Temporal Relations in Mandarin Chinese

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Temporal connectives play a crucial role in marking the sequence of events during language comprehension, particularly in tenseless languages which lack overt inflectional marking of tense. Mandarin Chinese, for instance, is a tenseless language which does not mark past, present, or future with dedicated morphemes, yet Mandarin speakers successfully comprehend temporal information, largely depending on temporal adverbials (e.g., yesterday, last week), viewpoint aspect morphemes (e.g., 'le' termination or completion, 'zài' ongoing state), and temporal connectives (e.g., 'zhiqian' before, 'zhihou' after).

Keywords: temporal connectives ; world knowledge

1. Introduction

Time is an unbounded dimension. To explore time, people usually rely on a reference point or an anchor for location such as space, albeit abstractly [1][2][3]. Languages often employ two devices to locate situations in time: the grammatical device *tense* and the lexical device *temporal connectives* [4]. Temporal connectives play a pivotal role in marking temporal location, particularly in tenseless languages which lack overt inflectional marking of tense. Mandarin Chinese, for instance, is a tenseless language which does not mark past, present, or future with dedicated morphemes, yet Mandarin speakers successfully comprehend temporal information, largely depending on temporal adverbials (e.g., yesterday, last week), viewpoint aspect morphemes (e.g., '*le*' termination or completion, '*zài*' ongoing state), and temporal connectives (e.g., '*zhiqian*' before, '*zhihou*' after [5][6][7]). In Mandarin, the temporal connectives *zhiqian* (before) and *zhihou* (after) involve the selection of an event over a period of time, which provides important cues to set a time frame [8]. These temporal connectives have been demonstrated to be more difficult to understand than other connectives (e.g., causal connective *because*) [9], yet it remains unclear whether these temporal connectives are processed differently. Although a number of studies have investigated how sentence comprehension is modulated by temporal connectives such as *before* and *after* [10][11][12][13][14][15][16], they have mainly focused on tense languages such as English. It thus remains unclear how temporal connectives are processed in tenseless languages such as Mandarin Chinese.

2. The Comprehension of Before and After

The temporal connectives *before* and *after* are different in expressing iconicity. Linguistically, iconicity is the conceived similarity between the linguistic form and the meaning in the real world [17]. In other words, if the sequencing of clauses described in a sentence is consistent with the sequencing of events occurring in the real world, it is viewed as iconic; otherwise, it is viewed as non-iconic. Suppose *p* occurs before *q*: this temporal sequence can be described by an *after* construction [*After p, q*] in which the temporal order of the event is consistent with the chronological order, and therefore is regarded as iconic. The same event sequence, however, can also be described by a *before* construction [*Before q, p*], in which the sequence of the described clauses is inconsistent with the sequence of occurrence in the real world. It is therefore considered to be non-iconic. Similarly, in a construction in which the temporal connective occurs in the sentence-middle position, [*p before q*] is iconic whereas [*q after p*] is non-iconic (see **Table 1**). Previous studies adopting various approaches have shown that a non-iconic sequence is more difficult to understand than an iconic sequence. For example, Mandler [11] found that participants spent more time reading sentences when the order of occurrence mismatched the order in which they were presented. Münte et al. [12], using the event-related potentials (ERPs) technique, observed a larger sustained negative ERP modulation for non-chronological *before*-sentences (1a) than chronological *after*-sentences (1b) over the left frontal scalp. Interestingly, the ERP difference was significantly correlated with a working memory score. Individuals with higher working memory span showed a more pronounced negative difference between *before* and *after* sentences, suggesting that computing a non-iconic temporal relation places high demands on the working memory system. Ye et al. [16] found that the caudate nucleus and middle frontal gyrus were more strongly activated for processing *before*-clauses than *after*-clauses. Moreover, another line of studies has revealed

that sentence-initial sentences headed by *before* are more difficult to understand than those headed by *after* for young children [18] as well as Parkinson patients [19][20].

Table 1. *Before* and *After* in semantic accounts.

	Semantic Accounts		
	Veridicality	**Iconicity**	**Polarity**
p *before* q	**non-veridical**	**iconic**	**positive**
q *after* p	**veridical**	**non-iconic**	**negative**
***Before* q, p.**	**non-veridical**	**non-iconic**	**positive**
***After* p, q.**	**veridical**	**iconic**	**negative**
q *zhiqian* p	**non-veridical**	**non-iconic**	**positive**
p *zhihou* q	**veridical**	**iconic**	**negative**

Note: *Veridicality* refers to the degree to which an experience, perception, or interpretation accurately represents reality

(1a)*Before* the scientist submitted the article, the journal changed its policy.

(1b)*After* the scientist submitted the article, the journal changed its policy.

The comprehension of *before* and *after* could also be influenced by their position in a sentence. Politzer-Ahles et al. [14] compared the neural correlates of processing *before* and *after* in both sentence-initial (e.g., 1a/b) and sentence-middle positions (e.g., 2a/b). They found that *before* elicited more negative ERP responses than *after* in the sentence-initial position but more positive ones in the sentence-middle position. The result in the sentence-initial context is consistent with previous studies (e.g., [12]), but the sentence-middle result shows the opposite, indicating that ERP modulations elicited by temporal connectives are related to the order in which events are presented.

(2a)The journal changed its policy *before* the scientist submitted the article.

(2b)The journal changed its policy *after* the scientist submitted the article.

The studies addressed so far seem to support the idea that a non-iconic temporal relation is semantically/pragmatically more costly to understand than iconic temporal relation (regardless of connective type). However, despite the difference in expression iconicity, temporal connectives also differ in frequency and polarity, and the explanation based on frequency and polarity will have a different prediction for processing temporal connectives such as *before* and *after*.

According to the polarity-based explanation, *before* shares a similar meaning with *in front of* in the pair *in front of–behind*, in which *in front of* is positive as it is used to describe the visible area of perception, whereas its counterpart *behind* is negative as it describes the invisible area [21][22]. Linguists therefore distinguish them by labeling *before* as positive and *after* as negative. Indeed, psycholinguistic evidence has demonstrated that people tend to acquire positive words such as *before* more easily than negative words such as *after* [23]. In an early behavioral study, Clark [10] found that children had greater difficulty comprehending *after*-clauses than *before*-clauses.

With regard to frequency of use as temporal connectives, *after* is used less often than *before* in both adults and children's language usage [24][25][26]. Besides functioning as a temporal connective, *after* is more frequently used as a preposition (like *behind*), and therefore has a less consistent mapping between form and meaning as compared to *before* in terms of temporal connective. This variability may lead to greater uncertainty in interpreting *after* sentences compared to *before* sentences, meaning that understanding *after* sentences could be cognitively more demanding.

Notably, there are cross-linguistic differences in expressing iconicity with temporal connectives. For example, the relationship between temporal connectives and iconicity in Mandarin Chinese is much clearer than in English, because in Mandarin, temporal connectives *zhiqian* (before) and *zhihou* (after) only occur at the non-initial position of a sentence. In this case, *zhiqian* generally expresses a non-chronological temporal relation whereas *zhihou* expresses a chronological temporal relation. This unambiguity provides a better opportunity to test the iconicity hypothesis.

In summary, regarding the different properties of *before* and *after* and especially their discrepancies between English and Chinese, it remains uncertain which of the two temporal connectives is cognitively more difficult to process. If iconicity is

the most relevant factor for processing, then *before* should be more cognitively demanding to process than *after*. If, however, the value of polarity and form–meaning mapping (frequency) is more important, then *after* should be more cognitively demanding than *before*.

3. How World Knowledge Is Activated during Temporal Connectives Processing

During language comprehension, readers not only rely on semantic and syntactic knowledge, but also depend on world knowledge to establish a coherent sentence/discourse model [27][28][29][30][31][32]. If the linguistic input is inconsistent with world knowledge, a negative-going brain response, appearing around 300–500 ms (i.e., N400), will be regularly elicited [27][28][29][30][31]. However, whether a semantically reasonable sentence is pragmatically valid could be constrained by the coherent markers, namely connectives. A number of studies have explored this issue. Using event-related potentials (ERPs), Xu et al. [31] investigated how world knowledge incongruency was modulated by causal and concessive connectives (‘*yinwei*’ because vs. ‘*jinguan*’ although). They found that causal and concessive connectives had different influences on pragmatic processing at different stages of sentence processing. During early retrieval processing, world knowledge anomalies (e.g., Harbin is *warm* in winter) evoked indistinguishable N400 effects in both causal and concessive structures; at the integration stage, however, they showed dissociable ERP effects: while violation of world knowledge elicited a P600 effect in causal structures, a late negativity (N600) effect was obtained in concessive structures.

Only a few studies have explored how different temporal information influences world knowledge processing. Rinck et al. [15] presented seven-sentence passages to their participants. In each passage, the temporal information conveyed at target sentence (e.g., *Claudia was already waiting for him when he got off the train with his huge bag*) was either consistent (e.g., *Markus’s train arrived at Dresden Central Station 20* ***min*** *after Claudia’s train*.) or inconsistent (e.g., *Markus’s train arrived at Dresden Central Station 20* ***min*** *before Claudia’s train*.) with the contextual sentences. The results showed that inconsistent sentences were processed longer than consistent ones. In an ERP study, Xiang et al. [33] presented not only ad hoc stimuli with ambiguous veridicality (similar to 2a/b in Münte et al. [12], but also real-world stimuli (e.g., *Before/After Tiger Woods won the Masters, Jake started playing golf*) which are veridical based on world knowledge. The result showed that *before*-sentences evoked a larger sustained negativity than *after*-sentences in ad hoc stimuli, but no effect was observed in real-event stimuli, suggesting that the difference underlying processing of these two types of temporal relations could be related to the uncertainty of the events. Nieuwland [13], using ERP techniques, also investigated how world knowledge was processed in *before* vs. *after* sentences.

(3a)After the global economic crisis, securing a mortgage was harder.

(3b)After the global economic crisis, securing a mortgage was easy.

(3c)Before the global economic crisis, securing a mortgage was easy.

(3d)Before the global economic crisis, securing a mortgage was harder.

The results demonstrated that while the world knowledge-inconsistent words (3b) elicited a larger N400 than the world knowledge-consistent words (3a) in *after* sentences, the N400 difference effect was largely attenuated in *before* sentences (3c/d). However, at the late time window, the inconsistent words (3d) elicited a larger P600 than the consistent words (3c) in *before* sentences. These results indicate that integrating mismatched pragmatic information into discourse could be delayed in a non-chronological temporal sequence in comparison to a chronological sequence.

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