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Time in Chinese hands

Gesture and sign

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This chapter examines how Chinese people (Mandarin monolinguals; Mandarin-English bilinguals; deaf Chinese Sign Language (CSL) signers; Mandarin learners of CSL) use gestures and signs to creatively represent time. All groups spatialize time on the lateral, vertical, and sagittal axes, but differ in their choices of axes and directions of movements. For instance, Mandarin-English bilinguals produce more vertical time gestures in Mandarin than in English. Mandarin speakers can produce past-in-front and past-at-back gestures, whereas CSL deaf signers only exploit past-at-back signs. Mandarin learners of CSL perform more past-at-back gestures than Mandarin-speaking non-signers. In short, cultural, linguistic, and bodily experiences can jointly shape how Chinese people express time creatively in different modalities.

Keywords: bimodal bilinguals, Chinese Sign Language, Mandarin, time spatialization

1. Introduction

Humans are creative in terms of expressing time. For instance, people can use spatial representations such as old-fashioned clocks, hourglasses, calendars, or sundials to represent the abstract concept of time (e.g. Casasanto and Boroditsky 2008). In ancient China, people also took advantage of natural and biological phenomena such as the crowing of cocks and the location of the sun to track the time of a day, and they exploited water (clepsydra) and fire (duration of burning an incense stick) to estimate the temporal durations of events. Apart from such cultural inventions, languages (both spoken and signed) can powerfully express time, particularly, through spatial metaphors. For instance, people not only talk about time spatially (e.g., a *long* time; looking *back* to the *past*), but also employ gestures or signs to visually position time in space.

There is no doubt that the way people spatialize time differs across cultures and languages (e.g. Boroditsky and Gaby 2010; Bylund and Athanasopoulos 2017; Moore 2011; Sullivan and Bui 2016; see reviews by Bender and Beller 2014; Núñez and Cooperrider 2013). Take the conception of the future for instance: People with an Anglo-Saxon background typically conceptualize the future as *ahead* of them (e.g., Miles et al. 2010; Ulrich et al. 2012), whereas the Aymara and Moroccans conceptualize the future as *behind* them (Núñez and Sweetser 2006; de la Fuente et al. 2014). Additionally, the future is towards the *left* for Hebrews (Fuhrman and Boroditsky 2010), moves to the *west* direction for Pormpuraaw people (Boroditsky and Gaby 2010), goes *uphill* for Yupno speakers (Núñez et al. 2012), and can run *downwards* for Chinese (Boroditsky 2001), etc.

In this chapter, I aim to shed some light on how, among the diverse range of human space-time mapping methods, Chinese people creatively convey time in language using different modalities (speech, gesture, and sign). I focus on Chinese people's linguistic expressions of timelines, including analyses of different populations (monolinguals, bilinguals, deaf signers, and bimodal bilinguals). These analyses reveal how the Chinese culture, language, and bodily experience of signing can shape people's conceptualization of time. Specifically, I first introduce space-time metaphors created by Chinese people in Mandarin language, followed by a review of recent studies on Mandarin speakers' temporal gestures, and a discussion on whether Mandarin-English bilinguals create different gestures about time between speaking in Mandarin and English. Then, I present how time is creatively expressed in Chinese Sign Language (CSL) and compare the differences in space-time mappings between Mandarin and CSL. Finally, following the comparison, I show how the bodily experience of CSL can influence Mandarin learners of CSL's co-speech temporal gestures.

2. Mandarin space-time metaphors

Like other languages, Mandarin Chinese has spatial language to metaphorically represent time, the mappings of which can deviate from Western space-time mappings. The most well-known one is the employment of vertical spatial metaphors to indicate a timeline running from top to down. Specifically, the spatial words 上/*shàng* (literally 'up') and 下/*xià* (literally 'down') are used to express the conceptions of *early* and *late*. For example, 上上周/*shàng-shàng zhōu* (literally 'up up week') means the week before last week, while 下周/*xià zhōu* (literally 'down week') refers to next week.

Despite its fame, vertical mapping only accounts for about 23.54% to 32.8% of Mandarin space-time metaphors, whereas sagittal temporal metaphors account for the majority (according to corpus surveys, 67.2%, Chen, 2007; 76.46%, Yang and

Sun, 2017). The corpus surveyors termed sagittal temporal metaphors as *horizontal* spatial metaphors, but using the term sagittal metaphors for time is more precise as Mandarin does not have left-right space-time metaphors, and the sagittal temporal metaphors employ overt sagittal words of spatial *front* (前/*qián*) and *back* (后/*hòu*) for the conceptions of *before/past* and *after/future*.

- (1) a. 前天/*qián-tiān*,
front day
'the day before yesterday',
后天/*hòu-tiān*
back day
'the day after tomorrow'
- b. 以前/*yǐ-qián*,
to front,
'before, past'
- c. 今后/*jīn-hòu*
today back
'future'

Importantly, as shown in Example (1a–1b), these temporal expressions are not ambiguous in that they can only refer to time. Hence such Mandarin sagittal metaphors for time suggest past-in-front/future-at-back space-time mappings (termed as EARLIER-TIMES IN-FRONT-OF LATER-TIMES METAPHOR in Xiao et al. 2018, and Yu 2012).

By contrast, the use of 前/*qián* (*front*) to express *future* and 后/*hòu* (*back*) to express *past* in Mandarin is rather rare.¹ According to a corpus survey (Peng 2012), in modern Chinese only 2.75% of the temporal use of 后/*hòu* refers to *early/before*. In ancient Chinese (before Late Middle Chinese), 前/*qián* (*front*) was only used to express the concept of *past* and 后/*hòu* (*back*) was only used to express the concept of *future* (Xu 2016).

Nevertheless, Mandarin does not exclusively use lexical cues to associate past with front, but also has the option to use words that suggest that the future is in front, and is similar to speakers of other future-in-front languages in this way (e.g., English: The future is *ahead* and the past is *behind*). As shown in Example (2), the Mandarin temporal expressions 过去/*guò qù* ('pass go', past) and 未/将来/*wèi/jiāng lái* ('hasn't come yet/will come', future) are also commonly used to convey the conception of the past and future. These metaphors suggest future-in-front/past-at-back mappings (Xiao et al. 2018; Yu 2012).

1. When 前/*qián* (*front*) is used in the word 前途/*qián-tú* (literally 'front path', meaning future career), it is metaphorically regarded as an expression for the conception of future.

- (2) a. 展/*zhǎn* 望/*wàng* 未/*wèi* 来/*lái*
 unfold gaze-into-distance hasn't come
 'Looking far ahead/into the future.'
- b. 回/*huí* 首/*shǒu* 过/*guò* 去/*qù*
 turn-around head pass go
 'Looking back to the past.'

3. Time in Chinese gestures

3.1 Temporal gestures in Mandarin monolinguals

When talking about time, speakers often produce temporal gestures, in which temporal references are made along the body's sagittal/vertical/lateral axes (e.g. Casasanto and Jasmin 2012; Cienki 1998; Cooperrider and Núñez 2009). The idea of using gesture to represent time is in line with the embodied cognition theory, which proposes that conceptual representations are largely grounded in sensorimotor experiences (Glenberg and Kaschak 2002), and that representations are activated and often instantiated in the forms of gestures (Hostetter and Alibali 2008). In other words, the way in which one thinks of time in space may be revealed by their gestural representation. There are an increasing number of studies on the relationship between speakers' gestures and their spatialization of time (e.g. Bostan et al. 2016; Bylund et al. 2020; Li 2018; Pagán-Cánovas et al. 2020; Walker and Cooperrider 2016), showing that the way people gesture about time may be vastly different across cultures and languages (e.g. Floyd 2016; Kita et al. 2001; Le Guen and Pool Balam 2012; Núñez et al. 2012; Rodríguez 2019; Sullivan and Bui 2016; Valenzuela and Alcaraz 2020).

It has been shown that Mandarin speakers can use gestures to metaphorically represent time laterally, vertically, and sagittally (Chui 2011, 2018; Gu et al. 2013, 2017, 2019a; Li 2018). Among the three axes, a large proportion (about 50%–60%) of temporal gestures used by Mandarin speakers are produced on the lateral axis (PAST IS LEFT; FUTURE IS RIGHT), whereas only about 26%–30% are produced on the vertical axis (PAST IS UP; FUTURE IS DOWN) and 12.5%–20.5% are produced on the sagittal axis (PAST IS FRONT/BACK; FUTURE IS BACK/FRONT, Gu et al. 2013, 2019a; Li 2018).

Note that there is no lateral space-time metaphor in Mandarin spoken language, and the past-to-left/future-to-right space-time mappings are mostly influenced by the left-to-right writing direction. Interestingly, this influence is so strong that Mandarin speakers may gesture laterally even when they are sometimes verbally speaking sagittal space-time metaphors. As a result, despite Mandarin sagittal

space-time metaphors being widely used in the expression of time, the proportion of sagittal gestures by Mandarin speakers is rather small. Thus, there is a disassociation between temporal language and temporal gestures (Casasanto 2016).

Li (2018) described that, on the sagittal axis, Mandarin speakers overall tend to gesture according to the future/later-in-front mappings, which also seems to suggest a mismatch between sagittal gestures and temporal language (but the study did not consider the linguistic wordings accompanying the sagittal gestures). A possible account proposed for such a dissociation is people's cultural attitudes toward time. According to the *Temporal-focus Hypothesis* (de la Fuente et al. 2014), Moroccan Arabic speakers, who place more value on tradition, are more past-focused and tend to gesture the past as *ahead* of and the future as *behind* them, even though their language only has future-in-front mappings. Chinese people are found to be slightly future-focused (Gu et al. 2019b) and their general preference of future-in-front gestural mappings may be due to their cultural temporal focus.

Nevertheless, there is also evidence showing that Mandarin vertical and sagittal metaphors for time can in fact influence speakers' temporal gestures. For instance, Gu et al. (2019a) set up an experiment to study Mandarin speakers' co-speech temporal gestures, in which lexical choices of Mandarin time expressions were elicited in three types. Specifically, the authors compared Mandarin speakers' gestures when they spoke vertical spatial metaphors (e.g. 上周/*shàng zhōu*, literally 'above week', meaning last week) or sagittal spatial metaphors for time (前天/*qián-tiān*, literally 'front day', meaning the day before yesterday) with gestures from when they spoke neutral temporal words that did not contain any spatial metaphor (e.g. 昨天/*zuó-tiān*, meaning yesterday). The results of their regression analysis showed that the concurrent temporal words influenced Mandarin speakers' choice of axis for temporal gestures. Mandarin speakers were significantly more likely to produce vertical temporal gestures when uttering vertical spatial metaphors for time, and more likely to produce sagittal temporal gestures when uttering sagittal spatial metaphors for time, in comparison to when uttering neutral temporal words.

On the sagittal axis (about 20.5% of whole temporal gestures), Mandarin speakers produce both future-in-front/past-at-back (50.96%) and future-at-back/past-in-front (49.04%) temporal gestures. Despite this, the movement direction of sagittal temporal gestures is also affected by the Mandarin past-in-front/future-at-back space-time metaphors. For example, the majority of the sagittal gestures were past-in-front/future-at-back (70.83%) when Mandarin speakers were uttering overt past-in-front/future-at-back temporal words, whereas the proportion was significantly lower (30.36%) when they were speaking other temporal words (Gu et al., 2019b). In short, space-time metaphors have an immediate impact on speakers' creation of temporal gestures.

In addition to studying the spontaneous temporal gestures that are ecologically more valid and efficient, researchers have also investigated Mandarin speakers' forced pointing gestures (e.g., participants were asked explicitly by the experimenters to deliberately point in space to indicate the concept of *future*, *last week*, or *yesterday*, etc.). Unsurprisingly, Mandarin speakers still gesture on 3D timelines, but the use of such temporal gestures is more congruent with the concurrent temporal expressions than with spontaneous co-speech gestures (Lai and Boroditsky 2013; Fuhrman et al. 2011; Li 2018). For example, 80% and 83.3% of the deliberate gestures on the vertical and sagittal axes were congruent with the axis mappings suggested by the linguistic metaphors (Li 2018).

Apart from looking at Mandarin monolinguals' spontaneous or forced pointing gestures, researchers have also made a comparison between two languages, e.g. by exploring the gestural expression of time in Mandarin and English by bilinguals. Such research has focused on the vertical timeline. Below I present how Mandarin-English bilinguals creatively express time in two languages.

3.2 Do Mandarin-English bilingual speakers gesture about time differently in Mandarin and English?

A growing body of evidence from behavioral experiments (e.g. Boroditsky 2001; Yang and Sun 2016), co-speech gesture (Gu et al. 2017) and eye movements (Zheng, et al. 2020) has shown that Mandarin speakers have a different vertical conceptualization of time than English speakers. Specifically, Mandarin speakers can often think of time vertically, with the *past above* and *future below*.² Compared to Mandarin speakers, English speakers think of time vertically less often, and the mental orientation of the vertical timeline of English speakers is usually realized as one whereby the FUTURE IS UP and the PAST IS DOWN (e.g. Boroditsky 2001; Fuhrman et al. 2011; Hendricks and Boroditsky 2017).

2. Xiao et al. (2018) reported results that showed a possibility of the reversed pattern for Mandarin speakers, with *up* for the *future* and *down* for the *past*. However, their results may be interpreted in a different way as the stimuli used in their study can be considered biased. For example, the stimuli of past concepts were mostly related to a person's stage of being an infant/child, and the stimuli of the future were mostly about being an adult/old person. These stimuli had a conceptual mapping that LESS (length, age, number) IS DOWN, and MORE IS UP (Lakoff and Johnson 1980). Additionally, there were vertical spatial metaphors in the stimuli of *past* concepts such as 呱呱坠地/*gū gū zhuì dì* (literally, 'crying and falling to the ground', meaning delivery of new-borns) that suggested a downward motion. Thus, it is difficult to tell in their study whether the vertical mappings that PAST IS DOWN are due to the conceptualization of time or to some other imagistic thinking or number-space mapping.

Unlike Mandarin, the use of vertical spatial metaphor for time in English is neither prevalent nor systematic (e.g. Boroditsky 2001; Casasanto 2016; Lakoff and Johnson 1980). For example, English rarely has vertical spatial metaphors with a mapping of LATE/FUTURE IS DOWN apart from cases like the house has been handed down from generation to generation, implying that the younger generation is below the old. Additionally, English speakers can say the *upcoming week* (suggesting a mapping in which the FUTURE IS UP), but it is not grammatical to say the *downcoming week*.

Given that time conceptions with Mandarin vertical spatial metaphors have different, non-vertical, lexical correlates in English (e.g. above week in Mandarin, last week in English), if the choice of language influences speakers' vertical conceptualization, one would expect Mandarin-English speakers to gesture more vertically when speaking Mandarin than English, especially for words with a lexical trigger in Mandarin. Alternatively, if it is the case that Mandarin speakers have a long-lasting (habitual) vertical thinking of time (regardless of being shaped by the cultural vertical writing direction or the vertical space-time metaphors), one would assume that they can also gesture about time vertically, irrespective of whether they speak English or Mandarin.

To test these hypotheses, Gu et al. (2017) have investigated how lexical choices of vertical spatial metaphors affected Mandarin-English late bilinguals' production and perception of gestures in Mandarin and English. In an experiment that was ostensibly set up as a test of speakers' short-term memory and addressees' long-term memory, Mandarin-English bilinguals were asked to remember each word list shortly after they had seen them twice, then to tell and explain the words as explicitly as possible to addressees who were told to "remember as many descriptions of the speaker as possible for a later memory test". Several of the wordlists were time expressions consisting of vertical spatial metaphors or neutral words (without containing any spatial metaphors). All participants took part twice in the experiment, once in Mandarin and once in English (counterbalancing sequences) with an interval of ten days between tests. Gestures were not mentioned at any moment.

It was found that Mandarin-English late bilinguals produced vertical temporal gestures spontaneously, both in Mandarin and in English. The between-language comparisons showed that the bilinguals produced more vertical gestures when talking about Mandarin time conceptions with vertical spatial metaphors than when talking about time conceptions in the corresponding English translations (no spatial lexicons) whereas the number of vertical gestures for the neutral time expressions (e.g. yesterday) was not different between the two languages. For example, Gu et al. (2017) provided an example of the same participant who produced vertical gestures for time expressions of *last week* and *next week* in Chinese but produced lateral gestures for *yesterday* and *tomorrow* in Chinese and for *last week* and *next week* in English (Figure 1).

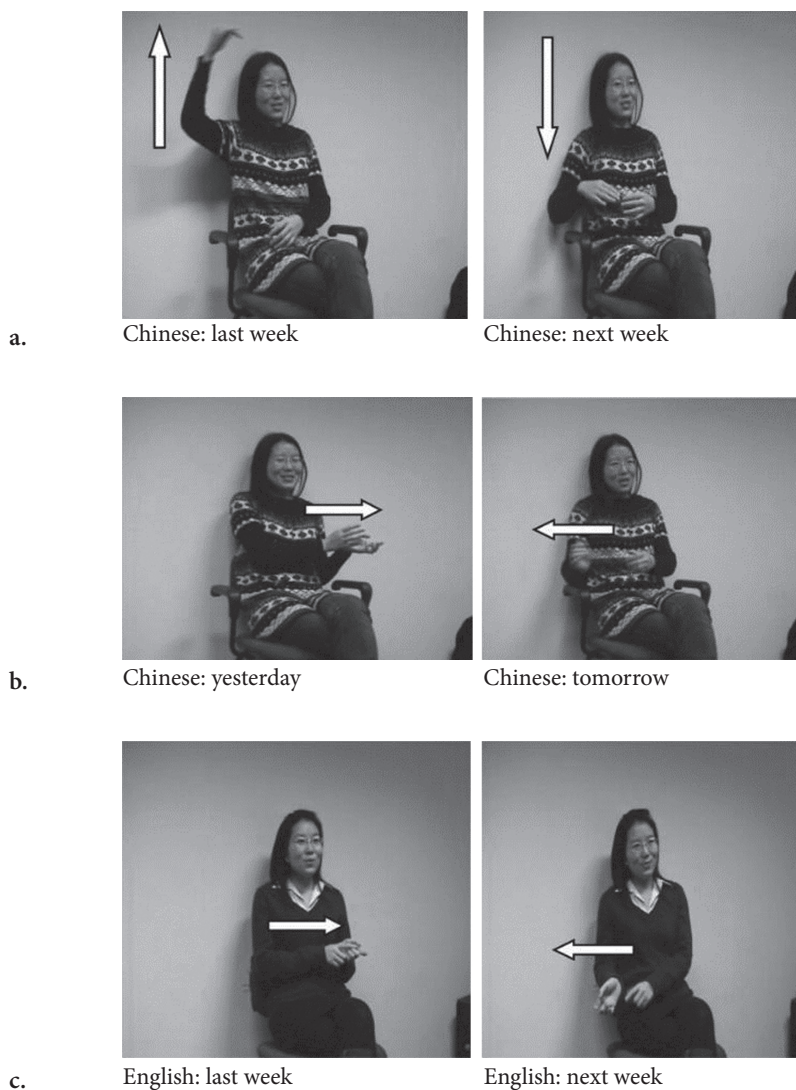


Figure 1. Gestures of *last week* and *next week* in Chinese, and *yesterday* and *tomorrow* in Chinese, and *last week* and *next week* in English by the same participant (reprinted from Gu et al. 2017)

Furthermore, in a gesture perception study, Gu et al. (2017) examined whether Mandarin-English bilingual observers prefer vertical gestures for phrases with explicit vertical spatial metaphors (e.g. 上周/*shàng-zhōu*, last week) over vertical gestures for neutral time expressions that do not have such an explicit spatial indicator (e.g. 昨天/*zuó-tiān*, yesterday), and additionally whether there would be

perceptual differences in that respect between Mandarin and English (e.g. 上周 (literally 'up week') vs. last week, 昨天 (literally 'yesterday') vs. yesterday). Participants were provided with a number of silent clips (not necessarily about time) in which an actor was performing gestures, each accompanied with a text instruction above the clip. For instance, a sentence was shown as "[t]he person is asked to perform body language that indicates the time directions of *last week* and *next week* symbolically". The clip below the sentence showed the actor who first pointed to his left side and then to the right side (lateral gesture plane) or, in a counterbalanced version, pointed upward and downward (vertical gesture plane) to indicate the time conceptions of *last week* and *next week*. Participants were asked to judge the extent to which the gestures in the clip expressed the instruction correctly. Late Mandarin-English bilinguals did the tasks once in Mandarin and once in English with an interval of a week. It was shown that they preferred vertical gestures to lateral gestures when perceiving time references with vertical spatial metaphors. This bias towards vertical gestures still existed when they perceived the corresponding English translations of Mandarin vertical space-time metaphors, but to a significantly lesser extent. Nevertheless, there was no such bias towards vertical gestures when they perceived time references without spatial metaphors.

In short, with a comparison between Mandarin and English, bilinguals produced and perceived temporal gestures differently in the vertical time expressions but not in the neutral time expressions. The parallel between the production and perception data seems to suggest that in addition to the habitual time conceptualization, the online linguistic encoding possibilities of time conceptions also have an influence on the production and perception of temporal gestures.

So far, I have discussed the creativity of time in spoken languages and gestures in Mandarin speakers. However, users of a signed language can create different ways of expressing time, which I present in the remainder of the chapter.

4. Time in Chinese Sign Language

4.1 Temporal expressions in CSL

Similar to gestures, it is visible that sign languages make use of space to express time (e.g. Nilsson 2016; Wilcox 2002), but with more creativity in terms of using space and body. Various elements such as lexical items, specific markers (e.g. not yet, finished), pointings, hand holds, or non-manual behavior (e.g. facial expressions; body movements) can be used to express time in sign languages, and the metaphorical representation of time, as timelines is an unavoidable starting point in any description of temporal marking (Sinte 2013).

Unlike spoken languages/gestures, there are many timelines in most sign languages (e.g., Danish Sign Language has four timelines, Engberg-Pedersen 1999; Dutch Sign Language has five timelines, Schermer and Koolhof 1990). The sequence and deictic timelines are some of the concepts suggested for certain directions in space used to convey time in signed languages. In American Sign Language (ASL), for instance, the sequential timeline can be parallel to signers' body and extends laterally, representing earlier to later time periods, and it can also be used when signers refer to a sequence of ordered events (Emmorey 2001). The deictic use of the back-to-front-timeline to refer to past, present, and future was first found in ASL and has also been described for many other sign languages such as British Sign Language (Brennan 1983), French Sign Language (Maeder and Loncke 1996), and Spanish Sign language (Cabeza Pereiro and Fernández Soneira 2004) (see a review in Sinte 2013).

Research on temporal expressions in Chinese Sign Language (CSL),³ however, is very limited. Zheng (2009) made the first attempt by interviewing four deaf signers about temporal signs, based on which she described that CSL deaf signers could employ the sagittal (future-in-front/past-at-back), vertical (future-to-down/past-to-up) and lateral (earlier-to-left/later-to-right) timelines. Nevertheless, the big variations among the small number of deaf signers made it hard to draw a clear conclusion. Additionally, Wu and Li (2012) surveyed temporal expressions of a CSL dictionary, and also identified these three timelines but claimed that the conception of PAST/FUTURE time at the lateral timeline can be either mapped to the left or right, though the past-to-right/future-to-left mappings appear more frequently. However, such observations are completely based on several CSL words in citation forms in the standardized dictionary, which are not representative of the natural sign language used by Chinese deaf signers.

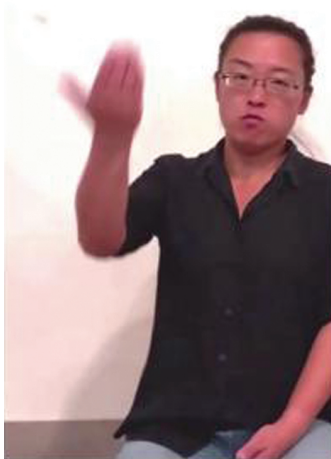
Recently, Lin and Gu (submitted) reported the first systematic investigation on temporal expressions in CSL based on a naturalistic corpus. The study looked into more than 2000 temporal expressions totally produced by 72 deaf signers when they were interacting freely with other deaf people. The results showed that time in CSL can be creatively expressed using a part of the body, iconicity, numeral incorporation, and timeline-based signs. For example, MORNING, NOON and AFTERNOON are expressed by touching the chin in different ways, and days of the week are expressed by a dominant arm extension near the armpit with number fingers (except for SUNDAY, which is a fake catching on the nose). The conception of TIME/HOUR

3. In addition to the Tibet Sign Language, CSL primarily has the northern (Beijing) and southern (Shanghai) variations, which sometimes can be mutually unintelligible (Fischer and Gong 2010). CSL has now been accepted by the general public, and is widely used in education, on television and by interpreters in China (Yang 2015).

and the four seasons are expressed with iconicity (e.g., the sign for TIME/HOUR imitates the shape of the watch or clock; SPRING is represented by signing a breeze through the face). The calendar time is simply expressed by finger numbers such as 1-9-8-6. The sequence of events or age order can be represented by the use of points-to-fingers (e.g. pointing to the thumb for first, index for second, or little fingers for finally), each of the points-to-finger formed the temporal connectives in CSL and could be patterned to put a conversation in order (Lin and Gu, revise and resubmit). Additionally, deictic time such as PAST, NOW and FUTURE, as well as time adverbials (e.g., JUST, ALWAYS, AGO) are realized through timelines. The corpus study found that sagittal, vertical, and lateral timelines account for the largest part of time expressions in CSL.

Interestingly, the creativity of expressing time is also evident in the distribution of timeline signs. Lin and Gu (submitted) discovered that there is a surprisingly asymmetric distribution of space-time mappings on each axis. Specifically, CSL only has past-to-backward but few future-to-forward mappings, only has future-to-downward but rare past-to-upward mappings, and on the lateral axis there are mostly future-to-left but few past-to-right mappings. Such timeline patterns are different from what has been reported in the previous case study or dictionary survey of CSL (cf. Wu and Li 2012; Zheng 2009), and deviate from the symmetric distribution of timelines in spoken Mandarin and gestures. Such deviation is also found in the frequency of using each axis, i.e., CSL signers most often use the sagittal axis for past concepts whereas they mainly use the vertical axis for future concepts. The lateral axis is used the least in CSL.

Furthermore, the creativity of CSL timelines is shown in the temporal movement direction in that CSL seems to have different temporal movement directions than Mandarin speech and gesture. On the sagittal axis, Mandarin speech and gestures have both past-in-front and past-at-back mappings whereas CSL only exploits the past-at-back mappings. Specifically, CSL has two types of sagittal temporal signs to express the conception of past. Firstly, it can be signed toward the back of the right shoulder (Figure 2a), thus indicating past-at-back mappings. Secondly, a sign of a person-classifier (A handshape formed by both hands) is located in a neutral space near a signer as a time reference point, and then the dominant hand is drawn back (Figure 2b). The back of the person-classifier is symbolized as the past. Although this type of sign for PAST is located in front of a signer, the concept of earlier/before is always signed behind the time reference point, which makes it remarkably different from the Mandarin earlier/past-in-front mappings.



a.



b.

Figure 2. Two types of temporal signs to express the conception of PAST in CSL

Additionally, on the lateral axis, despite it being observed that young CSL users may have some past-to-left mappings that are influenced by the literacy and writing direction, most deaf CSL users produce signs with future-to-left mappings which are opposite in direction compared to Mandarin temporal gestures (future-to-right). Such future-to-left mappings in CSL are mostly shaped by the frequent forms of TILL, DAY, and LIVING that start from the right side to the left side. Interestingly, such a dominant direction (right to left) will be mirrored (left to right) if the concepts are signed with the left hand (e.g. for left-handed signers, Lin and Gu, submitted).

In short, Mandarin speakers use gestures to represent time laterally, vertically, and sagittally, and CSL users also creatively exploit signs for this purpose but can differ from Mandarin speech and gestures on sagittal and lateral axes. Therefore, it is interesting to investigate the temporal gestures by Mandarin speakers who have sign language experience (Mandarin-CSL bimodal bilinguals), as they share a similar Chinese culture to non-signers but have acquired CSL which exploits different TIME-SPACE MAPPINGS than Mandarin.

4.2 Does bodily experience of CSL influence Mandarin speakers' co-speech temporal gestures?

Previous research suggests that gestures and signs stem from the same manual articulation system, and that there is an interaction between a signed language production system and the co-speech gesture production system (Brentari et al. 2012; Emmorey et al. 2008). For instance, the acquisition of a sign language as a second language may affect the production of co-speech gestures or facial expressions when bimodal bilinguals speak in their first language (Pyers and Emmorey 2008). Additionally, studies have shown that American Sign Language (ASL)-English bilinguals may have a higher co-speech iconic gesture rate than English non-signers (Casey and Emmorey 2009; Casey et al. 2012; Weisberg et al. 2020).

Given that Mandarin speakers gesture most frequently on the lateral axis, whereas signers use the lateral axis the least, and given that Mandarin temporal gestures and CSL temporal signs can have different timeline directions both on the sagittal and lateral axes, if gesture production and sign production systems are interconnected (e.g. Emmorey et al. 2008) in a way that Mandarin-CSL bimodal bilinguals are accustomed to performing manual movements in certain axes or directions, bimodal bilinguals are expected to have more sagittal and vertical temporal gestures but fewer lateral temporal gestures than Mandarin speakers who are non-signers. Additionally, focusing on the timeline direction at the sagittal and lateral axis, Mandarin-CSL bilinguals are expected to have fewer past-in-front/ future-at-back and past-to-left/future-to-right gestural mappings than Mandarin-speaking non-signers.

To this end, Gu et al. (2019b) have investigated the effects of CSL on Mandarin speakers' temporal gestures by comparing spontaneous temporal gestures of late bimodal bilinguals (Mandarin learners of CSL) and non-signing Mandarin speakers. Participants' spontaneous gestures were elicited via a wordlist definition task in which they had to explain a number of words (including temporal expressions) to non-signing addressees (same as the production of gesture experiment in Gu et al. 2017). Indeed, the results showed that first late bimodal bilinguals displayed a different distribution of temporal gestures on the three axes than the non-signers. For instance, bimodal bilinguals were significantly less likely to produce lateral temporal gestures (29.72% vs. 48.72%) whereas they tended to produce more sagittal ones (37.26% vs. 20.51%) than the non-signers.

As for the timeline direction on the sagittal axis, late bimodal bilinguals were less likely to produce past-in-front/ future-at-back temporal gestures than the non-signers (16.48% vs. 49.04%). When uttering Mandarin past-in-front metaphors (e.g. 前天/*qián-tiān*, literally 'front day', meaning the day before yesterday),



Figure 3. Spontaneous gestures of *this year*, *last year* and *the year before last year* in Mandarin by a Mandarin-speaking non-signer (top), and gestures of *the year before last year*, and *the year after next year* in Mandarin by a late Mandarin-CSL bimodal bilingual (bottom). Figure reprinted from Gu (2018)

72.34% of the sagittal temporal gestures by Mandarin-speaking non-signers were the past-in-front temporal gestures, whereas the proportion by late bimodal bilinguals was only 22.22% and the majority of sagittal temporal gestures were instead produced according to the future-in-front mapping (77.78%). Thus, late bimodal bilinguals produced a different direction of sagittal gestures than non-signers even when both groups were uttering the same overt past-in-front space-time metaphors in their first language (as shown in Figure 3).

On the assumption that spontaneous gesture is a visible embodiment of cognition (Hostetter and Alibali 2008) that provides a window into people's mental space-time mapping (e.g. Casasanto and Jasmin 2012; Cienki 1998; Núñez and Sweetser 2006; Walker and Cooperrider 2016), the authors claim that bodily

experience of sign language can not only impact the nature of co-speech gestures, but also spatio-motoric thinking and abstract space-time mappings. The claim has been further supported by a recent study on Chinese deaf participants (Gu et al., submitted). When Chinese deaf signers were presented with the 3D temporal diagram shown in Figure 4 (adapted from de la Fuente et al. 2014), they were asked to place a *future* and a *past* event in one of the two boxes, either in *front* or *behind* the character (the task was done once in CSL and once in Mandarin print). Given that previous research suggests that people's sagittal space-time mappings are also influenced by their cultural attitudes toward time (e.g. Callizo-Romero et al. 2020; de la Fuente et al. 2014; Li and Cao 2018), participants' values towards time were also collected. The results showed that irrespective of whether the instruction language of the task was in CSL or Mandarin, deaf signers were significantly more likely to place the *future* event in the *front* box compared to Mandarin speakers, while controlling for their values toward time. Furthermore, the study showed that deaf signers' age of acquisition of CSL and CSL proficiency levels are significant predictors of their sagittal space-time mappings, indicating that bodily experience of CSL timelines does have an influence on their conceptualization of time.

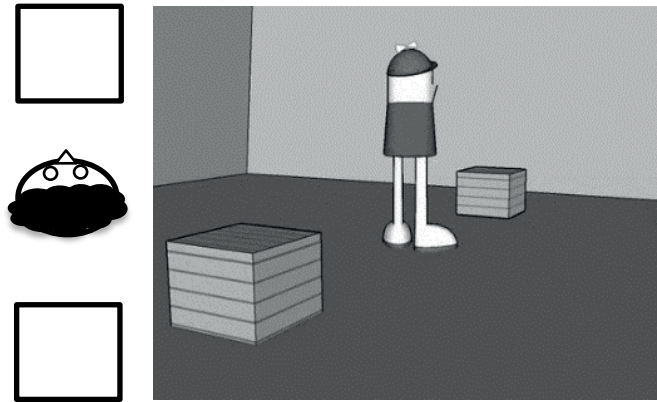


Figure 4. Left: Schematic illustration of de la Fuente et al. (2014)'s temporal diagram task. Right: A still picture from the 3D animated video of Experiment 1 in Gu et al. (submitted)

Finally, it needs to be pointed out that these studies on deaf or hearing signers have mostly focused on the sagittal axis and have not looked into the lateral timeline direction. Especially since CSL has mainly future-to-left mappings but deaf CSL signers also have the left-right reading direction (future-to-right mappings), it is worth further investigating whether Chinese deaf signers have a different lateral conceptualization of time than Chinese non-signers and how the acquisition of CSL influences a signer's mental space-time mappings.

5. What shapes the creation of time in Chinese hands?

5.1 The creativity of vertical space-time mappings

There is no doubt that Chinese people can talk, gesture and sign about time vertically. However, what remains controversial is the reason why they conceptualize time vertically (see a review by Chen and O'Seaghdha 2013). On the one hand, it has been found that the Chinese vertical writing direction in the old days can shape Mandarin speakers' vertical thinking (Bergen and Chan Lau 2012; Chen et al. 2015; Chen 2007; Fuhrman et al. 2011). For instance, vertical writing has been widely found in the bronze inscription on ancient antiques in China. The bronze inscription was one of the most historic writings found in Chinese history (in Shāng Dynasty, about 1200 B. C.; Boltz 2000). The texts were inscribed vertically inside or outside a bronze tripod. Gu (2018) speculated that the ancient vertical writing practice may have been shaped by the convenience of inscribing and reading the Chinese characters. If the texts were inscribed laterally, the inscriber and reader would have to keep on walking around the large and heavy bronze objects while inscribing and reading each line of the texts, which in practice would be comparatively less convenient and efficient than inscribing vertically where the writer/reader could just stand still. The tradition of vertical writing and reading may have been preserved and passed down to the ancient Chinese people who began to write on bamboo sticks (China has the largest area of bamboo around the world, and it was a custom that ancient Chinese often wrote on bamboo. Europe and Western America originally did not have bamboo; Kang and Hu 2011). In the long run, the practice of vertical writing and reading may have influenced Chinese people's vertical temporal thinking.

On the other hand, the Mandarin language itself has also been claimed to be responsible for the vertical space-time mappings (Boroditsky 2001; Frhrman et al. 2011; Lai and Boroditsky 2013). For example, the employment of Mandarin vertical spatial metaphors to express time has been used as a basis for proposals that suggest that these habitual speech patterns may influence thinking online, during linguistic processing. When speakers use certain speech patterns repeatedly, they may form habitual language-specific conceptual schemas (e.g. Boroditsky 2001; Slobin 1996). For Mandarin speakers, the use of vertical spatial metaphors for time may provide them a way of thinking about time vertically.

5.2 The creativity of asymmetric space-time mappings in CSL

Despite CSL also employing 3D timelines to express time, it is unclear why its pattern is so different from Mandarin speech and gestures given that CSL signers and Mandarin speakers share the same Chinese culture. Lin and Gu (submitted) propose an explanation that the ultimate outcome of signing a timeline is a result of interactions between culture, language, and modality experience. For instance, it is understandable that CSL can have a vertical timeline as CSL signers are exposed to the Chinese vertical writing culture. Interestingly, Lin and Gu also find that the space-time mappings in CSL change over generations. Although older signers may sign time with PAST IS UP mappings, younger signers no longer perform such signs.

Additionally, certain signs such as PAST IS BACKWARD OR FUTURE IS DOWN have been grammaticalized, thus excluding the need for using an additional sign to map PAST IS UP OR FUTURE IS FORWARD. Furthermore, unlike spoken Mandarin, CSL cannot have both PAST IS FORWARD and PAST IS BACKWARD mappings because such opposite mappings on the same timeline for the same concept may lead to an ambiguity in the visual modality of language. In short, culture, language contacts, and modality constraints may have jointly influenced the creativity of CSL timelines.

6. Summary and conclusions

Chinese people use vertical, sagittal, and lateral timelines, and the use of certain timelines can be influenced by the culture such as the vertical and lateral writing direction. Within the Chinese culture, Mandarin-English bilinguals creatively gesture differently about time when speaking Mandarin than when speaking English (e.g., positioning the past above on a vertical axis when speaking Mandarin but putting it to the left on a lateral axis when explaining in English). Additionally, Mandarin speakers can gesture the past to their front and the extent to which they perform past-in-front/ future-at-back mappings is sensitive to the wording of Mandarin space-time metaphors. Furthermore, Chinese signers create different timelines than Mandarin speakers, and Mandarin-CSL bimodal bilinguals perform different temporal gestures than Mandarin-speaking non-signers even when they both speak in their first language, Mandarin. All these studies seem to suggest that cultural, linguistic, and bodily experience may jointly shape how Chinese people express time creatively in different modalities.

Of course, people's conceptualization of time can sometimes be flexible (Santiago et al. 2007; Torralbo et al. 2006), and can be influenced by a specific context (Casasanto and Bottini 2014) and individual differences (Duffy et al. 2014;

Duffy and Evans 2017; Saj et al. 2014; Li and Cao 2018). However, the weight and respective role of different factors in shaping an individual's space-time mappings are still unclear. Time series analysis of big data sets collecting various related factors longitudinally from a large sample size may offer further insight. In addition, so far, no research has investigated Chinese people's conception of time from a developmental perspective. The few studies on English children have shown that young children's mental timeline can be quite flexible in axes (Tillman et al. 2018) but largely affected by changes in literacy (Stites and Özçalışkan 2021), and their temporal gestures also show great differences compared to adults' (Burns et al. 2019). Given that Chinese people create different ways to conceptualize time than English speakers, it would be interesting to investigate how such abstract concepts for Chinese children, deaf or hearing, are gradually shaped to become language-, modality- or cultural-specific. To better understand this, future research can investigate the topic longitudinally, combining linguistic and non-linguistic approaches. This is not only relevant to our understanding of the multiple creative ways of conceptualizing time within and across cultures, but also has important implications for children's language acquisition of abstract concepts.

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