# Surpassing Immediate Spatio-temporal Metaphors: The Enduring Impact of Language and Visuospatial Experience on Temporal Cognition in Native and Near-native Mandarin Speakers

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**Abstract**

This study employed the spontaneous gesture task to examine the spatio-temporal metaphor gestures during the temporal word cognition process among native Chinese speakers (in Exp1) and Mandarin learners of near-native proficiency (in Exp2). The aim was to explore their dominant mental timelines and to compare the influences of visuospatial (reading and writing) experience and spatio-temporal metaphors on temporal cognition. In the task, the participants were asked to orally explain the lists of temporal words and the filler words, and then their spontaneous gestures were recorded and analyzed. The results demonstrated that (1) both groups produced horizontal, vertical, sagittal, fused horizontal and vertical, and fused horizontal and sagittal gestures for all kinds of Chinese temporal words, indicating a strong preference for horizontal over vertical gestures. (2) Negligible correlations between immediate spatio-temporal metaphors and the mental timelines were observed, with an almost non-existent difference in gesture distribution across metaphorical types between the two groups. The findings indicate that (1) the horizontal mental timeline is the dominant timeline, and Mandarin speakers do not have a preference for understanding time vertically; (2) visuospatial experience exerts a greater influence on temporal cognition than spatio-temporal metaphors; (3) mental timelines formed by the long-term effects of language, such as vertical dimensions, may operate beyond the immediate metaphors, similar to the horizontal gestures. Furthermore, the similarity in temporal cognition between the two groups further highlights the powerful long-term influence of metaphors. Accordingly, a unified model proposing embodied experience as the underlying mechanism for activating mental timelines is presented.

**Keywords:** immediate and enduring impact of spatio-temporal metaphor; visuospatial experience; native Mandarin speakers; near-native proficiency Mandarin speakers

## Introduction

Time and space, being two fundamental cognitive domains for humans (Croft, 1993; Galton, 2011; Langacker, 1987; Talmy, 2000), exhibit a close interconnection. Individuals frequently employ spatial representations, a more concrete one, to contemplate time (Bender & Beller, 2014; Boroditsky, 2000; Casasanto & Boroditsky, 2008; Núñez & Cooperrider, 2013), and they tend to conceptualize time, from past to future or from earlier to later, as a specific direction or along a certain spatial axis, namely a mental timeline. The existence of mental timelines has been identified across three spatial dimensions: the lateral axis (left/right), the sagittal axis (front/back), and the vertical axis (up/down). Studies have indicated that the genesis of these timelines varies. The left-right mental timeline is primarily shaped by reading and writing habits (Fuhrman & Boroditsky, 2010; Gevers, Reynvoet, & Fias, 2003; Y.-Y. Gu & Zhang, 2012; Ouellet et al., 2010; Tversky, Kugelmass, & Winter, 1991). Conversely, the front-back and up-down mental timelines are predominantly molded by spatio-temporal conceptual metaphors (Boroditsky, 2001; Casasanto & Jasmin, 2012; Fuhrman et al., 2011; Gevers et al., 2003; Y. Gu et al., 2017; He et al., 2020; Ouellet et al., 2010; Sell & Kaschak, 2011; Tversky et al., 1991). For instance, Mandarin speakers conceptualize temporal constructs along a lateral dimension influenced by left-to-right writing direction, a sagittal dimension shaped by metaphors like "前天 - the day before yesterday (前 - before)", and a vertical dimension formed by metaphors such as "上周 - the previous week (上 - up)", when comprehending temporal concepts (Ding et al., 2020; Li, 2014, 2017).

However, there is ongoing debate regarding whether the vertical mental timeline is advantageous for Mandarin speakers, particularly when contrasted with horizontal axis (Sun & Zhang, 2021). This debate also encompasses the extent to which spatio-temporal metaphors impact temporal cognition, especially in comparison with the influence of reading and writing experiences. Research, including Boroditsky (2001) and Liu and Zhang (2009), using spatial priming paradigms, found that Chinese speakers prefer a vertical axis, for the prevalence of vertical metaphors in Chinese. Nonetheless, recent studies, particularly investigations utilizing the temporal gesture paradigm, have consistently found that Mandarin speakers tend to construct their mental timeline along the horizontal axis (Bergen & Lau, 2012; Boroditsky, Fuhrman, & McCormick, 2011; Y. Gu et al., 2013; Li, 2014, 2017).

When discussing the impact of spatio-temporal metaphors on time cognition, it is essential to consider not only the competitive interaction between the effects of these metaphors and the experiences of reading and writing but



In L. K. Samuelson, S. L. Frank, M. Toneva, A. Mackey, & E. Hazeltine (Eds.), *Proceedings of the 46th Annual Conference of the Cognitive Science Society.* 

also the competition between metaphors' immediate and long-term impacts (Boroditsky et al., 2011; Boroditsky, 2018; Fuhrman et al., 2011; Lai & Boroditsky, 2013). Lai and Boroditsky (2013) noted that Mandarin speakers tend to construct sagittal mental timelines when understanding corresponding metaphors, and similarly, vertical representations for up-down metaphors, suggesting the immediate influence of metaphors. Mandarin speakers are more likely to form vertical time representations in non-linguistic tasks, more than English speakers (Fuhrman et al., 2011), showing long-term influence of spatio-temporal metaphors beyond linguistic systems. Intriguingly, Hendricks and Boroditsky (2017) discovered that after learning vertical metaphors, English speakers continue to perceive time vertically in non-linguistic settings, even when faced with verbal interference. This demonstrated that newly formed space-time associations not only transcend linguistic boundaries but also withstand verbal disruption, which mirrors the mode of left-right axis, developed through extensive visuospatial experience over the years (Boroditsky, 2018).

Additionally, Mandarin-native bilinguals with higher English proficiency tend to adopt an ego-moving perspective in time conception, mirroring English monolinguals' approach (Lai & Boroditsky, 2013). In contrast, English-native bilinguals who are more proficient in Mandarin are more likely to visualize time vertically, reflecting the pattern of Mandarin monolinguals (Fuhrman et al., 2011). These findings pointed out the long-term effects of linguistic experience on temporal cognition, highlighting that the higher the proficiency in a foreign language, the closer a learner's temporal cognition aligns with that of native speakers. Such observations prompt an inquiry: as language learners attain native-level proficiency, do they also mirror the native speakers' mental representations of time? Thus, to investigate the long-term effects of using spatio-temporal metaphors, this study will examine native Mandarin speakers (Experiment 1) as well as Mandarin learners with near-native proficiency (Experiment 2).

Therefore, the purpose of this study is to investigate the impact of spatio-temporal metaphors on temporal cognition: (1) whether Mandarin speakers exhibit a vertical bias, that is, whether the influence of spatio-temporal metaphors or the effect of reading and writing experience (i.e. visuospatial experience) is more significant; (2) whether individuals are more inclined to think about time vertically when understanding vertical spatio-temporal metaphors, and sagittally when understanding front-back spatio-temporal metaphors, namely, a comparison between the immediate and long-term impacts on temporal cognition.

Based on the task in the present study and the recent findings using spontaneous gestures mentioned above, we hypothesize that native mandarin speakers will produce more horizontal gestures, that is, they tend to construct their mental timeline along the horizontal axis. Furthermore, it is hypothesized that if the learner group mirrors the native speakers, they would also produce more H gestures, but not V gestures that were found in Fuhrman et al. (2011).

To test this hypothesis, the study will employ a spontaneous gesture task (Casasanto & Jasmin, 2012; Y. Gu et al., 2013; Y. Gu, Zheng, & Swerts, 2019; Li, 2014). This task examines participants' spontaneous gestures that accompany temporal words during speech，revealing their mental time representation through these gestures. Unlike other methods, it avoids issues like the limited choices for timelines, allowing us to observe the authentic mental timelines exhibited by participants across all three dimensions. Furthermore, this study will categorize temporal vocabulary according to metaphor types to better observe the immediate impact of metaphors on temporal cognition.

## Experiment 1: Native Speakers

### Method

**Participants** Previous studies have used different numbers of participants, for instance, 13 in Y. Gu et al. (2013), 30 in Li (2017), or 34 in Y. Gu, et al. (2019). Considering the amount of experimental material and duration of our study, 24 participants were used. They were 24 university students at Beihang University, Peking University, and University of Chinese Academy of Social Sciences. All participants are native Chinese speakers from mainland China, right-handed, and have normal or corrected-to-normal vision.

**Materials** 12 target words were selected to represent temporal concepts based on Modern Chinese Dictionary (Institute of Linguistics, 2016) and the Peking University CCL Corpus (Zhan, Guo, & Chen, 2003). These words were divided into three categories: (1) 4 words with explicit vertical spatial metaphors: 上周 - last week, 下午 - afternoon, 上个月 - last month, 下半年 - second half of the year (上 - up, 下 - down); (2) 4 words with explicit front-back spatial metaphors: 后半夜 - late night, 前一年 - last year, 后天 - the day after tomorrow, 前年 - year before last (前 - before, 后 - after); (3) 4 words without spatial metaphors: 早晨 - morning, 傍晚 - evening, 黄昏 - dusk, 早期 - early stage. In addition, the experiment includes 12 everyday words (e.g. 工作 - work, 吃饭 - eat, 地铁 - subway) and 12 words related to historical periods and figures (e.g. 唐代 - Tang Dynasty, 孔子 - Confucius, 李白 - Li Bai) as fillers.

We constructed three experimental word lists, each containing 12 words: 4 temporal words (respectively 4 vertical metaphors, or 4 front-back metaphors, or 4 time words without metaphors), 4 everyday words, and 4 historically related words. To avoid potential cross-category influences of different metaphors on participants' mental timelines, the target temporal words within each list were of the same type and presented consecutively. Moreover, the arrangement of all words within each list and the test order

of lists were pseudo-randomized. Participants were tested across all three lists, ensuring a balanced exposure to different types of temporal words and fillers. The sequence of list presentation was rotated among participants to control for order effects: participants 1-8 received the lists in order 1 to 3, participants 9-16 in order 2 to 1, and participants 17-24 in order 3 to 2.

**Experimental Procedure** The experiment was conducted in Mandarin and took place in a quiet classroom or outdoor space. Participants were informed that the experiment was a vocabulary interpretation test, and the entire procedure would be recorded. After obtaining verbal consent, the experiment commenced, and video recording began. Words were presented in black text on a white background at the center of a computer screen. Participants were instructed to read the word aloud and then provide a clear explanation of the word's meaning to the experimenter. After explaining a word, the experimenter navigated to the next term. Participants continued this task until completing the explanation for all 12 words in a word list. During the experiment, participants could choose to take a half-minute break or proceed without resting after explaining each word. Prior to the formal experiment, participants completed a practice task involving nine words, including three temporal words, with one word from each time-related category. Participants could practice as many times as needed to become familiar with the requirements and procedures. We required participants to complete all formal experiments within one hour, and all participants adhered to this time frame. After completing the experiment, participants underwent random debriefing, and the results indicated that none of the participants had discerned the true purpose of the experiment.

## Analysis and Results

The recordings of the experiment were coded using ELAN software to document the axe, direction, and corresponding temporal word of each gesture as participants explained the target words. Two coders initially aligned on coding standards, specifying that horizontal gestures (H) must be within 25.5 degrees of the horizontal axis, and vertical gestures (V) within 25.5 degrees of the vertical axis. Gestures that fell between these measurements, exceeding 25.5 degrees from both the horizontal and vertical axes, were classified as diagonal. The definitions for other related gesture orientations were determined in a similar manner. Following independent coding, the coders discussed any discrepancies until consensus was reached.

Participants exhibited all kinds of gestures in all metaphorical categories of temporal words, including horizontal (H), sagittal (S, except for non-metaphorical words), and vertical (V) dimensions. The gestures also included fused horizontal and vertical (HV) and fused sagittal and horizontal (HS) gestures. The fused gesture, as shown in Figure 1, was produced by the participants when explaining the term "Early stage". Among the 528 produced gestures, H gestures were the most prevalent, accounting for 64.4% ($N$ = 340) of the total, while HV movements constituted 22% ($N$ = 116). The other three types of gestures were less frequent, with V gestures representing only 6.3% ($N$ = 33) of the total. This suggested that the left-right horizontal mental timeline is the dominant temporal representation for Mandarin Chinese speakers.

A Chi-square test showed a significant link between types of temporal words and directional gestures ($X^2$ = 45.69, $df$ = 8, $p$ < .001), but Cramér's $V$ indicated a weak correlation ( Cramér's $V$ = .208, $p$ < .001). Analysis revealed that sagittal metaphors in temporal words tended to prompt H and S gestures more than vertical or non-metaphorical expressions (adjusted residuals: 2.3, 4.4). Vertical metaphors favored HV gestures over sagittal or non-metaphorical ones (adjusted residual: 3.9), while non-metaphorical terms more often led to HS movements compared to those with vertical or sagittal metaphors (adjusted residual: 2.5). However, there was no significant difference in the production of vertical gestures among the three types of temporal words, indicating that Mandarin Chinese speakers do not exhibit a clear preference for the vertical dimension in constructing mental timelines.

To summarize, in addition to producing the predominantly observed H, V, and S gestures identified in many studies, Mandarin native speakers also generated integrated diagonal HV and HS gestures. Notably, horizontal gestures are the most prevalent, and the percentages and adjusted residual values suggested a lack of vertical bias in temporal thinking among Mandarin native speakers. Furthermore, a Chi-square test and Cramér's $V$ indicated a mild immediate influence of metaphors on temporal gestures.


Figure 1: Mirrored HV Gestures for "早期 - Early Stage"

# Experiment 2: Near-native Proficiency Mandarin Speakers

## Method

**Participants** Previous This study involved 24 participants (aged 18–34), including two working professionals and 22 students from Beijing Foreign Studies University, Beijing Normal University, Guangxi University for Nationalities, Peking University, University of Pennsylvania, and Xiamen University. Participants hailed from Egypt, Indonesia, Japan, Mongolia, Myanmar, Russia, Rwanda, Slovakia, South Korea, Turkey, the United States, and Vietnam. These countries have adopted horizontal writing and reading

formats in modern times. All of these participants studied Chinese in mainland China and are right-handed with normal or corrected-to-normal vision.

Participants met two prerequisites: they were non-native speakers with near-native proficiency. In this study, we adopted an age criterion reflecting its stabilization: participants were required not to have been exposed to Mandarin before the age of six. Around age six, individuals' mental timelines tend to stabilize (Nava et al., 2018; Tillman et al., 2018). Given this, we inferred that those not exposed to Mandarin by this age likely form their temporal constructs with minimal Mandarin influence, suggesting Mandarin is not the first and primary linguistic framework for their mental timeline development. Due to the absence of standardized benchmarks for near-native proficiency of Chinese learners, the study assessed the duration of the language study ($M$ = 7.19, $SD$ = 4.14) and residency in China ($M$ = 4.34, $SD$ = 2.89) to gauge near-native proficiency. Further, a majority ($N$ = 20, 83%) had fields related to Chinese. Post-experiment native speaker evaluations of random participant language samples further confirmed the high proficiency levels and the viability of proficiency assessment ($M$ = 3.94, $SD$ = 0.94).

**Materials and Procedure** This experiment used the same materials as Experiment 1, except that "上个月 - last month" and "前一年 - last year" were replaced with "上午 - morning" and "前天 - the day before yesterday" to further standardise the materials.

For the purpose of facilitating comparison, this experiment employed the same methodology, procedure, presentation order, and mode of material display. However, due to the geographical diversity of the participants, the experiment was conducted online via VooV Meeting, with each subject participating from a quiet room. All participants were instructed to complete the formal experiments within a one-hour limit, which was successfully met by all. After the experiment, interviews revealed that none of the participants were aware of our true experimental objectives.

## Analysis and Results

The same methodology as experiment 1 was used in this experiment. The results showed that participants exhibited gestures in all metaphorical categories of temporal words, including H, S, V, HV and HS (except for non-metaphorical words) gestures. H gestures accounted for the majority of all gestures (69.2%, $N$ = 292 out of 422). V gestures were comparatively infrequent, constituting just 8.5% ($N$ = 36) of the total. This indicated that near-native speakers of Chinese predominantly employ a left-right horizontal mental timeline. A significant association was observed between the number of different gestures and the types of words used ($X^2$ = 27.505, $df$ = 8, $p$ < .001), albeit with a weak correlation (Cramér's $V$ = .181, $p$ < .001).

Besides, temporal words with sagittal metaphors more readily elicited S and HS gestures than those with vertical metaphors or non-metaphorical temporal expressions (adjusted residuals of 3.1 and 2.1, respectively). Words with vertical metaphors tended to prompt HV gestures but less frequently resulted in S gestures (adjusted residuals of 2.9 and -3.1, respectively). Nonetheless, the frequency of vertical gestures did not significantly differ across the three temporal word types, suggesting that near native learners demonstrate no marked preference for verticality in mental timelines.

In short, like native speakers, Mandarin learners with near-native proficiency produced H, V, S, HV and HS gestures. The percentages and adjusted residual values also indicated an absence of vertical bias in their conception of time. A Chi-square test and Cramér's $V$ demonstrated a mild immediate metaphorical impact on temporal gestures.

## Post-hoc Analysis: Native speakers VS Near-native Proficiency Speakers

The findings from the two experiments indicated that Mandarin learners with near-native proficiency can develop mental timelines similar to those of native speakers. In the following parts, the results of the two participant groups will be further compared.

A Chi-square test demonstrated a significant difference in the overall gesture distribution between native speakers and near-native learners ($X^2$ = 39.98, $df$ = 4, $p$ < .001), with a moderate effect size (Cramér's $V$ = .205, $p$ < .001). The results indicated that, overall, native speakers (adjusted residuals: 5.6) are more inclined to produce HV-oriented gestures, whereas learners of Chinese (adjusted residuals: 3.2) tend to produce more S-oriented gestures than native speakers.

To further understand the differential effects of spatial metaphors on the temporal cognition of two groups, this study conducted a comparative analysis of gesture distributions under different metaphorical conditions. Under vertical metaphor conditions, native speakers showed a stronger preference for HV-oriented gestures (adjusted residual of 4.3) compared to Chinese learners, who favored H gestures more (adjusted residual of 2.0). In front-back metaphor conditions, native speakers were more inclined to produce HV gestures (adjusted residual of 2.5), while Chinese learners preferred S gestures (adjusted residual of 2.0). When interpreting non-metaphorical vocabulary, native speakers more frequently utilized HV (adjusted residual of 3.7) and HS (adjusted residual of 2.2) gestures, whereas learners tended to favor S (adjusted residual of 3.2) and H (adjusted residual of 2.1) gestures.

Overall, native Chinese speakers and near-native Chinese learners show significant differences in the overall percentages of S and HV gestures. In all three metaphorical conditions, native speakers consistently prefer HV gestures more than Chinese learners. In non-metaphorical and front-back metaphorical conditions, Chinese learners exhibit a distinct preference for S gestures compared to native

speakers. However, the overall pattern of gesture use between the two groups is similar, involving H, V, S, HV, and HS gestures, with H gestures being the most common.

## Discussion and conclusion

To explore the relationship between visuospatial experience, the immediate and enduring impacts of spatial metaphors on temporal cognition, this study utilized a spontaneous gesture task, presenting temporal words categorically. The findings revealed that, both native speakers and near-native speakers uniformly exhibited mental timelines in the H, V, S, HV, and HS dimensions across all kinds of temporal words. Horizontal gestures were most common, while vertical gestures were consistently rarer and statistically similar across all temporal word types, indicating a preference for the horizontal mental timeline. This reflected that reading and writing experience exerts a more substantial influence on temporal cognition than language itself.

Besides, the study found that, for both native speakers and Mandarin learners of near-native proficiency, the immediate influence of spatial metaphors on shaping temporal axes was minimal. However, the abundant presence of gestures related to spatial metaphors (V, S, HV, HS), without being significantly affected by the spatial metaphors in use at the moment, underscored their association with the enduring impact of spatial metaphors, as evidenced by near-native learners who, through prolonged exposure, could even employ these metaphors as freely as native speakers. Contrary to Lai and Boroditsky (2013), who argued for the significant immediate effects of linguistic metaphors, this discrepancy may be attributed to their use of a deliberate gesture task (three-dimensional pointing paradigm), explicitly instructing participants to point out the location of time like "上个月 - last month (上 - up)". Unlike spontaneous gesture task, such approach may direct participants' attention more towards spatial representations within temporal vocabulary (Casasanto & Jasmin, 2012), leading to a higher production of gestures consistent with temporal metaphors, which might not accurately reflect the genuine state of how individuals conceptualize time in their everyday lives.

Additionally, native Chinese speakers displayed a preference for HV gestures and used fewer S gestures compared to near-native Chinese learners. This pattern is likely influenced primarily by the long-term linguistic effects, as the correlation between immediate metaphors and temporal gestures is minimal. Vertical metaphors are more prevalent in Chinese than front-back metaphors (Boroditsky, 2001), resulting in fewer timelines. The more frequent use of vertical metaphors contributes to a V mental timeline, which, when combined with the significant influence of horizontal reading and writing experiences, leads to a predominance of HV timelines. Conversely, near-native learners, influenced by their native languages (such as English), which utilize more front-back metaphors, formed more S mental timelines (Boroditsky,2001). Specifically, learners exhibited a preference for S timelines in front-back and non-metaphorical conditions. Moreover, under vertical and non-metaphorical conditions, learners showed a stronger preference for H-oriented gestures. This may be attributed to the greater linguistic distance between Chinese and their native languages. For example, the predominance of vertical metaphors in Chinese starkly contrasts with the prevalence of front-back metaphors in English. This disparity might cause learners to depend more heavily on the influential reading and writing experiences that shaped their preference for horizontal gestures. In non-metaphorical conditions, native speakers were more inclined to use HS gestures, whereas learners favored S and H gestures more, which were not integrated. This may suggest that native speakers prefer integrative gestures, while learners favor distinct gestures. Besides, whether overall or under specific metaphorical conditions, native speakers show a greater preference for HV gestures, and also HS gestures under non-metaphorical conditions, while learners prefer H and S, and both S and H gestures under vertical, front-back, and non-metaphorical conditions, respectively. This further demonstrates native speakers' preference for integrative gestures and learners' preference for distinct gestures, possibly indicating that greater familiarity with a language enables more flexible application of different mental timelines, leading to more integrative mental timelines.

After investigating the effects on spatio-temporal cognition, a more in-depth analysis of the aforementioned pattern and its underlying causes is warranted. Regarding the activation mechanism of mental timelines, there are currently two main perspectives: the unified view and the separate view (He et al., 2020). The unified view posits that even if the origins of mental timelines are different, the activation mechanisms across the three dimensions of mental timelines should be consistent, involving high-level semantic activation mechanisms (He et al., 2020). However, the present study and some other researches, did not support this viewpoint. For example, Ding et al. (2020) proposed that spatio-temporal congruency effects could simultaneously occur in the H and S dimensions, as well as the H and V dimensions, but not in the S and V dimensions, suggesting that the mental timelines in the H and S dimensions, as well as the H and V dimensions, could coexist, while those in the S and V dimensions mutually inhibited each other. Based on the multi-channel theory of attention, mental timelines under the same mechanism compete for resources, preventing them from coexisting. Therefore, the V and S dimensions share the same activation mechanism, differing from the horizontal dimension (He et al., 2020). In other words, the origin and activation mechanism of mental timelines are closely linked. More specifically, the activation of the H dimension timeline is related to bodily writing and reading experience (Fuhrman & Boroditsky, 2010; Gevers et al., 2003; Y.-Y.Gu & Zhang, 2012; Ouellet et al., 2010; Tversky et al., 1991), while the S and V dimensions are associated with high-level semantic activation mechanisms (Boroditsky, 2001; Fuhrman et al., 2011; Y. Gu et al., 2017; He et al., 2020). This study

similarly identified HV and HS gestures, but did not observe gestures resulting from the fusion of the S and V dimensions, providing evidence supporting the separate mechanism

According to the separate mechanism perspective, the dominant mental timelines for front-back and up-down metaphorical temporal words should be S and V timelines respectively, while the dominant timeline for non-metaphorical time words should be H. However, this viewpoint struggles to fully explain various findings. For instance, this study also discovered the significant disconnection between temporal gestures and immediate temporal vocabulary among both native speakers and near-native Mandarin learners. Additionally, in Amarakaeri, a language where the past is linguistically positioned in the front, speakers nonetheless produce gestures suggesting the future in the front (de la Fuente et al., 2014). These findings contradict the separate mechanism perspective, suggesting that language metaphors and temporal gestures are independent and compete for cognitive resources, indicating a separation between immediate language metaphor and spatio-temporal cognition (Li, 2014, 2017).

Furthermore, some research has discovered that newly constructed timelines through language metaphors can be represented in non-linguistic tasks and are less susceptible to linguistic interference (Hendricks & Boroditsky, 2017). In other words, the timelines formed by language exist beyond the linguistic system and are no longer easily influenced by language (Boroditsky, 2018). The present study revealed that the effect of immediate linguistic metaphors on mental timeline activation is minimal, even for near-native foreign language learners. Instead, it appears that the repeated use of metaphors has made them as fundamental as the experience of reading and writing, echoing Boroditsky (2018) observation that metaphoric representations are processed similarly to visuospatial experiences acquired over time, which highlights the long-term impact of metaphors. If this is the case, the activation mechanisms for the three different dimensions of mental timelines may be unified. It also implies that cognition of temporal words under various metaphorical conditions may result in similar patterns of mental timelines, thus exhibit all types of mental timelines, with H timelines being the most prevalent, and without an inherent preference for constructing V timelines. In summary, this study suggests that the activation of mental timelines associated with temporal words is primarily determined by embodied experiences, which include both the long-term effects of engaging with spatio-temporal metaphors and the accumulated experiences of reading and writing in the past, albeit with the immediate influence of language metaphors still present but diminished.

Generally, this study revealed that both native Mandarin speakers and near-native learners demonstrated a strong preference for H over the V within H, V, S, HV and HS gestures. The connection between immediate metaphors and the temporal axes by individuals was minimal for two groups. The results implied that the direct effect of spatio-temporal metaphors on temporal cognition is modest, overshadowed by the significant, enduring impact of reading and writing experience and the extended influence of spatial metaphors. This led to the proposal of a unified model for the activation of mental timelines.

There are two issues that are worthy of further investigation in the future. One is to explore the impacts of different native languages on the Chinese temporal word cognition. The other is to explore the mechanism of the fused HV and HS gestures, which has only recently received limited attention in the field of temporal cognition (Walker & Cooperrider, 2016).

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