

Previous studies on counterfactual processing have mainly targeted Indo-European languages which have explicit syntactic counterfactual markers. It is still unclear how counterfactuals are processed in languages that mainly resort to contextual and pragmatic cues. Different from Indo-European languages, there are no dedicated linguistic devices in Chinese to signal entry into the counterfactual world. The counterfactual interpretation of a sentence is usually derived from a combination of factors, including contextual cues, encyclopedic knowledge, negation, temporal reference to past time, and lexical cues such as the using of perfective marker *le* (了; Chen, 1998; Jiang, 2000, 2011; Wang, 2012, 2016; Yong, 2014, 2015; Yuan, 2015). There has long been some debate on whether the lack of distinct syntactic markers leads to a deficit in counterfactual reasoning for Chinese speakers (e.g., Au, 1983, 1984; Bloom, 1981, 1984). Although most off-line behavioral studies have not shown any significant differences in the general

ability of understanding counterfactuals between Chinese speakers and English speakers (Lardiere, 1992; Liu, 1985; Wu, 1994), some studies indeed report differences in processing among different counterfactual constructions. Using a self-paced reading paradigm, Yeh and Gentner (2005) compared counterfactual comprehension in transparent (e.g., “If antibiotics had never been discovered . . .”) and nontransparent contexts (e.g., “If Michael had gone out with his girlfriend that night . . .”) with both Chinese and English native speakers (Yeh & Gentner, 2005). Results revealed that English speakers are better at understanding the counterfactuals than Chinese speakers in nontransparent counterfactual contexts, but not in transparent contexts. This result is discussed with respect to language relativity: due to the ambiguity of Chinese grammar in expressing counterfactuals (relative to the explicit counterfactual markers in English), when general world knowledge is insufficient for indicating counterfactuality (i.e., in nontransparent context), Chinese readers need to more actively engage pragmatic inference of the context, resulting in a need for reprocessing previous information and a risk of compromising accuracies. From this perspective, transparent contexts would also benefit Chinese speakers in counterfactual comprehension.

However, findings from usage-based approaches suggest a different picture. Usage-based theories hold that language processing mechanisms are modulated by language experience and the frequency of linguistic structures in natural language (Ellis, 2002; Gries & Ellis, 2015; Tyler & Ortega, 2016). Comprehenders tend to perceive the most probable semantic and syntactic analyses of a new utterance based on frequencies of previously perceived utterance analyses (Ellis, 2002). The effects of frequency and linguistic experience have been found not only in lexical and syntactic processing (Farmer et al., 2017; Farmer et al., 2011; Wells et al., 2009), but also in the processing of discourse-level relations (e.g., Arnold et al., 2018). For instance, Arnold and colleagues (2018) found that pronoun comprehension biases are related to the individual’s linguistic exposure: in line with the corpus findings which suggest a “subject-bias” for pronoun reference, people with more print exposure assigned pronouns to the grammatical subject more consistently and quickly compared to the grammatical object in online comprehension. In terms of counterfactual comprehension, the frequency of different counterfactual constructions might also influence the online processing of counterfactuals. Corpus studies on the content and function of counterfactual usage revealed that, although logical reasoning and causal inference is common in English counterfactuals (e.g., used as an analytical tool in discussing sports or as a rhetorical strategy in litigation discourse), Chinese counterfactuals are mostly uttered as an emotional catharsis (e.g., to express regret or relief) in relating to personal experience or down-to-earth situations, but seldom uttered to describe abstract or nonrealistic events (Wu, 1994; Yuan, 2015; Yuan & Zhang, 2016). Pragmatic inference of implicit contextual information therefore plays a crucial role in counterfactual reading in Chinese (Jiang, 2000; Yong, 2016). Of particular relevance, a recent corpus study (Wang, 2016) on the distributional characteristics of Chinese counterfactual elements reveals that, among all the linguistic elements that can enhance and contribute to counterfactuality, discourse context (also known as pragmatic implicature) has the highest frequency of occurrence (90.7%), followed by negation (62.7%) and temporal reference (19.7%), whereas world knowledge comes last (9.3%), despite of it being the most accessible and

effective factor for deriving counterfactuality. This further suggests that Chinese speakers are more frequently engaged in counterfactual thinking in pragmatic-driven, nontransparent contexts, but less engaged in explicit world-violating contexts.

These findings bring us back to the very first empirical study on Chinese counterfactual comprehension by Bloom (1981): when asked the question “if all circles were large and this small ‘ Δ ’ were a circle, would it be large?”, 83% of American college students responded “Yes” to the question, whereas only 25% Chinese students responded in the same way; instead, many of them either rejected or questioned the premise, “How could triangles be circles” or “but triangles are not circles.” Chinese participants seem to be reluctant and less common to exercise counterfactual thinking following a nonrealistic premise, probably due to the infrequent exposure and usage of nonrealistic counterfactuals in Chinese speakers’ language experience. Although these previous studies did not directly address the real-time cognitive process underlying Chinese counterfactuals, they provided some evidence that Chinese counterfactuals are specifically context-dependent and pragmatically driven. From the perspective of language processing, according to the graded salience hypothesis (Giora, 1997), conventionality, frequency, familiarity, and prototypicality determine the salience of a linguistic code. The more salient a language input is coded, the faster its meaning will be accessed. In this regard, the semantic retrieval of a word from long term memory depends on the learned relationship between the target word and a given situation/discourse model. As the nonrealistic counterfactuals depicting surreal events involve less common situation models, its semantic retrieval might not be as strong and as quick as for counterfactuals set in realistic and everyday situations. In this case, the effect of context transparency on counterfactual processing might exhibit a different pattern in Chinese as compared with Indo-European languages.

The Present Study

This study addresses the role of counterfactual context transparency in Chinese counterfactual comprehension. Specifically, we aimed to investigate whether and how Chinese speakers exhibit different processing patterns in transparent and nontransparent counterfactual contexts. The operational definition of *counterfactual transparency* in the current study is how easily counterfactuality can be detected, that is, whether the reader can easily and clearly tell that the situation described by the statement is different from the factual world. Ideally, we want to compare semantically matched expressions that only differ in how transparently counterfactuality is expressed by means of adding or removing some counterfactual elements such as modals or adverbials signaling past tense. However, due to the lack of dedicated counterfactual markers in Chinese, counterfactuality is typically derived from a combination of counterfactual enhancing elements: the removal of an element not only leads to a change in transparency but also a cancellation of counterfactuality, which makes it an open hypothetical statement (Yong, 2016). Due to this limitation, we manipulated the transparency of the context essentially based on whether the antecedent event of the counterfactual conditional was a plausible real-world event (e.g., “If better preparations were made at that time”; see Table 1) or an implausible event (e.g., “If everything in the world could go back in time”). To minimize confound-

Table 1*Example Stimuli and Approximate Translations by Condition*

Condition	Example stimuli
Transparent-congruent	A: 如果时光 可以倒流,我就能把握住这个难得的机会了。 A: ruguo shiguang keyi daoliu, wo jiuneng bawozhu zhege nandede jihui le A: If everything in the world could go back in time, I would be able to grasp this valuable opportunity. B: 真的/为你/感到/可惜。 B: zhende/weini/gandao/ <u>kexi</u> B: I really feel <u>sorry</u> for you.
Transparent-incongruent	A: 如果时光 可以倒流,我就能把握住这个难得的机会了。 A: ruguo shiguang keyi daoliu, wo jiuneng bawozhu zhege nandede jihui le A: If everything in the world could go back in time, I would be able to grasp this valuable opportunity. B: 真的/为你/感到/高兴。 B: zhende/weini/gandao/ <u>gaoxing</u> B: I really feel <u>happy</u> for you.
Nontransparent-congruent	A: 如果那时好好准备,我就能把握住这个难得的机会了。 A: ruguo nashi haohao zhunbei, wo jiuneng bawozhu zhege nandede jihui le A: If better preparations were made at that time, I would be able to grasp this valuable opportunity. B: 真的/为你/感到/可惜。 B: zhende/weini/gandao/ <u>kexi</u> B: I really feel <u>sorry</u> for you.
Nontransparent-incongruent	A: 如果那时好好准备,我就能把握住这个难得的机会了。 A: ruguo nashi haohao zhunbei, wo jiuneng bawozhu zhege nandede jihui le A: If better preparations were made at that time, I would be able to grasp this valuable opportunity. B: 真的/为你/感到/高兴。 B: zhende/weini/gandao/ <u>gaoxing</u> B: I really feel <u>happy</u> for you.

Note. Critical words are underlined for expository purposes.

ing semantic differences, we kept the consequent event following the antecedent sentence the same (“I would be able to grasp this valuable opportunity”). In addition, the critical word was in a separate reply sentence (“I really feel sorry/happy for you”) that probed the understanding of this consequent event (whether the person actually got that valuable opportunity or not). In this way, we investigated whether and how people follow different processing routes to arrive at the counterfactual interpretation of the same event in different contexts that vary in transparency. We used sentences in a dialogue form rather than a continuous narrative to keep the discourse more natural: our stimuli included a counterfactual to factual world shift, that is, readers needed to shift from the unreal world representation to the real world representation. A dialogue is more natural to realize this shift, because in conversations people typically follow the cooperative principles to infer the interlocutor’s intended meaning (Grice, 1975). By mimicking a social interactive situation in our discourses, we intended to keep the information flow smoother and the counterfactual interpretation clearer.

We measured participants’ neural activity while they read transparent and nontransparent counterfactual dialogues containing critical words belonging to word pairs (e.g., *sorry* and *happy*; see Table 1). The critical words rendered the dialogue congruent or incongruent with the preceding context, respectively. Based on previous ERP studies concerning counterfactual processing (Dai et al., 2019; Ferguson & Cane, 2015; Ferguson & Sanford, 2008; Nieuwland, 2013; Nieuwland & Martin, 2012), we focus on the N400 and P600 components. N400 has historically been an index of semantic violation (e.g., “He spread the warm bread with socks”; Kutas & Hillyard, 1980). Its amplitude is sensitive to a variety of semantic factors, especially the degree to which a word can be predicted from the preceding context (e.g., Brouwer et al.,

2017; Brouwer et al., 2012; Kutas & Federmeier, 2000, 2011; Lau et al., 2008). The N400 is thus usually interpreted to reflect the process of semantic access/retrieval (Brouwer et al., 2012; Kutas & Federmeier, 2000, 2011; Lau et al., 2008; van Berkum, 2009, 2010; see also semantic integration account of N400, Hagoort et al., 2004; van Berkum & Hagoort, 1999). The P600, on the other hand, was initially associated with cost of syntactic repair or reanalysis (e.g., Friederici, 1995; Hagoort et al., 1999; Kaan & Swaab, 2003; Osterhout & Holcomb, 1992). More recent findings show that P600 effects are also elicited in response to semantic reversal anomalies, figurative meaning or pragmatic inference (Delogu et al., 2018; Kim & Osterhout, 2005; Regel et al., 2011), supporting the interpretation of the P600 as an index of semantic/discourse integration process at the global discourse level (e.g., Bornkessel-Schlesewsky & Schlewsky, 2008; Brouwer et al., 2012, 2017). In the current study, we evaluated how semantic anomalies in Chinese counterfactuals are processed, as manifested by N400/P600 effects, and whether the processing patterns are modulated by counterfactual context transparency.

From the perspective of semantic accessibility, in the transparent context (e.g., “If everything in the world could go back in time”), the antecedent event itself is sufficient to establish counterfactuality, as the information for detecting counterfactuality is highly accessible and easily retrieved. We expect this to make it easy to detect semantic/discourse inconsistency, resulting in a pronounced N400 effect or P600 effect. In the nontransparent counterfactual context, without world knowledge and explicit linguistic cues (e.g., subjective mood), readers need to engage more cognitive resources for processing the implicit information of the context to obtain the intended communicative meaning, and generate new specific representations of counterfactual/factual world, which could compete with each other and reduce the inconsistency

effect. As a consequence, we expect that the N400/P600 effect evoked by semantic/discourse inconsistency would be reduced or even disappear.

Hypotheses based on a usage-based perspective, however, lead to a different prediction. Usage-based approaches to language hold that language processing is intimately tuned to input frequency. More frequently occurring constructions will be processed faster than low frequency ones. As Chinese counterfactuals are mostly uttered in everyday situations to express personal feelings, and the close-to-fact counterfactuals involve only a minimal change from reality (Lewis, 1973; Yuan, 2015; Yuan & Zhang, 2016), comprehension of this kind can thus be directly mapped onto reader's real life experiences, demanding less cognitive effort to alter existing knowledge of the real world, compared to the counterfactuals depicting novel scenarios that violate world knowledge. As mentioned above, previous studies have also suggested that Chinese speakers seldom produce abstract and surreal counterfactuals about nonrealistic events for pure logical reasoning (Wu, 1994; Yuan, 2015; Yuan & Zhang, 2016). If this is the case, Chinese speakers will be more familiar with semantic processing in realistic, pragmatic-driven counterfactual scenarios, and the anomaly detection effects should be more pronounced in nontransparent contexts compared to transparent contexts.

Method

Participants

Thirty-two native Chinese speakers, all of whom gave written informed consent, volunteered to participate in the present study. Participants were compensated for their participation. Four participants were excluded from data analysis due to excessive artifacts in the electroencephalogram (EEG), leaving 28 participants in the final analysis (10 men; M age = 22.12 years, range = 18–28 years). All participants reported being right-handed, having normal or corrected-to-normal vision and no history of neurological or psychiatric disorders. This study was carried out in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of Nanjing Normal University.

Materials

Written Chinese dialogue quadruplets (140) were constructed as shown in Table 1 (see Appendix for more examples). Each dialogue consisted of a sentence from Speaker A (e.g., "If everything in the world could go back in time, I would be able to grasp this valuable opportunity"), which introduced a counterfactual scenario, and a reply sentence from Speaker B (e.g., "I really feel sorry for you"), which contained the critical word in the sentence-final position. The critical word was either congruent or incongruent with the preceding context (e.g., *sorry* vs. *happy*). Crucially, the initial subordinate clause ("if . . .") of Speaker A's statement set up a transparent or nontransparent counterfactual context (as confirmed by the Context Transparency Rating Test), followed by a main clause which described a consequence resulting from the premise. This resulted in a within-subject design that crossed counterfactual context (transparent vs. nontransparent) and congruency (congruent vs. incongruent). In a transparent context (e.g., "If everything in the world could go back in time . . ."), the

information needed to identify counterfactuality can be directly drawn from our general world knowledge, which is highly accessible and well entrenched. That means, the initial subordinate clause by itself is sufficient to establish a counterfactual proposition even without the following main clause. In a nontransparent context (e.g., "If better preparations were made at that time . . ."), however, although the general area of the scenario is familiar to or can be well understood by readers, the specific events were not. Identification of the assertion as a counterfactual must be derived from pragmatic inference of linguistic cues and contextual information of the whole conditional sentence. In short, what differs between these two contexts is the immediacy and accessibility of the information that is needed for detecting counterfactuals.

Experimental items were normed on sentence counterfactuality, dialogue acceptability, cloze probability, context transparency, semantic relatedness, and context familiarity, as we describe in more detail in the following text. We excluded quadruplets with low counterfactuality and cloze probability or containing congruent/incongruent dialogues of which the acceptability was rated below/over 4 (based on a 7-point Likert scale). In the 120 quadruplets selected for the main study, transparent and nontransparent counterfactual dialogues had similar ratings and cloze values across congruent/incongruent conditions. Critical words were also matched across conditions for word length, number of strokes, and mean log frequency (see Table 2; $ps > .10$). The context transparency, semantic relatedness, and context familiarity normings were conducted on these 120 quadruplets only.

Sentence Counterfactuality Rating

Due to the lack of dedicated counterfactual markers in Chinese, we first conducted a sentence counterfactuality rating test to examine whether the statement from Speaker A was unambiguously interpreted as counterfactual. Testing sentences (Speaker A's words only) together with filler sentences, were divided into two versions using a Latin square method. Fifty-four participants evaluated the factuality of a short statement (e.g., "I got this valuable opportunity") based on its corresponding sentence (e.g., "If better preparations were made at that time, I would be able to grasp this valuable opportunity"), using a 7-point Likert scale (1 = *not real, counterfactual*, 7 = *definitely happened and real*). The pairwise t test was conducted allowing generalization by item. In the ultimate set of experimental stimuli, transparent and nontransparent conditions of Speaker A's statements were equally interpreted as counterfactuals (M rating = 1.2 vs. 1.3), $t(119) = -1.357$, $p > .10$.

Context Transparency Rating

A norming study on the critical manipulation, context transparency, was conducted to examine whether the counterfactual mean-

Table 2
Mean Scores and Standard Deviations of Stroke Number and Word Frequency for Critical Words in Congruent and Incongruent Conditions

Condition	No. of strokes		Word frequency	
	M	SD	M	SD
Congruent	18.1	6.5	2.6	0.9
Incongruent	18.8	7.1	2.5	1.0

ing was already clearly established in the context clause of the counterfactual utterance (the antecedent *if*-clause was extracted from Speaker A's utterance, e.g., "If better preparations were made at that time"). Thirty participants who did not participate in any of the other rating studies were asked to evaluate the factuality of a short statement (e.g., "Better preparations were made at that time") based on a given antecedent clause (e.g., "If better preparations were made at that time . . ."), using a 7-point Likert scale (1 = *did not happen, counterfactual*, 7 = *definitely happened and real*). Experimental items were divided into two versions using a Latin-square design and interleaved with filler items. A pairwise *t* test was conducted allowing generalization by item. The pairwise *t* test showed that the transparent conditions were rated significantly lower in factuality than the nontransparent conditions (M rating = 1.1 vs. 3.1), $t(119) = -45.303$, $p < .001$, suggesting that the antecedent clauses set up a counter-to-fact proposition in transparent context but not in nontransparent context.

Dialogue Acceptability Rating

To make sure that the manipulation of context transparency did not affect dialogue plausibility, 32 participants who did not take other tests evaluated the overall acceptability of each dialogue using a 7-point rating scale (1 = *least acceptable*, 7 = *most acceptable*). They were instructed to evaluate the overall acceptability based on whether the dialogue sentences were semantically coherent, grammatically correct, and pragmatically appropriate. Both congruent and incongruent versions were tested. Dialogues were divided into four counterbalanced lists with fillers. The item-based analysis of variance (ANOVA) revealed a significant main effect of congruency: The dialogues containing congruent critical words were more acceptable ($M_{\text{transparent}} = 6.36$; $M_{\text{nontransparent}} = 6.37$) than dialogues containing incongruent words ($M_{\text{transparent}} = 1.33$; $M_{\text{nontransparent}} = 1.32$), $F(1, 119) = 11306.103$, $p < .001$, but Context Transparency or the Transparency \times Congruency interaction did not influence ratings ($F_s < 1$, $p_s > .10$), suggesting that our stimuli are matched in terms of dialogue plausibility across transparent and nontransparent contexts.

Cloze Probability Rating

To evaluate the extent to which the critical words are predictable, 30 different participants were invited to complete one of the two lists with one version of each item truncated before critical word. They were asked to complete the dialogue with the first sensible word that came to mind. Cloze probability was calculated as the percentage of people who used the intended critical word. The item-based ANOVA showed that participants were significantly more likely to complete sentences with congruent critical words ($M_{\text{transparent}} = 46\%$; $M_{\text{nontransparent}} = 45\%$) than with incongruent critical words ($M_{\text{transparent}} = 0$; $M_{\text{nontransparent}} = 0$), $F(1, 119) = 418.453$, $p < .001$. However, context transparency (transparent vs. nontransparent) did not modulate this difference ($F_s < 1$, $p_s > .10$).

Semantic Relatedness Rating

As we used different antecedent events to manipulate context transparency, their semantic relatedness or causal relation with the consequent event might have been different between the two contexts and might have led to an undesired confound. To evaluate

this concern, we conducted a norming study to examine the semantic relatedness between antecedent and consequent event. Thirty-five native Chinese speakers who did not participate in any of the other tests evaluated the semantic relatedness of two events (e.g., Event 1: "I made better preparations at that time"; Event 2: "I grasped this valuable opportunity"). More specifically, they were asked to rate the likelihood that the two sentences occur in the same/common discourse context on a 7-point Likert scale (1 = *not related at all, cannot occur in the same discourse*, 7 = *very related, definitely can occur in the same discourse context*). The experimental event-pairs were divided into two versions using a Latin-square design and interleaved with filler items. The item-based pairwise *t* test showed that semantic relatedness is not significantly different between the transparent and nontransparent conditions (M rating = 5.4 vs. 5.5), $t(119) = -0.941$, $p > .10$.

Context Familiarity Rating

From the usage-based perspective, the frequency of language input, or people's lifetime experience with the pattern of language input, will modulate language processing. To further test whether input frequency/familiarity with the context played a role in our materials, we conducted another norming study in which another group of 30 native Chinese speakers was asked to rate the familiarity of Speaker A's utterances (e.g., "If better preparations were made at that time, I would be able to grasp this valuable opportunity"). Participants were instructed to base their ratings on the extent to which they encounter such utterances in daily conversations or texts using a 7-point Likert scale (1 = *very awkward, people rarely say or write things like this*, 7 = *very natural and readable, commonly seen or heard*). Pairwise *t* test showed that the transparent counterfactuals were regarded as less common ($M = 5.6$) than nontransparent counterfactuals ($M = 6.1$). This difference was significant, $t(119) = -5.103$, $p < .001$. Although the numerical difference between the ratings is rather small, this finding does suggest that counterfactuals set in nontransparent contexts are generally more familiar to Chinese speakers.

For the ERP experiment, four lists were created using a Latin square design, with each list containing 120 experimental items (30 per condition). To avoid that participants would place undue emphasis on experimental manipulation or adopt certain processing strategies, 120 filler dialogues were constructed and randomly interspersed among experimental items, including 30 real-world causal context dialogues (e.g., *because*), 30 real-world adversative context dialogues (e.g., *but*), 30 concessive context dialogues (e.g., *even if*), and 30 dialogues with no explicit conjunctions to denote coherence relation. Equal numbers of participants were randomly assigned to one of the four counterbalanced lists.

Procedure

Participants were seated in a sound attenuated, dimly lit room. They were instructed to read sentences carefully and silently from a monitor and answer a yes/no comprehension question when prompted. Each trial began with the presentation of a centrally located fixation cross for 500 ms, followed by a blank screen for 500 ms. Next, Speaker A's statement was presented on the screen in its entirety. After finishing reading this sentence, participants immediately pressed the spacebar to initiate Speaker B's reply, which was presented segment by segment in the center of the

screen. Each segment was presented for 400 ms followed by a blank screen for another 400 ms. For the purpose of keeping participants focused and attentive, half of the dialogues were followed by a yes/no comprehension question that probed the understanding of either Speaker A's statements (e.g., "The camping trip has to be canceled") or Speaker B's reply (e.g., "We do not agree to cancel the trip," after the dialogue, i.e., Speaker A: "There is a hurricane on the way, so we have to cancel our camping trip." Speaker B: "Ok, we all agree on that."). The assignment of yes/no responses to the left/right buttons was counterbalanced across participants.

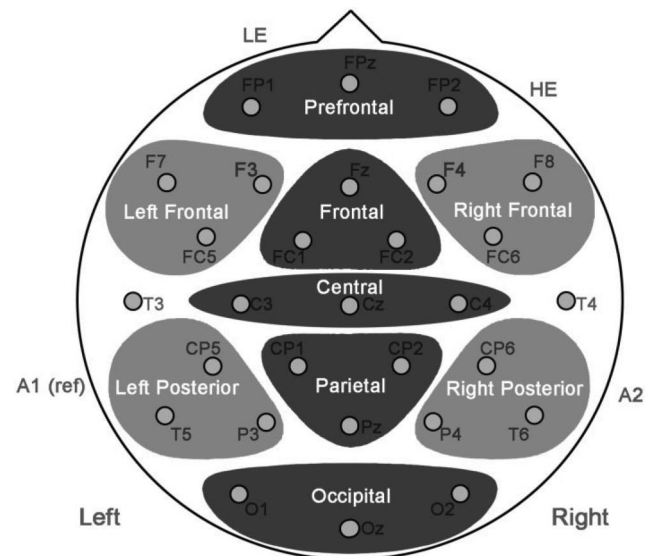
The experimental session began with a practice run of 15 dialogues which had similar structures as the test stimuli, after which participants were presented with four blocks of 60 dialogues each. Participants took a 3-min to 5-min break between blocks. Formal experiment lasted approximately 2 hr per participant, including set-up.

The Electroencephalogram (EEG) Recording and Data Analysis

EEG was recorded from 29 tin electrodes mounted in a secured elastic cap (Electro-cap International), digitized with a sampling rate of 500Hz and filtered with a 0.016-70Hz band-pass filter. The EEG was referenced online to the tip of nose and rereferenced offline to the algebraic average of the activity measured in the left mastoid and right mastoid. The electrooculographic (EOG) activity was recorded using vertical and horizontal bipolar electrodes placed above the right eye and at the outer canthus of the left eye. Impedance was kept below 5 k Ω . Automatic combined with manual rejection was carried out to exclude periods containing artifacts (motion, EOG artifact, or technical problems). Trials with incorrect responses in the comprehension task were also discarded from statistical analysis. This procedure resulted in a loss of 12% of trials per condition, on average. The ERPs to critical words were measured in 1,000-ms epochs (starting 200 ms before critical word onset, which was used as baseline).

Mean amplitudes per condition were calculated on critical words in two time windows based on prior literature: 300 ms to 500 ms to capture the N400 (e.g., Fields & Kuperberg, 2015; Wittenberg et al., 2014) and 500 ms to 800 ms for the P600 (e.g., Nieuwland, 2014; Osterhout & Mobley, 1995). Scalp distributions of effects were examined using electrodes grouping into regions of interest (ROIs; Fields & Kuperberg, 2015; Wittenberg et al., 2014; see Figure 1). The scalp surface was thus subdivided into regions along the anterior-posterior distribution, at both midline and lateral sites. Two omnibus analyses of variance (ANOVAs), one covering the midline regions and the other covering the lateral regions, were conducted in each time window. In the midline regions ANOVA, context type (transparent, nontransparent), congruency (congruent, incongruent), and region (prefrontal, frontal, central, parietal, occipital) were within-subjects factors. In the lateral regions ANOVA, region had two levels (frontal, posterior), and hemisphere (left, right) was an additional within-subjects factor. The Greenhouse-Geisser correction was performed when appropriate.

Figure 1
Electrode Configuration and ROI Clusters Used for Statistical Analyses



Note. Dark gray = midline regions; light gray = lateral regions; ROI = regions of interest.

Results

Behavioral Results

The average comprehension accuracy and response time for each condition are shown in Table 3. For comprehension accuracy, ANOVAs involving context type and congruency revealed a significant main effect of context type, $F(1, 27) = 5.854, p = .023, \eta^2 = 0.178$, with higher accuracy for transparent context than for nontransparent context; and a main effect of congruency, $F(1, 27) = 21.267, p < .001, \eta^2 = 0.441$, with higher accuracy for congruent dialogues than for incongruent dialogues. With regard to response time, there was only a main effect of congruency, $F(1, 27) = 17.697, p < .001, \eta^2 = 0.396$, suggesting that congruent dialogues were generally easier to understand than incongruent dialogues.

Electrophysiological Results

Grand average ERPs, time-locked to the critical word and topographic maps of the 300-ms to 500-ms/500-ms to 800-ms time windows, illustrated in Figure 2, showed that the congruency effect differed between transparent and nontransparent context. While semantic incongruency evoked P600 effects in transparent contexts, N400 effects were obtained in the nontransparent contexts.

The 300-ms to 500-ms Time Window (N400)

For midline electrodes, repeated measures ANOVA revealed a Context Type \times Congruency \times Region interaction, $F(4, 108) = 3.145, p = .048, \eta^2 = 0.112$. Resolving the three-way interaction by ROI revealed a Context Type \times Congruency interaction in the central, $F(1, 27) = 3.969, p = .056, \eta^2 = 0.128$, parietal, $F(1, 27) = 4.392, p = .046, \eta^2 = 0.140$, and occipital regions, $F(1,$

Table 3

Mean Percentage of Accuracy and Response Time for Each Condition

Condition	Accuracy (%)		Response time (ms)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Transparent-congruent	99	2.1	931	207
Transparent-incongruent	95	6.6	1101	202
Nontransparent-congruent	97	2.8	942	164
Nontransparent-incongruent	93	5.0	1138	210

27) = 4.377, $p = .046$, $\eta^2 = 0.139$. Follow-up comparisons examining the effects of congruency showed that larger negative responses were evoked by incongruent words than congruent words in nontransparent context in the central, $F(1, 27) = 6.800$, $p = .015$, $\eta^2 = 0.201$, and parietal regions, $F(1, 27) = 6.754$, $p = .015$, $\eta^2 = 0.200$, whereas no difference effects were found between them in transparent context ($ps > .10$). Comparing the effect of transparency within each congruency condition (transparent-congruent vs. nontransparent-congruent; transparent-incongruent vs. nontransparent-incongruent) revealed no significant differences ($ps > .10$).

The analysis of lateral electrodes revealed a robust Congruency \times Hemisphere interaction, $F(1, 27) = 8.860$, $p = .006$, $\eta^2 = 0.247$, and a marginally significant two-way interaction between context type and congruency, $F(1, 27) = 3.671$, $p = .066$, $\eta^2 = 0.120$. Follow-up analysis resolving the interaction between congruency and hemisphere revealed that incongruent words evoked larger N400s relative to congruent words over the right hemisphere, $F(1, 27) = 4.293$, $p = .048$, $\eta^2 = 0.137$. Comparisons resolving the Context Type \times Congruency interaction showed that incongruent words elicited a larger N400 relative to congruent words in the nontransparent context, $F(1, 27) = 4.970$, $p = .034$, $\eta^2 = 0.155$. No other comparisons reached significance ($ps > 0.1$).

The 500-ms to 800-ms Time Window (P600)

Midline analysis revealed a significant Context Type \times Congruency interaction, $F(1, 27) = 7.311$, $p = .012$, $\eta^2 = 0.213$. Further analyses resolving the two-way interaction showed that enlarged positivities were elicited by the incongruent words relative to congruent words in the transparent condition, $F(1, 27) = 4.855$, $p = .036$, $\eta^2 = 0.152$, but not in the nontransparent condition ($p > .10$). Comparing the effect of transparency for each congruency condition revealed that congruent words evoked a larger P600 in the nontransparent context relative to the transparent context, $F(1, 27) = 4.921$, $p = .035$, $\eta^2 = 0.154$; incongruent words showed the reverse pattern: a larger P600 was elicited in the transparent context compared to the nontransparent context, $F(1, 27) = 4.996$, $p = .034$, $\eta^2 = 0.156$.

For the lateral electrodes, there was also a significant interaction between context type and congruency, $F(1, 27) = 6.005$, $p = .021$, $\eta^2 = 0.182$. Further analysis to resolve the interaction revealed that a larger P600 was elicited by incongruent words relative to congruent words in transparent context, $F(1, 27) = 4.190$, $p = .050$, $\eta^2 = 0.134$, but no significant difference between the two

conditions in the nontransparent context ($p > .10$). No other effects were significant.

Discussion

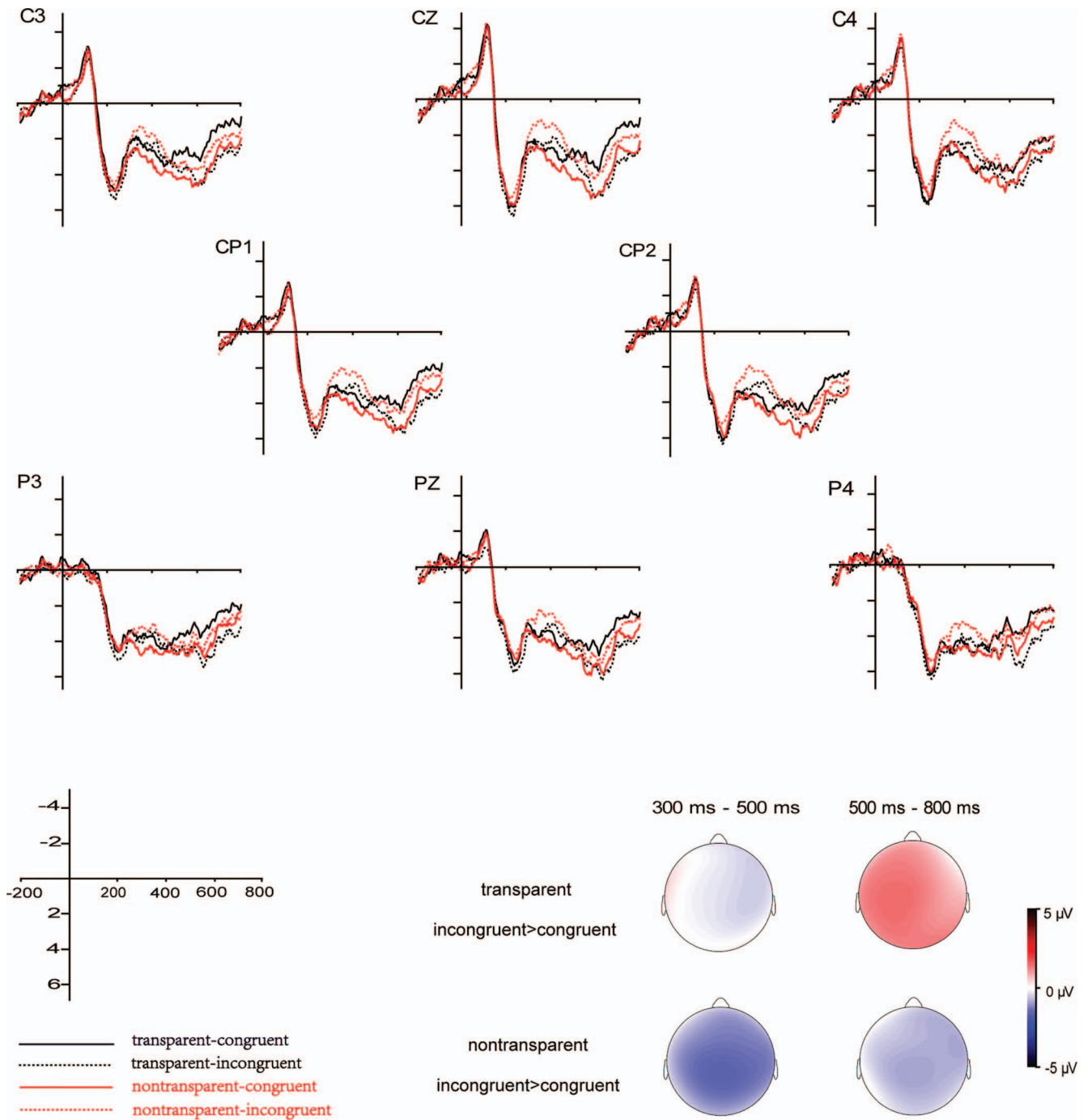
The present study investigated the role of context transparency on the comprehension of Chinese counterfactuals. We measured participants' neural activity while they read transparent and non-transparent counterfactual dialogues that contained discourse congruent or incongruent target words. Our study yielded two main findings. First, Chinese readers showed rapid brain responses (N400, P600) to contextual incongruity in both nontransparent and transparent contexts. We take this to argue against disruption by competing representations during counterfactual discourse comprehension. Chinese speakers can rapidly map incoming utterances onto the unfolding counterfactual discourse and make appropriate inferences to predict and interpret subsequent narratives. Second, and more importantly for the purpose of this study, the effect of incongruity was different depending on whether the counterfactual used in the dialogue was transparent or nontransparent. Specifically, incongruent critical words elicited a P600 effect in the transparent contexts, while an N400 effect was obtained in the nontransparent contexts. This suggests that transparency of counterfactuality can influence both the process and the time course of online counterfactual comprehension. Following the two-stage model of sentence processing (i.e., the retrieval-integration model; Brouwer et al., 2012, 2017), our results suggest that the semantic anomaly is detected or evaluated from the early moment of semantic retrieval for nontransparent counterfactuals, but only in a later integrative stage for transparent counterfactuals. We elaborate on this in the following text.

Dual Meaning and Counterfactual Processing

One central notion of counterfactual processing is the dual representation hypothesis (see mental model theory from Johnson-Laird & Byrne, 1991, 2002 and the mental space framework from Fauconnier, 1994, 1997), that is, people maintain and update two representations during counterfactual processing: a presupposed factual event and an imagined alternative. This makes counterfactual a good test for the ongoing debate about the competition between factual world knowledge and contextual information in incremental sentence build-up. In the present study, we present participants a counterfactual scenario followed by a statement referring to the implied factual world. We observed rapid brain responses to words that were semantically anomalous, although distinct neural signatures were observed in transparent contexts (P600 effects) and nontransparent contexts (N400 effects). This suggests that ongoing semantic processing is not impeded by the dual meaning, and the factual world representation is quickly accessed and integrated into discourse context, without being hindered by the literal suppositional representation. This complements previous evidence that people can rapidly accommodate a real-world anomalous counterfactual representation without interference from real-world knowledge (e.g., "If dogs had gills, Dobermans would breathe under water," Nieuwland, 2013; Nieuwland & Martin, 2012; Warren et al., 2008). Our results therefore add to the argument that people can access and evaluate information based on the fit with counterfactual world in the same time-

Figure 2

Waveforms Showing the Grand Average ERPs Elicited by Critical Words per Condition at Eight Selected Electrodes



Note. Stimuli consist of transparent and nontransparent counterfactual dialogues containing a sentence-final word which was either congruent or incongruent with the discourse context. Scalp distributions of the congruency effects (incongruent minus congruent conditions) in the 300-ms to 500-ms and the 500-ms to 800-ms time windows are shown in the lower left part of the figure. ERPs = event-related potentials. See the online article for the color version of this figure.

frame as they make inferences about reality (Ferguson et al., 2019).

On the other hand, some other studies failed to find anomaly effects in counterfactual contexts, suggesting competition between

the factual and counterfactual representations. For instance, a recent ERP investigation found that when reference to the counterfactual world switched back to the factual world in the target sentence (e.g., “If David had been wearing his glasses, he would

have read the poster easily. From this distance, David found that the words were *clear/blurry*.”), readers showed no difference in their brain responses to congruent and incongruent critical words, suggesting that they simultaneously evaluated upcoming information against both possible worlds and experienced interference in ongoing semantic processing (Ferguson & Cane, 2015). This is different from the immediate anomaly detection effects in the present study. A closer look at the norming data of Ferguson and Cane (2015) reveals that the cloze probability of critical word in counterfactual-factual congruent and incongruent condition was 33.6% versus 11.3%, and the plausibility rating did not vary greatly between critical word pairs (0.77 for congruent condition and -0.26 for incongruent condition, using a -2 to $+2$ rating scale). Therefore, the salience of either representation (i.e., the factual representation “blurry” and suppositional representation “clear”) might not be strong enough to dominate processing and consequently lead to an interference effect. However, the cloze probability and plausibility of the critical word in the present study are very high in both transparent context (45% vs. 0%; 6.36 vs. 1.33, using a 1 to 7 rating scale) and nontransparent context (46% vs. 0%; 6.37 vs. 1.33). The strength of contextual constraints on the critical word might explain the between-experiment discrepancy: when the constraint is weak, there are not enough contextual cues to rapidly resolve the activated dual meanings, resulting in delayed or disrupted truth-value computation; when the constraint is strong, contextual discourse can guide predictions toward the intended counterfactual representation and overrule the interference from the alternative representation, leading to rapid detection of the contextual incongruency. This is consistent with memory-based view of text processing: both contextual information and real world knowledge are immediately available to readers, meaning that either source of information can dominate initial processing, depending on the strength of memory trace and its feature overlap with incoming information (e.g., Albrecht & O’Brien, 1991; Myers et al., 2000; O’Brien & Cook, 2016). Stronger contextual constraints (either local or global level constraint) will have the potential to influence the earliest moment of text processing (Kendeou et al., 2013).

It should be noted that we do not intend to suggest that dual meanings are not activated during counterfactual comprehension at all, or that our results suggest a similar processing mechanism underlying counterfactuals and simple declarative sentences. Instead, we interpret the present findings on Chinese counterfactuals as similar to those from previous studies on Indo-European counterfactuals (Nieuwland, 2013; Nieuwland & Martin, 2012): given a sufficiently constraining context, people can quickly incorporate incoming information into the counterfactual discourse and make contextually appropriate inferences using cues from the evolving linguistic input. Since the critical word we manipulated is in a sentence following a prior counterfactual context, it is possible that dual meanings are initially activated, but when contextual cues become evident and constraining enough in successive narrative to trigger a specific interpretation (i.e., counterfactual-world or implied factual-world interpretation of the following event), readers will suppress access to one world and shift to the preferred world for parsing incoming information.

Counterfactual Transparency Modulating Online Discourse Comprehension

Although semantic processing was not disrupted by the dual nature of counterfactuality in both contexts, distinct neural signatures were elicited by incongruent words in transparent (P600 effects) and nontransparent (N400 effects) counterfactual contexts, suggesting that processing the semantic anomaly engaged different mechanisms in the two contexts. Traditionally, the N400 has been associated with semantic processes (e.g., Brown & Hagoort, 1993, 1999) and the P600 with syntactic processes (e.g., Brown & Hagoort, 1993, 1999; Friederici, 1995; Hagoort et al., 1999). However, our two transparency conditions do not differ with respect to the syntax of the target sentence. An explanation in terms of semantic versus syntactic integration therefore does not apply.

Instead, our results can be better accommodated within the Retrieval-Integration account of sentence processing (Brouwer et al., 2012, 2017), which was motivated by the “semantic P600” effect. The semantic P600 is frequently observed in syntactically well-formed but semantically anomalous or complex sentences. For instance, in a study that examined semantic illusions, Nieuwland and Van Berkum (2005) found a P600 effect rather than a N400 for semantic anomalous words (e.g., “Next, the woman told the *suitcase*” following a travel related scenario). The absence of an N400 effect was explained in terms of the semantic association between the critical word and context, so there was no linking problem in the retrieval process. The presence of a P600 rather suggests that the anomaly was dealt with at the discourse integration process. Indeed, more ERP evidence speaks to an access/retrieval account of the N400 (Delogu et al., 2019; Kutas & Federmeier, 2000, 2011; Lau et al., 2008; van Berkum, 2009, 2010), and a combinational/integration account of the P600 (Bornkessel-Schlesewsky & Schlewsky, 2008; Brouwer et al., 2012; Kuperberg, 2007). Kuperberg (2007) proposed that language comprehension engages at least two processing streams. One stream is the semantic memory-based system that compares lexical information of an incoming word with the existing information that is already activated and stored in semantic memory. The N400 component is considered closely related to this processing route. The other stream is a combinational process that integrates incoming words into the unfolding sentence representation on basis of multiple constraints. This route determines the final interpretation of the sentence and is proposed to be reflected in the P600 component. Kuperberg’s approach was centered around thematic and morphosyntactic constraints. The Retrieval-Integration model of sentence processing extends this proposal by covering a broader language comprehension scope, including syntactic, semantic and pragmatic phenomena (Brouwer et al., 2012, 2017).

Therefore, assuming a retrieval-integration model, the N400 effect elicited in nontransparent contexts indicates that the conceptual knowledge associated with the incoming words is readily activated/accessed by the preceding discourse information, so an incongruent word incurs immediate processing difficulty in the meaning retrieval phase. The P600 effect in transparent contexts with a lack of an N400 effect suggests that the incongruency is dealt with in the integration phase in this context. This semantic P600 effect resembles the effect found in previous studies on semantic illusions (e.g., Hoeks et al., 2004; Kim & Osterhout,

2005; Nieuwland & van Berkum, 2005; Sanford et al., 2011; van Herten et al., 2006). The absence of an N400 effect in the transparent conditions seems to suggest that there is no contextually driven facilitation for congruent compared to incongruent words in the semantic retrieval process. To see whether it is because the congruent word is less primed by the preceding context in transparent relative to the nontransparent condition, we compared the N400 elicited by the congruent words in the transparent versus the nontransparent conditions. Results showed no significant difference, this suggests that the null N400 is not due to the weaker contextual priming of congruent word in transparent context, but that both the congruent and incongruent words were temporarily associated with preceding context information and remained active in semantic memory.

Our results therefore suggest that discourse incongruency incurs processing cost from the early moment of semantic retrieval in nontransparent contexts (N400), while it is detected and evaluated in the subsequent integration process (P600) in transparent contexts. One potential problem with our account is that according to the retrieval-integration model, integration difficulty for semantic violations is indexed by a P600. We however do not observe a P600 in the nontransparent conditions. One possible explanation is component overlap: the P600 effect might have been obscured by the spatiotemporal overlap with a long-lasting negativity (Brouwer et al., 2017; Luck, 2005). An inspection of the waveform (see Figure 2) suggests a prolonged N400, which might attenuate any positive deflection in the late time window. In particular, recent literature on N400 has revealed that sentence plausibility can be associated with a smaller right-lateralized effect that started after the effect of predictability reached its peak and can continue well beyond the typical N400 window (Nieuwland et al., 2019). To explore this, we did a post hoc comparison between the congruent and incongruent nontransparent conditions in the 300-ms to 800-ms time window and found a marginally significant negative effect over the right hemisphere. In this case, the “extended N400 effects” might reflect not only semantic retrieval cost, but also the continued effort to integrate a word with its context (Nieuwland et al., 2019; Romero-Rivas et al., 2017; Van Berkum et al., 2005). However, no matter whether the N400 effects here reflect integration effort, the observation that the discourse incongruency elicited an N400 in the nontransparent and a P600 in the transparent condition suggests that the incongruency was dealt with from an earlier stage (semantic retrieval) in nontransparent than the transparent context.

Differences Between Nontransparent and Transparent Contexts

The question then arises as to why discourse incongruency was detected and processed from the early moment of semantic retrieval in nontransparent contexts but did not elicit an anomaly effect until the integration phase in transparent contexts. This result is inconsistent with our initial prediction from the perspective of semantic transparency: a transparent context will promote semantic processing as counterfactual meaning is more easily accessed from long term memory, but in nontransparent context the counterfactual meaning is achieved through implicit contextual information, which should postpone or attenuate the discourse incongruency effects. The differential ERP effects in the two

contexts cannot be due to differences in plausibility and predictability of critical words between transparent and nontransparent contexts, as our contexts were matched on these factors (see our norming studies). One potentially confounding factor, however, might have been the difference in the semantic relation between the antecedent and the consequent. In the nontransparent context, the antecedent of counterfactual conditional was a possible real-world event (e.g., “If better preparations were made at that time”), whereas in the transparent context it was an impossible surreal event (e.g., “If everything in the world could go back in time”). The semantic relatedness or causal relation with the consequent event (e.g., “I would be able to grasp this valuable opportunity”) might therefore have been different between the two contexts. However, the results from the semantic relatedness norming (see the Materials section) showed that semantic relatedness was not different between the transparent and nontransparent conditions, suggesting that the differences in the ERP effects between the two contexts are not caused by differences in semantic relatedness between the antecedent and consequent events.

A more plausible explanation seems to be related to the cognitive difference underlying the retrieval process. As the memory retrieval of a target word from long term memory depends on learned relation between the target word and a given situation/discourse model, if an uncommon fictional event (i.e., transparent context) is involved in this memory retrieval process, the retrieval process might be hindered in some way. This echoes the proposal from the usage-based approach, that is, language processing is intimately tuned to input frequency. The more frequently we experience a discourse pattern, the more fluently and faster it is processed. Indeed, the result from the familiarity norming test (see the Materials section) supports the view that the counterfactuals in nontransparent contexts are generally more familiar to Chinese speakers. It is also consistent with the findings from corpus studies that Chinese speakers mostly utter counterfactuals in everyday situations for affective functions, but seldom use them to reason about nonrealistic scenarios (Wu, 1994; Yuan, 2015; Yuan & Zhang, 2016).

In the case of Chinese counterfactuals, contextual transparency is therefore tightly related to familiarity and frequency of use. We should point out that the notion of familiarity pertains to the entire counterfactual construction. One might argue that it is the fictional antecedent events (i.e., if one can go back in time) that make the transparent conditions less familiar. However, the context transparency norming revealed that Chinese participants had no trouble judging these surreal antecedents as counterfactual, indicating that such world knowledge (e.g., that people cannot go back in time) is familiar to the participants. Also note that the familiarity rating test is conducted on the whole conditional sentence, but not the antecedent event, therefore the familiarity difference between transparent and nontransparent condition does not result from the fictional antecedents (vs. real-world antecedents), but from the entire discourse model.

Different from the Nieuwland and Martin (2012) study, in which the target sentence probed well-known world knowledge (e.g., “If NASA had not developed its Apollo Project, the first country to land on the moon would have been Russia/America”), the critical word in the current study does not test the understanding of world knowledge, but how people use the outright impossibility of the situation expressed by the anteced-

ent (e.g., one cannot go back in time) to infer the counterfactual reading of a consequent event (e.g., one actually did not grasp the valuable opportunity). Understanding the target word is therefore based on newly constructed local discourse in both transparent and nontransparent context, but people follow different processing routes to arrive at the counterfactual meaning. In transparent contexts, counterfactual reading is accessed through explicit antecedent falsity (i.e., contradicting world knowledge), while in nontransparent context, counterfactual interpretation is derived through implicit contextual information and pragmatic inference. The familiarity difference between the two types of contexts therefore reflects familiarity with the processing routes/counterfactual thinking mode (i.e., the implicit, contextual-driven comprehension mode vs. counterfactual inference based on explicit world-violating information).

Given these observations, the N400/P600 distinction in transparent and nontransparent context can be explained in the following way. As Chinese readers are more familiar with counterfactual thinking in nontransparent context, they are more likely to actively update their discourse representation (factual representation) and inhibit irrelevant representations (suppositional representation) in this context, leading to an immediate memory retrieval N400 effect. On the other hand, the less common discourse model in the transparent (surreal) contexts might prevent readers from making contextually driven predictions about the unfolding discourse. In the latter case all representations (both factual and suppositional representation) remain active in memory until more information comes in to resolve the uncertainty. Therefore, the incongruity effects took place in the discourse integration process (P600), but not the semantic access process (no N400).

We should point out that the present result does not imply that processing nontransparent counterfactuals is easier than processing transparent counterfactuals. Comparing the effect of transparency across the two congruent conditions (transparent-congruent vs. nontransparent-congruent) revealed that congruent critical words elicited larger P600 responses in nontransparent contexts relative to transparent contexts, and behavioral results also showed a slightly lower comprehension accuracy in the nontransparent condition relative to the transparent condition. This suggests that later integrative processing in nontransparent context might engage more complex cognitive operations, probably due to the effort in pragmatic reasoning and updating discourse representation. Therefore, with the present findings we do not intend to suggest that semantic processing is simpler or easier in nontransparent contexts, but that truth-value computation of discourse congruency undergoes differential cognitive processes in transparent and nontransparent contexts, and that semantic incongruity was dealt with from an earlier processing stage in nontransparent counterfactuals.

Concluding Remarks

In conclusion, the present study suggests that, provided a constraining context, the supposed dual nature of counterfactuality does not disrupt discourse-semantic processing, even in a language that has no dedicated linguistic devices for marking counterfactuals. Second, our results suggest that discourse pro-

cessing is modulated by counterfactual transparency in Chinese: in a transparent context, people maintain access to both factual and suppositional representation in the semantic memory, and only update discourse representation when all the information are integrated. Discourse incongruity is therefore evaluated and detected in the integration process. On the other hand, a nontransparent context facilitates the updating of the discourse representation based on preceding linguistic cues and at the same time inhibits the irrelevant representations, leading to an immediate anomaly detection effect in the early semantic access stage. Overall, our results support the view that, as opposed to the Indo-European languages tested thus far, processing counterfactuals in Chinese is highly context- and pragmatics-driven, and that the degree of transparency of the counterfactual can affect the nature of subsequent semantic processing.

One limitation of the present study is that we manipulated contextual transparency by using different types of antecedents in the counterfactual. Even though we matched the two context conditions in plausibility, predictability, and semantic relatedness, we cannot completely exclude that semantic and lexical differences between the antecedent events introduced some confounds. Future studies can disentangle this question by investigating other languages which allow for constructing materials that differ in counterfactual transparency while remaining semantically matched.

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Appendix

Examples of Experimental Sentences

(1) Transparent-Congruent

- A: 如果能预知未来,她当初不会做这个事儿。
- A: If (she) had the ability of predicting future, she wouldn’t have done it at that time.
- B: 是啊,她现在感到很后悔。
- B: Yeah, now she feels very regretful.

(1) Transparent-Incongruent

- A: 如果能预知未来,她当初不会做这个事儿。
- A: If (she) had the ability of predicting future, she wouldn’t have done it at that time.
- B: 是啊,她现在感到很庆幸。
- B: Yeah, now she feels very relieved.

(1) Nontransparent-Congruent

- A: 如果能够冷静些,她当初不会做这个事儿。
- A: If (she) could have calmed down a little bit, she wouldn’t have done it at that time.
- B: 是啊,她现在感到很后悔。
- B: Yeah, now she feels very regretful.

(1) Nontransparent-Incongruent

- A: 如果能够冷静些,她当初不会做这个事儿。

- A: If (she) could have calmed down a little bit, she wouldn’t have done it at that time.
- B: 是啊,她现在感到很庆幸。
- B: Yeah, now she feels very relieved.

(2) Transparent-Congruent

- A: 如果我是万能的超人,就能帮他解决这个大麻烦了。
- A: If I were the almighty Superman, his big trouble would have been solved.
- B: 他现在一定很苦恼。
- B: He must be very upset now.

(2) Transparent-Incongruent

- A: 如果我是万能的超人,就能帮他解决这个大麻烦了。
- A: If I were the almighty Superman, his big trouble would have been solved.
- B: 他现在一定很振奋。
- B: He must be very exhilarated now.

(2) Nontransparent-Congruent

- A: 如果小敏当初愿意帮忙,就能帮他解决这个大麻烦了。
- A: If Min were willing to give him hand at that time, his big trouble would have been solved.
- B: 他现在一定很苦恼。
- B: He must be very upset now.

(Appendix continues)

(2) Nontransparent-Incongruent

- A: 如果小敏当初愿意帮忙,就能帮他解决这个大麻烦了.
- A: If Min were willing to give him a hand at that time, his big trouble would have been solved.
- B: 他现在一定很振奋.
- B: He must be very exhilarated now.

(3) Transparent-Congruent

- A: 如果动物可以说人话,我们之间就可以正常交流了.
- A: If animals could speak human language, we could then have normal conversations.
- B: 是啊,我们之间的沟通很困难.
- B: Yeah, it's hard for us to communicate.

(3) Transparent-Incongruent

- A: 如果动物可以说人话,我们之间就可以正常交流了.
- A: If animals could speak human language, we could then have normal conversations.
- B: 是啊,我们之间的沟通很顺利.
- B: Yeah, it's easy for us to communicate.

(3) Nontransparent-Congruent

- A: 如果黄佳对我们没有偏见了,我们之间就可以正常交流了.
- A: If Huang Jia had no prejudice against us, we could then have normal conversations.
- B: 是啊,我们之间的沟通很困难.
- B: Yeah, it's hard for us to communicate.

(3) Nontransparent-Incongruent

- A: 如果黄佳对我们没有偏见了,我们之间就可以正常交流了.
- A: If Huang Jia had no prejudice against us, we could then have normal conversations.
- B: 是啊,我们之间的沟通很顺利.
- B: Yeah, it's easy for us to communicate.

(4) Transparent-Congruent

- A: 如果人可以选择自己的出生,小薇就不用经历这么多坎坷了.
- A: If people could choose where they come from at birth, Xiaowei wouldn't have experienced so many misfortunes.
- B: 嗯,这孩子的确很苦命.
- B: Yeah, she's really a poor girl.

(4) Transparent-Incongruent

- A: 如果人可以选择自己的出生,小薇就不用经历这么多坎坷了.
- A: If people could choose where they come from at birth, Xiaowei wouldn't have experienced so many misfortunes.
- B: 嗯,这孩子的确很好命.
- B: Yeah, she's really a lucky girl.

(4) Nontransparent-Congruent

- A: 如果当年能有人帮她家一把,小薇就不用经历这么多坎坷了.
- A: If someone could have given her family a hand at that time, Xiaowei wouldn't have experienced so many misfortunes.
- B: 嗯,这孩子的确很苦命.
- B: Yeah, she's really a poor girl.

(4) Nontransparent-Incongruent

- A: 如果当年能有人帮她家一把,小薇就不用经历这么多坎坷了.
- A: If someone could have given her family a hand at that time, Xiaowei wouldn't have experienced so many misfortunes.
- B: 嗯,这孩子的确很好命.
- B: Yeah, she's really a lucky girl.

(5) Transparent-Congruent

- A: 如果人光喝水就能维持生命,我们就不用着急去救她了.
- A: If people could stay alive with only water, we wouldn't rush to save her in such a hurry.
- B: 所以现在时间很紧迫.
- B: So time is urgent at present.

(Appendix continues)

(5) Transparent-Incongruent

- A: 如果人光喝水就能维持生命,我们就不用着急去救她了。
 A: If people could stay alive with only water, we wouldn't rush to save her in such a hurry.
 B: 所以现在时间充足。
 B: So time is sufficient at present.

(5) Nontransparent-Congruent

- A: 如果李辉早些联系好救援队,我们就不用着急去救她了。
 A: If Li Hui had contacted the rescue team earlier, we wouldn't rush to save her in such a hurry.
 B: 所以现在时间紧迫。
 B: So time is urgent at present.

(5) Nontransparent-Incongruent

- A: 如果李辉早些联系好救援队,我们就不用着急去救她了。
 A: If Li Hui had contacted the rescue team earlier, we wouldn't rush to save her in such a hurry.
 B: 所以现在时间充足。
 B: So time is sufficient at present.

(6) Transparent-Congruent

- A: 如果白血病可以不治而愈,欢欢就不用住院化疗了。
 A: If leukemia could be cured without medical treatment, Huanhuan wouldn't need to be hospitalized for chemotherapy.
 B: 嗯,为了这件事她最近总是愁眉不展。
 B: Yeah, she looks miserable for this at present.

(6) Transparent-Incongruent

- A: 如果白血病可以不治而愈,欢欢就不用住院化疗了。

A: If leukemia could be cured without medical treatment, Huanhuan wouldn't need to be hospitalized for chemotherapy.

B: 嗯,为了这件事她最近总是喜笑颜开。

B: Yeah, she looks cheerful for this at present.

(6) Nontransparent-Congruent

- A: 如果之前方姨早些送她去做检查,欢欢就不用住院化疗了。
 A: If auntie Fang had taken her to health examination earlier, Huanhuan wouldn't need to be hospitalized for chemotherapy.
 B: 嗯,为了这件事她最近总是愁眉不展。
 B: Yeah, she looks miserable for this at present.

(6) Nontransparent-Incongruent

- A: 如果之前方姨早些送她去做检查,欢欢就不用住院化疗了。
 A: If auntie Fang had taken her to health examination earlier, Huanhuan wouldn't need to be hospitalized for chemotherapy.
 B: 嗯,为了这件事她最近总是喜笑颜开。
 B: Yeah, she looks cheerful for this at present.

(7) Transparent-Congruent

- A: 如果人一生下来就什么都懂,她就不用去学校上课了。
 A: If human beings were born knowing everything, there would be no need for her to go to school.
 B: 所以去学校上课对她来说是必要的。
 B: So having classes in school is necessary for her.

(Appendix continues)

(7) Transparent-Incongruent

- A: 如果人一生下来就什么都懂,她就不用去学校上课了.
- A: If human beings were born knowing everything, there would be no need for her to go to school.
- B: 所以去学校上课对她来说是多余的.
- B: So having classes in school is needless for her.

(7) Nontransparent-Congruent

- A: 如果慧慧真的能够自学成才,她就不用去学校上课了.
- A: If Huihui had the initiative to be a self-taught talent, there would be no need for her to go to school.
- B: 所以去学校上课对她来说是必要的.
- B: So having classes in school is necessary for her.

(7) Nontransparent-Incongruent

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- B: 所以去学校上课对她来说是多余的.
- B: So having classes in school is needless for her.

(8) Transparent-Congruent

- A: 如果现代生活中没有手机,我们就无法随时保持联系了.
- A: If there were no mobile phones in modern life, we wouldn't be able to keep in touch with each other at any time.
- B: 嗯,现在我们联系起来很方便.

B: Yeah, now our communication is very convenient.

(8) Transparent-Incongruent

- A: 如果现代生活中没有手机,我们就无法随时保持联系了.
- A: If there are no mobile phones in modern life, we wouldn't be able to keep in touch with each other at any time.
- B: 嗯,现在我们联系起来很困难.
- B: Yeah, now our communication is very difficult.

(8) Nontransparent-Congruent

- A: 如果不是给每人派发了对讲机,我们就无法随时保持联系了.
- A: If we hadn't been given the interphones, we wouldn't be able to keep in touch with each other at any time.
- B: 嗯,现在我们联系起来很方便.
- B: Yeah, now our communication is very convenient.

(8) Nontransparent-Incongruent

- A: 如果不是给每人派发了对讲机,我们就无法随时保持联系了.
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