

Chinese hands of time

The effects of language and culture on temporal gestures and spatio-temporal reasoning

Across languages and cultures, people use space to represent time. In this dissertation Chinese people's conceptualisation of time is investigated, with a focus on the production and perception of gestures, mental space-time mappings, and cultural temporal values. These issues are studied cross-culturally and within the Chinese culture, including analyses of different Chinese populations.

The results show that, firstly, Chinese may have different mental space-time mappings than Spaniards and Moroccans, in line with their different cultural values towards time. Secondly, within the Chinese culture, Mandarin-English bilingual speakers gesture differently about time when speaking Mandarin Chinese than when speaking English. Thirdly, 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, Mandarin-Chinese Sign Language (CSL) bimodal bilinguals perform different temporal gestures than Mandarin-speaking non-signers, even when both speak in their L1 Mandarin Chinese. Finally, deaf users of CSL display a different spatio-temporal reasoning than Mandarin speakers, and there is an effect of written Mandarin proficiency on signers' spatio-temporal reasoning. All these studies suggest that there are not only long-term effects of cultural attitudes on the spatialisation of time, but also immediate effects of the linguistic space-time metaphors that probe people's mental representations. In conclusion, culture and language may not simply influence how we *think* about time, but also shape the way we *move* our hands to refer to time.

This dissertation may be of interest to researchers working on gestures, bilingualism, language and cognition, and cross-linguistic/cultural differences in space-time mappings.

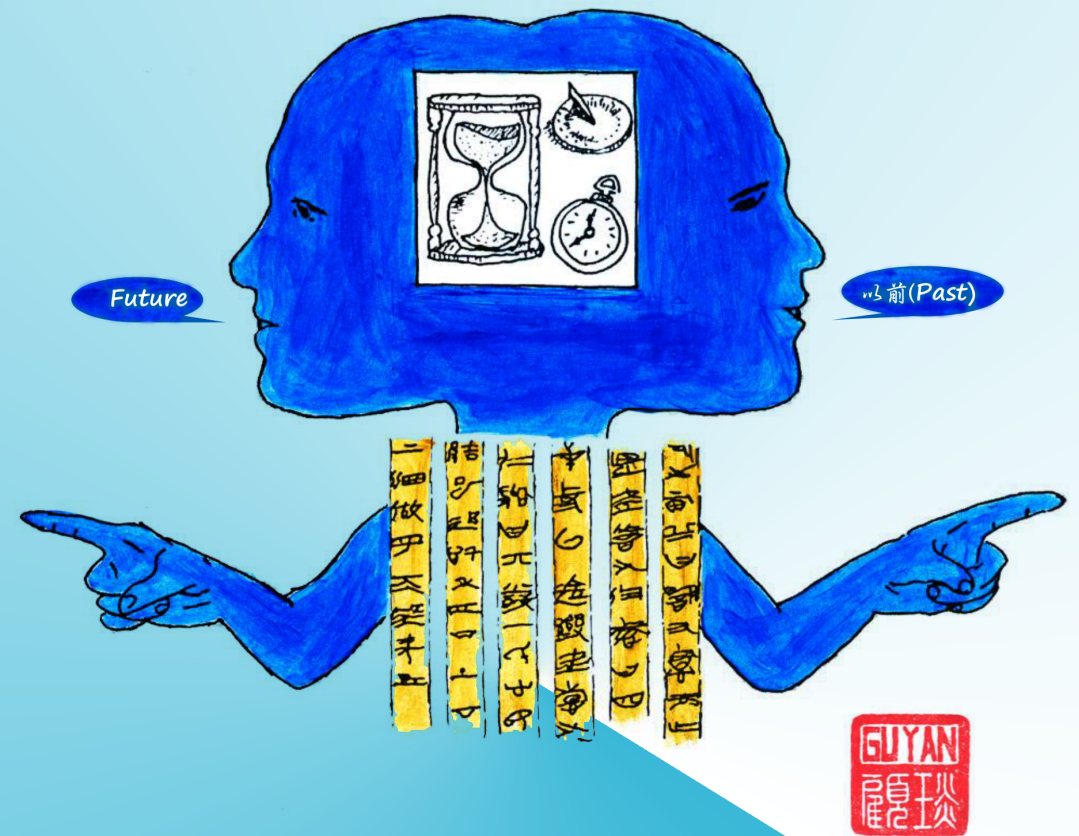
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— Grandfather shaped my dream.

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1

Introduction

It has been claimed that the structure of a language may indicate how a specific community conceptually organises the world (Slobin, 1996). In addition, cultures may differ in the way they view the world and how that is linguistically expressed (Levinson, 2012). For example, if a speaker of Mandarin would like to refer to a third person's cousin, the personal pronoun that the speaker uses will not reveal the gender of the third person (at least in spoken Mandarin). Unlike in English, where the use of a word like "his" automatically indicates that the third person is male, in spoken Mandarin the pronoun "tā (de)" can refer to "his", "her", and "its". However, the Mandarin equivalent of the word "cousin" will reveal aspects that the English word does not make clear, such as the gender of the cousin, as well as whether s/he is from the father's side or from the mother's side, and whether s/he is older or younger than the third person. Interestingly, in Dutch, the word "cousin" specifies the gender whereas it does not distinguish whether s/he is a "cousin" or a "niece/nephew". These differences in kinship and how they are lexically expressed represent one example of culture-embedded language differences that reflect differences in how people conceptually organise the world.

The hypothesis that language can influence thought is known as the (weak) Whorfian hypothesis, which proposes that the structure of one's language can influence one's understanding of the world and, therefore, can lead to a specific perception of the world (Whorf, 1956). Admittedly, differences in speaking do not *necessarily* lead to differences in thinking, yet the past decades have witnessed a renewed interest among psychologists and linguists into the relation between language and thought, and into how a language may influence various aspects of humans' experience of the world. For instance, speakers in different parts of the world may vary in the way they perceive colour, space, time, causality, etc. because of differences in the way their specific language is structured (see a review in Boroditsky, 2011).

Although a body of empirical evidence from different disciplines shows that language influences thinking in several important ways, there is still much to explore. For instance, there has been a longstanding debate on whether Chinese and English speakers conceptualise time differently (e.g., Boroditsky, 2001; Boroditsky, Fuhrman, & McCormick, 2010; Chen, 2007; Chen & O'Seaghdha, 2013; January & Kako, 2008), and whether these possible differences are the result of variation between the different languages (e.g., spatial metaphors for time) or of different conventions of the respective cultures (e.g., writing directions) (Bergen & Chan Lau, 2012; Fuhrman *et al.*, 2011; Chen, Friedrich, & Shu, 2015; Hendricks & Boroditsky, 2017; Xiao, Zhao, & Chen, 2017).

The present dissertation aims to contribute to the aforementioned debate by studying the effects of language and culture on gestural and spatial representation of time by Chinese people. Gesture is an important topic in this thesis. It is known that people not only talk about time, but also use gestures to visualise time conceptions. Such temporal gestures may reveal speakers' spatio-temporal thinking that may not be evident in linguistic spatial metaphors for time. For instance, English speakers often gesture to the left and right to refer to the concepts of past and future (Casasanto & Jasmine, 2012; Cienki, 1998; Cooperrider & Núñez, 2009; Walker & Cooperrider, 2016), despite the fact that English does not have left or right spatial metaphors for time. However, it is yet unknown whether Chinese people spontaneously gesture about time differently than English speakers. Furthermore, past studies have mostly focused on general cross-cultural and cross-linguistic comparisons between Chinese and English people, in that sense somewhat ignored possible variation within a specific community. As it will be pointed out later, there are reasons to assume Chinese people may gesture about time differently when speaking different languages (e.g., Mandarin vs. English). Likewise, Mandarin hearing speakers may be expected to change their temporal gestures when speaking Mandarin after learning Chinese Sign Language. And there is circumstantial evidence to suspect that Chinese deaf signers have a different spatial-temporal reasoning than Mandarin-speaking non-signers. This thesis aims to find out the answers to questions related to these topics by studying the possible influence of the temporal language people speak on their gestures about time and spatial-temporal reasoning, looking both at variation across and within a culture. Additionally, it will also investigate the effect of cultural attitudes towards time on Chinese people's mental space-time mappings.

Throughout the four independent studies reported in this thesis, various issues related to language, space, gestures and the conception of time will be discussed. Based on the results of psycholinguistic experiments, this thesis aims to better understand the cross-cultural and within-cultural differences in the conceptualisation of time, and to contribute to theories on the relationship between language, culture, and thought. Furthermore, the studies on temporal gestures are expected to also provide an insight into the mechanisms of how metaphorical gestures are produced. The purpose of this introductory chapter is to provide background information on space-time mappings and gestures, and to give an overview of the four studies, including explanations of some methodological aspects.

1.1 Using Space to Represent Time

It is claimed to be universal that people use concrete space to represent the abstract concept of time as manifested in old-fashioned clocks, hourglasses, calendars, or sundials (e.g., Casasanto & Boroditsky, 2008). Interestingly, in ancient China, people also used 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 used water and fire to estimate the temporal durations of events. For instance, Figure 1.1 shows such a water device, a copper clepsydra, which drips down water drop by drop as an indication of time passing. The amount of time passed would then be represented by the water level in the containers. An example of fire as time indicator was the burning of incense. An incense stick was marked at regular intervals and the length of each interval indicated a specific amount of time that had passed. It is generally believed that each stick takes half an hour to burn completely, and therefore Chinese people often say *the duration of burning an incense stick* (一炷香, yízhǔ-xiāng, Baidu).



Figure 1.1. Copper clepsydra in ancient China, photo taken by Jiawei Zhai (a friend of the author) at Diaohua Building, Dongshan, in Suzhou.

However, the way people spatialise time differs across languages and cultures (e.g., Boroditsky & Gaby, 2010; Bylund & Athanasopoulos, 2017; Moore, 2014;

Sullivan & Bui, 2016; see reviews by Bender & Beller, 2014; Núñez & Cooperrider, 2013). Taking the mental timeline, for instance, it has been shown that people with an Anglo-Saxon background (as well as many Westerners) typically think about the past as behind and the future as ahead of them (e.g., Miles, Nind, & Macrae, 2010; Ulrich *et al.*, 2012). This mental space-time mapping is also consistent with the spatial metaphors for time in the language (e.g., Calbris, 2008; Clark, 1973; Evans, 2004, 2013; Lakoff & Johnson, 1980; Traugott, 1978) as shown in (1). By contrast, Aymara speakers (South America) conceptualise the future as *behind*, and the past as *in front* of them (Núñez & Sweetser, 2006), and in Aymara, too, this past-in-front space-time mapping is visible in their language use, see (2).

- (1) a. We look *forward* to the bright future lying *ahead*.
- b. We look *back* at the beautiful times we had together.
- (2) *qhipa mara*, literally *back year*, meaning “next year”.

Similar to the Aymara, Moroccans (North Africa) also have a past-in-front space-time mapping. That is remarkable, because in Arabic the metaphoric expression of time on the sagittal (front-back) axis closely matches that of most future-in-front languages like English and Spanish. Moroccans, however, have a strong tendency to place past events in front. In Moroccan culture, tradition and old generations are highly valued, and Moroccans are strongly past-focused. It is claimed that people who are past-focused have a tendency to place the past in front of them, “in the location where they could focus on the past literally with their eyes [as] if past events were physical objects that could be seen” (de la Fuente, Santiago, Román, Dumitrache, & Casasanto, 2014, p.1684). Thus space-time mappings in people’s minds may also be conditioned by their cultural attitudes towards time, which could be independent from the space-time mappings expressed in language (de la Fuente *et al.*, 2014).

In addition to the sagittal, front-back timeline, Westerners often arrange a time sequence according to the order of left-for-past and right-for-future (e.g., Santiago, Lupáñez, Pérez, & Funes, 2007). By contrast, because of a right-to-left writing direction, Hebrew people tend to have a reversed space-time mapping when using a lateral axis, with the future to the left and the past to the right (Fuhrman & Boroditsky, 2010; Tversky, Kugelmass, & Winter, 1991).

Furthermore, a few studies have suggested that the English language also uses a vertical timeline (e.g., Boroditsky, 2001; Casasanto, 2016; Lakoff & Johnson, 1980). For instance, English speakers use vertical spatial metaphors to express time such as

in (3a), suggesting a mapping in which the *future* is *up*. However, the mapping of time on the vertical axis is not very clear, since English also has vertical spatial metaphors with a mapping of *late/future* is *down* like in (3b), implying that the younger/future generation is *down*.

- (3) a. in the *upcoming* week
 b. The house has been handed *down* from generation to generation.

The English vertical spatial metaphors for time linguistically appear to suggest two different temporal orientations, but the mental orientation of the vertical timeline of English speakers is usually realised as one whereby the *future* is *up* and the *past* is *down* (e.g., Boroditsky, 2001; Fuhrman *et al.*, 2011). Furthermore, recent eye-tracking studies revealed that, Swiss-Germans may also have a vertical mental timeline with the *future* as *upwards* (Hartmann, Martarelli, Mast, & Stocker, 2014; Stocker, Hartmann, Martarelli, & Mast, 2016).

Additionally, people's mental space-time mappings can sometimes be flexible (Santiago, Lup áñez, Pérez, & Funes, 2007; Torralbo, Santiago, & Lup áñez, 2006), as they can be influenced by a specific context and personal bodily experience (de la Fuente *et al.*, 2014; Duffy, Feist, & McCarthy, 2014; Duffy & Evans, 2017; Saj, Fuhrman, Vuilleumier, & Boroditsky, 2014). For instance, pregnant women are more likely to have future-in-front mappings than non-pregnant women (Li & Cao, 2018), and one's mental timelines can be altered after a brief exposure to mirror-reversed orthography (Casasanto & Bottini, 2014).

Chinese Spatial Metaphors for Time and Mental Timelines

Mandarin speakers have been argued to have three timelines, expressed on the lateral, vertical, and sagittal axes (e.g., Boroditsky, 2001; Fuhrman *et al.*, 2011; Xiao, Zhao, & Chen, 2017; Yang & Sun, 2016). Firstly, the lateral axis is similar to that of the Westerners who map the past and the future to the left and the right. This is likely to be shaped by the education and the reading/writing direction rather than by linguistic space-time metaphors, as there are hardly any left-right spatial metaphors for time in the Mandarin language.

Secondly, the most well-known timeline for Mandarin speakers is the one expressed on a vertical axis. That is, a vertical conceptualisation of time runs the timeline from top to down (past to future) (but see an exception in Xiao, Zhao, &

Chen, 2017)¹. However, the reason why Mandarin speakers conceptualise time vertically remains controversial (see a review by Chen & O’Seaghdha, 2013). Although it has been found that the Chinese vertical writing direction in the old days can shape Mandarin speakers’ vertical thinking (Bergen & Chan Lau, 2012; Chen, 2007; Chen, Friedrich, & Shu, 2015; Fuhrman *et al.*, 2011), the Mandarin language itself has also been claimed to be responsible for the vertical space-time mappings (Boroditsky, 2001; Boroditsky, Fuhrman, & McCormick, 2010; Lai & Boroditsky, 2013). For example, as (4) shows, Mandarin speakers can use vertical spatial metaphors to express time, with *above* (上/shàng) indicating an *early* event and *below* (下/xià) a *late* one. This 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, 1987).

- (4) a. 上周/shàng zhōu, literally, *above week*, meaning, “last week”
 b. 下周/xià zhōu, literally, *below week*, meaning, “next week”

Thirdly, Mandarin speakers can use sagittal spatial metaphors to express time (Yu, 2012). First, similar to English, Mandarin speakers can linguistically suggest that the future lies *ahead* and the past *behind* the speakers, such as in phrases as (5). Second, different from English, it is quite often the case that the Mandarin expressions of the temporal conceptions of “past” and “future” themselves contain lexical references to sagittal space, such as “前/qián” (literally “front”) and “后/hòu”

¹ Xiao, Zhao and Chen (2017) reported results that showed a reversed pattern for Mandarin speakers, with *up* for the *future* and *down* for the *past*. It is not impossible for Mandarin speakers to have such a vertical timeline. 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 or a child, and the stimuli of the future were mostly about being an adult or an old person. These stimuli had a risk of eliciting a conceptual mapping that *less* (in length or age number) is *down*, and *more* is *up* (Lakoff & 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 on the ground, meaning “new-borns”) that suggests a downward motion. Thus, it is difficult to tell in their study whether the vertical mappings that *past* is *down* is due to conceptualisation of time or to some other imagistic thinking or number-space mapping.

(literally “back”). Such a space-time word of “前/qián” can indicate both the spatial concept of “front” and the temporal concept of “early/before” (6a), whereas “后/hòu” indicates both the spatial concept of “back/behind” and the temporal concept of “late/after” (6b)². In this way, these Mandarin temporal expressions contain space-time words that suggest past-in-front/future-at-back space-time mappings³.

- (5) 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.
- (6) a. 前天/qián tiān, literally, *front day*, meaning, “the day before yesterday”
- b. 今后/jīn hòu, literally, *today back*, meaning, “from now on”



The fact that Mandarin has spatial metaphors suggesting different sagittal orientations of time, as exemplified in (5) and (6), means that it is still unclear how Mandarin speakers conceptualise the front-back timeline exactly. For instance, there are different views regarding sagittal space-time mappings by Chinese people, given the debate as to whether they are facing the past (Alverson, 1994), facing the future (Yu, 2012; Xiao, Zhao, & Chen, 2017; Ng, Goh, Yap, Tse, & So, 2017), or both the past and the future (Ahrens & Huang, 2002). Therefore, more experimental studies on Chinese people’s psychological reality of the sagittal timeline are needed.

² There are also examples of using “前/qián” (front) to indicate “late/after” and “后/hòu” (back) to indicate “early/before” such as “前途/qián tú (front path, future)”. However, such cases are rare, especially for “后/hòu (back)”. According to a corpus survey, only 2.75% of temporal use of “后/hou” refers to “early/before” (Peng, 2012).

³ Note that the Mandarin “前/qián” and “后/hòu” are the only words for the purely spatial use of “front” and “back”. They are different from English “before” and “after” that are widely used as temporal expressions but rarely used as pure references to space (Casasanto, 2016). Admittedly, there are examples like “The priest stands before the altar”, yet it is more common in English to use “front/back” and “ahead/behind” to refer to the space of “front” and “back”.

For within-culture comparative reasons, the study of Chinese people’s space-time mappings may benefit from analyses of (deaf) users of Chinese Sign Language (CSL). To date, few studies have researched deaf signers’ spatio-temporal reasoning, which, in the case of Chinese, represent an interesting comparison group, as they share a similar culture as speakers of Mandarin Chinese, but use a language which exploits different front-back time-space mappings (China Association of the Deaf and Hard of Hearing, 2003; Wu & Li, 2012; Zheng, 2009). Specifically, CSL users exploit future-in-front/past-at-back space-time metaphors whereas Mandarin speakers can additionally use past-in-front/future-at-back metaphors (see Table 1.1). So far no study has investigated whether deaf signers of CSL have a different spatial-temporal reasoning from Mandarin speakers. Furthermore, little is known about the effect of such cross-linguistic differences on the sagittal space-time mappings of Mandarin speakers who have learned CSL.

Table 1.1. Examples of expressing the temporal concepts of “the day before yesterday” and “the day after tomorrow” in Mandarin Chinese (past-in-front/future-at-back) and CSL (future-in-front/past-at-back) space-time metaphors.

Temporal concepts	Mandarin past-in-front/future-at-back metaphors	CSL future-in-front/past-at-back metaphors
The day before yesterday	前天 (<i>front day</i>)	 <p>The index and middle fingers point to the back once.</p>
The day after tomorrow	后天 (<i>back day</i>)	 <p>The index and middle fingers point forward.</p>

Given that Chinese Sign Language is mentioned, it is worth to point out to the reader that a sign language differs from co-speech gestures, although both of them

can be considered as cases of spatial manual movements to express meaning. They are different in the sense that a sign language is a full-fledged language whereas gestures are often considered to be a part of language which does not tend to have linguistic properties (McNeill, 1992). The following section will provide more information on gesture, space, and time.

1.2 Gestures and Space-Time Mappings

Gestures

Everyone gestures, including the blind (Iverson & Goldin-Meadow, 1998; Özçalışkan, Lucero, & Goldin-Meadow, 2016). People gesture even when talking on the phone (Bavelas, Gerwing, Sutton, & Prevost, 2008). One common interpretation of gesture is “visible bodily action” that has a close link with speech (Kendon, 2004; McNeill, 1992), which can be regarded as “language in the hands” (Mol, 2011) or “talking hands” (Hoetjes, 2015). However, people not only gesture spontaneously when they speak but also when they think or solve problems silently (co-thought gestures) (Chu & Kita, 2008, 2011, 2016). Therefore, gestures can be defined as symbolic movements of hands, arms, and other body parts that are related to people’s ongoing speech and expressive intention, as well as those movements that are related to people’s silent thinking. The gesture studies in the current thesis will focus on co-speech gestures.

There are different types of co-speech gestures, usually classified as iconic gestures, metaphoric gestures, deictic gestures, beat gestures, and emblems. Iconic gestures bear a close formal relationship to the semantic content of speech and illustrate aspects of the accompanying speech topic (e.g., using fingers to indicate the shape of the ears of a rabbit). Metaphoric gestures are similar to iconic gestures, but depict abstract ideas (e.g., showing left and right hands to represent bad and good things). Deictic gestures are pointing gestures that can be performed to refer to concrete entities or abstract concepts in space and time. Beat gestures are the hand or finger movements of up and down/forward and backward according to the rhythm of speech (McNeill, 1992), which are often used to emphasize some parts of speech (Krahmer & Swerts, 2007). Finally, there are gestures whose form and meaning relation is conventionalised (e.g., “thumb up” for “good”), which are often termed *emblems* (Ekman & Friesen, 1969).

Why Gesture?

People produce gestures for different purposes. One obvious reason is to communicate (e.g., Alibali, Heath, & Myers, 2001; de Ruiter, 2000; Kendon, 2004; Kita, 2000; McNeill, 1992; Mol, Krahmer, Maes, & Swerts, 2009, 2011; Özyürek, 2002). For instance, gestures can replace parts of speech (e.g., emblems), contribute extra information to speech (e.g., McNeill, 1992), and can be used to deal with grammatical difficulties and disfluency in a foreign language conversation (e.g., Gullberg, 1998). Speakers also tend to semantically align their gestures with lexical representations or syntactic structures in order to make these congruent (e.g., Kita, Özyürek, Allen, Brown, Furman, & Ishizuka, 2007; Özyürek, Kita, Allen, Furman, & Brown, 2005). For instance, an English speaker might express a “roll down” event in a one-clause sentence (e.g., the cat *rolled down*) accompanied by a gesture that conflates path and manner information (e.g., the index finger makes circles while moving down). By contrast, Japanese or Turkish speakers express the same event in two clauses (e.g., the cat descended as it rolled) and also produce two separate gestures for path and manner (e.g., one for moving down and another for circular movement) (e.g., Kita & Özyürek, 2003; Özçalışkan, Lucero, & Goldin-Meadow, 2016). Another reason why people gesture is as part of religious rituals, such as blessings, legal practices, and swearing (Seyfeddinipur, 2009).

Furthermore, performing gestures has been shown to provide cognitive support to the speaker. For instance, speakers produce gestures to retrieve their lexicons (Krauss, Chen, & Gottesman, 2000), to help to package information for speaking (Alibali, Kita, & Young, 2000; Kita, 2000), to reduce cognitive load (e.g., Cook, Yip, & Goldin-Meadow, 2010; Goldin-Meadow, Nusbaum, Kelly, & Wagner, 2001), and to help solve spatial-related problems (Chu & Kita, 2008, 2011). Interestingly, performing gestures also helps people learn new concepts and makes the learning last (e.g., Aussems & Kita, 2017; Cook, Mitchell, Goldin-Meadow, 2008; Tellier, 2008). Additionally, a recent study shows that encouraging children to use gestures while thinking might help them come up with more creative ideas (Kirk & Lewis, 2017). In short, gesturing can influence both people’s thinking and speaking (e.g., Kita, 2000; see a review in Kita, Alibali, & Chu, 2017).

Gesture: A Window into Spatial Cognition

Having said that there is a close link between gestures, speech, and cognition, gestures may also provide a window into a speaker’s mind (e.g., McNeill, 1992; Goldin-Meadow, 2003), and convey information not necessarily expressed in speech. Especially, gestures have an inherent spatial property that can reveal

speakers' spatial-motoric thinking (e.g., Alibali, 2005; Kita, 2000), so they can be viewed as a unique natural source of evidence (ecologically valid and efficient) for the use of space in abstract reasoning (e.g., space-time mappings) (Walker & Núñez, 2016). As Levinson (2003, p. 216) said, gesture “gives us insight into another level of mental life, representations of space that are at least partially independent of language, and that seem close to the very heart of our spatial thinking and spatial imagery”.

Temporal Gestures

Given the fact that people use space to represent time (e.g., Casasanto & Boroditsky, 2008), and that speakers also gesture when talking about time (temporal gestures), the co-speech gesture is a ubiquitous information modality next to speech (Iverson & Goldin-Meadow, 1998), and can “provide salient, additional information” about aspects of a speaker's (temporal) conceptualisation (Chui, 2011, p. 444; Müller, 2008). Several recent studies have confirmed that speakers from different cultures do perform temporal gestures in a systematic way when talking and reasoning about time (Casasanto & Jasmin, 2012; Cienki, 1998; Cooperrider & Núñez, 2009; Kita, Danziger, & Stolz, 2001; Li, 2018; Núñez & Sweetser, 2006; Núñez, Cooperrider, Doan, & Wassmann, 2012; Walker & Cooperrider, 2016). For instance, as mentioned previously, English speakers can think about time on the lateral and sagittal axes, and they also tend to produce temporal gestures on these axes. However, the Aymara speakers and Moroccans have past-in-front/future-at-back mental space-time mappings, which are also visible in their temporal gestures as they point past to their front and the future to their back (de la Fuente *et al.*, 2014; Núñez & Sweetser, 2006).

In this thesis, spontaneous gestures of Chinese people, representing different populations will be studied to reveal their space-time mappings. The overall aim of the studies presented in this thesis is to better understand the effects of linguistic spatial metaphors of time and the effect of culture on Chinese people's conceptualisation of time, with additional implications on how metaphorical gestures are produced. Before continuing with an overview of the studies, I will address some methodological aspects.

1.3 Methodology

There are several methodological aspects that are common to the studies presented in this thesis. In each chapter one or more production experiments will be reported,

and for some chapters perception experiments and a survey study will also be reported.

The production experiments consist of word definition tasks (Chapters 2, 3 and 4), temporal performance tasks (adapted from the temporal diagram task in de la Fuente *et al.*, 2014) (Chapters 3 and 5), and a clock question paradigm (Lai & Boroditsky, 2013) (Chapter 5). In the word definition task, participants were asked to talk about temporal expressions, during which their spontaneous gestures about time were elicited and recorded. In comparison to previous studies in which Mandarin speakers were forced to produce deliberate pointing gestures to show their space-time mappings (Fuhrman *et al.*, 2011; Lai & Boroditsky, 2013), spontaneous gestures are deemed more natural and may reveal a more implicit mental space-time mapping. In the temporal performance task, participants were explicitly instructed to label the concepts of the past and future. This paradigm has been used in several studies across cultures (e.g., de la Fuente *et al.*, 2014; Li & Cao, 2017, 2018; Li, Van Bui, & Cao, 2018), and the task has been adapted to be more appropriate for Chinese people in the present studies. In the clock question paradigm, participants had to give a specific time as an answer (e.g., 2 PM), according to their interpretation of a Mandarin space-time word. The answer to this question has been shown to be quite efficient in showing participants' understanding of time, and may indicate the effect of space-time metaphors on participants' spatio-temporal reasoning (Lai & Boroditsky, 2013).

In the perception experiments (Chapter 2), participants were shown written instructions and silent video clips displaying people who gesture, and were asked to rate the extent to which the gestures in the video clip expressed the instruction correctly. The instructions contained items of temporal references and video clips of temporal gestures. Participants' judgments allow the researchers to more explicitly examine their understanding of space-time mappings.

Furthermore, a temporal-focus questionnaire was used to investigate Chinese people's cultural attitudes towards time (Chapter 3). Previous research has used this questionnaire to examine attitudes towards time in Spanish and Moroccan cultures (de la Fuente *et al.*, 2014), and the survey of Chinese culture enables a comparison of cross-cultural differences.

This thesis reports on a series of studies that were conducted on different samples of Chinese populations, including Mandarin speakers (Chapter 3), Mandarin-English bilinguals (Chapter 2), Mandarin-Chinese Sign Language bimodal bilinguals (Chapter 4), and deaf users of Chinese Sign Language (Chapter 5). The topic of the thesis not only concerns the effect of spoken space-time

metaphors on Chinese people's space-time mappings, but also covers the cross-modal influence of spatial metaphors for time on temporal thinking within the Chinese culture.

1.4 Focus and Outline

This thesis contains four studies, which are all based on papers that have been published or submitted for publication in peer-reviewed journals. Although the theme of all studies is related to linguistic and cultural influences on the temporal gestures and spatial conceptions of time, each study can be viewed as a self-contained publication, with its own abstract, introduction, discussion, and reference list. Thus, it is unavoidable that there is some overlap in literature reviews across chapters. Additionally, there may be differences in statistical and analytic procedures due to the fact that papers were submitted to different journals with different policies, and whose reviewers may have different requests.

Chapter 2 presents a study of Mandarin speakers' vertical conceptualisation of time and reports on Mandarin-English bilinguals' spontaneous gestures about time. The research question is whether and why Mandarin-English bilinguals systematically perform vertical gestures to represent time. The aim is to find out whether the production of vertical gestures is due to the fact that Chinese people have a stable vertical time conceptualisation and "think vertically" when visualising time (see, e.g., Boroditsky, 2001; Fuhrman *et al.*, 2011), or that it is because these gestures are merely a result of the fact that Chinese speakers use specific words that express vertical spatial metaphors of time (e.g., *above week*, *last week*), or that the production of vertical gestures is a consequence of both factors. The aim is addressed by studying whether lexical choices of temporal-spatial expressions have any online influence on Mandarin-English speakers' production of vertical gestures in both Mandarin Chinese and in English. To elicit spontaneous gestures, participants were asked to do a word definition task, in which they talked about different types of temporal expressions (i.e., with vertical spatial metaphors or not). Additionally, the research questions are studied in a perception experiment, in which an addressee processes another person's co-speech temporal gestures.

Chapter 3 reports on a study on the conceptualisation of the past as in front of or behind Chinese people, entitled "*Which is in front of Chinese people, Past or Future*". The aim of this study is to examine the roles of cultural attitudes towards time and of the linguistic space-time metaphors in shaping Chinese people's sagittal space-time mappings. In addition to a survey on Chinese cultural attitudes towards time, results of different experiments on Chinese people's sagittal space-time

mappings are reported, including their spontaneous temporal gestures and action performances. As the action performance task was conceptually similar to the temporal diagram task (a labelling of the past and the future) used in de la Fuente *et al.* (2014)'s study, a cross-cultural comparison in space-time mappings was made between the Chinese data and de la Fuente *et al.* (2014)'s Moroccan and Spanish data.

Chapter 4 reports on a study on the effects of Chinese Sign Language (CSL) on the production of co-speech gestures about time in bimodal bilinguals. In Mandarin Chinese there are not only future-in-front/past-at-back space-time metaphors, but also past-in-front/future-at-back metaphors (Chapter 3). However, the sagittal lexical signs of CSL do not show this variation, as they represent only future-in-front/past-at-back space-time mappings. The research question is whether the experience of CSL temporal signs will influence bimodal bilinguals' L1 co-speech temporal gestures. The research explores firstly whether Mandarin-CSL bimodal bilinguals perform different patterns of temporal gestures from Mandarin speakers (that is, the proportion of temporal gestures produced on the vertical, lateral, and sagittal axes). Furthermore, focusing on the temporal orientation on the sagittal axis, the study examines whether hearing Mandarin speakers who have learned CSL have a different direction of sagittal temporal gestures than Mandarin non-signers. The same experimental paradigm was used as used in Chapter 2 to elicit bimodal bilinguals' spontaneous temporal gestures and compared the results with those of Mandarin speakers (Chapter 3).

In Chapter 5, the relation between spatial metaphors for time and spatio-temporal reasoning is further explored but now in deaf users of Chinese Sign Language. Given that Chinese signers use future-in-front/past-at-back space-time metaphors whereas Mandarin speakers can additionally exploit past-in-front/future-at-back metaphors, the study aims to find out whether such linguistic differences lead deaf signers to having a different time conceptualisation than Mandarin speakers, and whether acquiring written Mandarin sagittal space-time metaphors influences signers' spatio-temporal reasoning. A clock question paradigm and a temporal performance task (temporal diagram task, Chapter 3) were used to study participants' understanding of time.

The thesis ends with Chapter 6, in which a general discussion of all the studies, a brief outlook on future work, and the final conclusions are provided.

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Conceptual and lexical effects on gestures: The case of vertical spatial metaphors for time in Chinese

Abstract

The linguistic metaphors of time appear to influence how people gesture about time. This study finds that Chinese English bilinguals produce more vertical gestures when talking about Chinese time references with vertical spatial metaphors than (1) when talking about time conceptions in the English translations, and (2) when talking about Chinese time references with no spatial metaphors. Additionally, Chinese English bilinguals prefer vertical gestures to lateral gestures when perceiving Chinese time references with vertical spatial metaphors and the corresponding English translations, whereas there is no such preference when perceiving time references without spatial metaphors. Furthermore, this vertical tendency is not due to the fact that vertical gestures are generally less ambiguous than lateral gestures for addressees. In conclusion, the vertical gesturing about time by Chinese English bilinguals is shaped by both the stable language-specific conceptualisations, and the online changes in linguistic choices.

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- Gu, Y., Mol, L., Hoetjes, M., Swerts, M. (2014). Does language shape the production and perception of gestures? A study on late Chinese-English Bilinguals' conceptions about time. In P. Bello, M. Guarini, M. McShane, & B. Scassellati (Eds.), *Proceedings of the 36th Annual Conference of the Cognitive Science Society* (pp. 547-552). Austin, TX: Cognitive Science Society.

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2.1 Introduction

When people speak, they tend to accompany their utterances with gestures, in particular movements of speakers' hands, arms, and other body parts. These gestures are not accidental, but are functionally related to the ongoing speech and to the speakers' expressive intention (Kendon, 2004). Across cultures and languages, speakers' gestures can be vastly different. This has already been shown convincingly for specific classes of gestures such as emblems, as these rely on culture-specific conventions to associate specific gestural forms with certain meanings (Kendon, 2004; Kita, 2009). For instance, to express the number "two", Germans may perform a gesture by extending the thumb and index fingers with other fingers closed (like an "L"), whereas Chinese typically extend the index and middle fingers (the L-like German "two" would be interpreted as a gesture of "eight" by a Chinese). Additionally, studies have shown how cultures can differ regarding speech-accompanying gestures that are more spontaneously created on the fly, and are not conventionally associated with specific functions (e.g., Kita, 2009). The current paper addresses the latter kind of gestures, where we are specifically interested in so-called temporal gestures, that is, gestures that represent time conceptions, in which temporal reference is made along the body's sagittal (front-to-back), lateral (left-to-right), or vertical (top-to-down) axis (Casasanto & Jasmin, 2012; Cooperrider & Núñez, 2009). For example, when talking about specific time events such as *last week* or *next week*, English speakers may point to the back and front of the body, or in a sequence from left to right (Casasanto & Jasmin, 2012; Cooperrider & Núñez, 2009), even though there is no explicit rule that prescribes that they should use their gestures this way.

Temporal gestures differ in various languages and cultures. For instance, speakers of Aymara typically position the future behind their back, which is consistent with their language (*qhipa mara*, literally *back year*, meaning *next year*, Núñez & Sweetser, 2006). Residents of Pormpuraaw gesture the past at the direction of their East because they always arrange temporal order from the east to the west (cardinal directions) (Boroditsky & Gaby, 2010). A case study (Chui, 2011) suggests that Chinese speakers can employ the vertical axis to gesture about time. However, it is as yet unclear why Chinese speakers produce vertical gestures to indicate time like this. The purpose of this study is first to examine whether Chinese speakers systematically produce vertical temporal gestures. If so, we investigate how these vertical gestures are produced and perceived under different circumstances (e.g., Are vertical gestures more often produced for a certain type of time reference, and are they still produced when Chinese people talk in English?

When perceiving gestures about time, is there a bias for vertical gestures by Chinese people?).

2.1.1 Time, Space, and Gestures

People use spatial representations to think about time (Bender & Beller, 2014; Boroditsky, 2000; Casasanto & Boroditsky, 2008; Núñez & Cooperrider, 2013), such as sundials, graphs, hourglasses, clocks, timelines, and calendars; in ancient China one could also tell the time by the burning of incense (an incense stick was marked with regular intervals and the distance between each interval corresponded to a specific length of time). Studies have revealed that bodily, cultural, and environmental experiences can influence people's conceptualisations of time (de la Fuente *et al.*, 2014). For instance, patients with left spatial neglect also have difficulty in thinking of the past (Saj, Fuhrman, Vuilleumier, & Boroditsky, 2014). Hebrew people have a writing direction from the right to the left, and also tend to think that time goes from the right to the left (Fuhrman & Boroditsky, 2010). Yupno speakers rely heavily on topographic contrasts (environment-based absolute terms) and construct the past as downhill and the future as uphill (Núñez, Cooperrider, Doan, & Wassmann, 2012). Additionally, spatio-temporal thinking can be rapidly affected by the context. For example, people's mental timelines can be reversed after brief exposure to mirror-reversed orthography (Casasanto & Bottini, 2014).

How people conceive time can also be derived from their lexical expressions, especially through the use of spatial metaphors, although the pattern of spatial metaphors that people use to talk about time can be different across languages (e.g., Bylund & Athanasopoulos, 2017; Moore, 2014; Sullivan & Bui, 2016). For example, it is quite common for speakers of English to say "The future lies not too far ahead". They can use their body as a reference point for the "now" and then conceptualise the past at their back, and the future in front (Calbris, 2008; Clark, 1973; Evans, 2004, 2013; Traugott, 1978), or they can use the lateral axis, to order time from left (past) to right (future) (Santiago, Lupáñez, Pérez, & Funes, 2007). Therefore, in English, as well as in many other languages (e.g., Spanish, Dutch, and Chinese), two metaphorical timelines are often employed: The sagittal (front to back) and lateral (left to right) axes (However, left-right spatio-temporal metaphors are actually absent from English speech. Instead, this lateral time axis is likely due to the reading/writing direction).

Chinese speakers also use the vertical axis to express time, by employing vertical spatial metaphors of "上" (shàng: above) and "下" (xià: below) to indicate the time conceptions of "early" and "late" (e.g., Boroditsky, 2001). For example, "

上周” (shàng zhōu) can literally be translated as “above week”, which means “last week”, while “下下周” (xià xià zhōu) as “below below week”, referring to “the week after next week”⁴.

Interestingly, the metaphorical use of language for representing time can also be linked to how people spontaneously gesture about time. That is, the spatio-temporal concept can also be expressed in speakers’ co-speech metaphoric gestures (e.g., Casasanto & Jasmin, 2012; Cienki, 1998; Cooperrider & Núñez, 2009; Núñez *et al.*, 2012; Núñez & Sweetser, 2006; but for an alternative view, see e.g., Le Guen & Balam, 2012). As mentioned above, Chinese speakers can employ a vertical axis to gesture about time. However, it is not yet clear exactly why Chinese speakers produce vertical gestures.

2.1.2 Theories Accounting for Chinese Vertical Gesturing about Time

Due to the differences in the use of spatial metaphors in time conceptions, Boroditsky (2001) argues that Chinese speakers may have a different conceptualisation (a vertical one) of time than English speakers. Her argument is based on Slobin’s (1987) “thinking-for-speaking” hypothesis that habitual speech patterns can shape thinking online, during linguistic processing. When the preferred speech patterns are repeatedly used, language-specific conceptual schemas may be habitually formed. Specifically for Chinese, Boroditsky (2001) believes that the habitual use of vertical spatial metaphors to talk about time shapes Chinese speakers’ language-specific conceptual schema⁵. Interestingly, after learning Chinese vertical spatial metaphors, English speakers are also more inclined to think of time vertically (Boroditsky, 2001; Hendricks & Boroditsky, 2015). Additionally, Boroditsky found that Chinese speakers can conceptualise time vertically, even when they think in English. If it is the case that Chinese speakers have a long-lasting (habitual) vertical thinking of time, one would indeed assume that they can also gesture about time vertically, irrespective of whether they speak English or Chinese.

⁴ In Chinese, when talking about time on the lateral axis, “left” (左/zuǒ) and “right” (右/yòu) are only used together following a specific time point. It refers to “being earlier/later than a certain time point (around that time)”, e.g., “around one o’clock” is “一点左右/yī-diǎn zuǒ-yòu”, which literally means “one o’clock left right”.

⁵ Another account that can contribute to Chinese speakers’ vertical conceptualisation of time is the vertical writing direction in the old days (e.g., Chen, 2007; Fuhrman, McCormick, Chen, Jiang, Shu, Mao & Boroditsky, 2011). This factor is also addressed in the analyses section, and will be discussed intensively in Chapter 6.

These ideas are in line with what has been claimed in theories about embodied cognition, which propose that conceptual representations are largely grounded in sensorimotor experiences (Glenberg & Kaschak, 2002), and that representations are activated and often instantiated in the forms of gestures (Hostetter & Alibali, 2008). In other words, the production of gestures is influenced by how people think of using the body to interact with the physical environment (or in Kita’s (2000) terminology, spatio-motoric thinking). Specifically, in this case it is the way how one thinks of time in space that affects the gestural representation.

However, a slightly alternative reasoning is that Chinese may gesture vertically simply as a result of the fact that they use specific lexical words that express time, which in turn drive the way they gesture. In other words, such a view stresses the fact that speakers tend to align their gestures with the lexical representations in order to make these congruent (Kita *et al.*, 2007; Kita & Özyürek, 2003; Özyürek, Kita, Allen, Furman, & Brown, 2005); hence Chinese speakers will produce vertical temporal gestures when speaking about time conceptions through the use of vertical spatial metaphors.

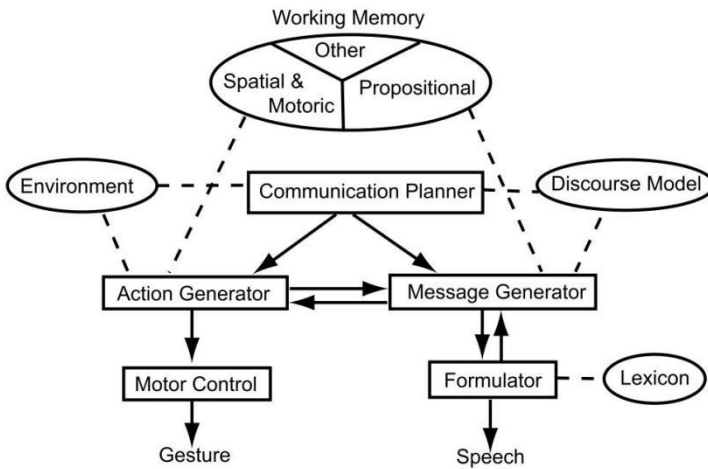


Figure 2.1. Kita and Özyürek’s (2003) speech and gesture production model.
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According to Kita and Özyürek’s (2003) Interface Hypothesis, spontaneous gestures are not only shaped by the imagistic (spatio-motoric) representations of

events, but are also adjusted to be compatible with linguistic encoding possibilities. In other words, the generation of a gesture is modulated by two forces: the spatio-motoric experience from the Working Memory, and the linguistic choices (linguistic formulation possibility, for example, different semantic and syntactic choices that a speaker can choose from when communicating, Kita *et al.*, 2007) from the Message Generator, both of which interact with each other (see Figure 2.1). The linguistic influence on gesture production is represented in the model by the arrow running from the Message Generator to the Action Generator. Then the Action Generator determines the ultimate content of a gesture by taking into account the two forces, such that gestures are adjusted to fit the verbalisation.

For instance, Kita and Özyürek (2003) found that a scene of a “Rolling Event” could be expressed as “rolling down” in English, with manner and path conflated into a single clause. Accordingly, this information tended to be conflated in gesture too, with one gesture expressing both manner and path. However, in Turkish and Japanese (verb-framed languages), manner and path need to be expressed separately in two clauses (i.e. “move down, in a rolling fashion”). Consequently, compared to English speakers, Turkish and Japanese speakers were more likely to produce manner only and path only gestures. Interestingly, the cross-linguistic differences in gestures disappeared when English and Turkish speakers were asked to describe motion events without the speech but only by gestures (silent gesture). This indicates that the verbal task had an effect on the gesturing of motion and path (Özçalışkan, 2016; Özçalışkan, Lucero, & Goldin-Meadow, 2016). Similar evidence was also revealed by an eye-tracking study, in which participants were instructed to watch animations depicting motion events (e.g., skating) that participants later had to describe. Native speakers of Greek (a verb-framed language similar to Turkish) were significantly more likely to look at path (where the moving character was heading) over manner (instrument regions, e.g., skating – the area of the feet that included the skates) than native speakers of English. The findings suggest that there are cross-linguistic differences in how people distribute visual attention to components of a scene when preparing for language production. However, there were no such differences when they were simply told to watch the video clip (Papafragou, Hulbert, & Trueswell, 2008). In sum, the studies above suggest that a speaker’s use of gestures is not only a result of spatio-motoric processing, but is affected online by specific linguistic choices as well (such as specific syntactic or lexical surface forms).

In addition to research that focused on differences between languages, there are several studies that looked at gesture production by bilinguals, although these have

yielded some mixed results. Speakers of verb-framed languages (e.g., Spanish, Turkish) often produce gestures for the path of the motion with verbs, and tend not to accumulate gestures for path and manner, whereas speakers of satellite-framed languages (e.g., English, Dutch) tend to produce path gestures with a satellite component, and tend to accumulate gestures for path and manner in a single clause. First, some case studies about bilinguals' gestures for motion events described that Spanish/Turkish learners of English maintained an L1-like gesture pattern in the L2, for example, Spanish and Turkish speakers still performed path gestures with verbs when speaking English, although the findings were based on a very small sample (Kellerman & Van Hoof, 2003; Negueruela, Lantolf, Jordan, & Gelabert, 2004; Stam, 2006). Second, another study found that there was a parallel trend in L2 speech and gesture production. Turkish learners of English were more likely to use conflated manner-path gestures when they verbally used conflated constructions in the L2 English (Özyürek, 2002). Finally, there is also evidence of bi-directional influences of L1 and L2 (co-activation of both languages) in both speech and gesture production. For example, Brown and Gullberg (2008) found that Japanese learners of English (L2 English) did not differ significantly in how they encoded "manner" in speech or gestures in their L1 or L2 productions, but their gesture pattern differed significantly from that of monolingual Japanese speakers and of monolingual English speakers. In short, previous studies on motion events suggest that gestures may result both from specific mental representations and from linguistic choices, but it remains to be explored how these two factors relate or interact when bilinguals describing abstract conceptions such as time events.

2.1.3 The Current Study

In the current study we investigate gestures about time references. First we will find out whether Chinese–English bilinguals perform vertical temporal gestures. If so, the study aims to shed light on why they produce vertical gestures to indicate time. Specifically, we aim to explore whether the production of vertical gestures is due to the fact that Chinese people have a stable vertical time conceptualisation and "think vertically" when visualising time (Boroditsky, 2001), or is it because their gestures are merely a result of the fact that they also use specific words that express vertical spatial metaphors of time ("above week" for "last week"; "below week" for "next week"), or are the vertical gestures a consequence of both these factors? We answer these questions by studying whether lexical choices of vertical temporal-spatial expressions have any online influence on vertical gesturing.

We have set up a series of experiments in which lexical choices are manipulated in two important ways, to see how these affect the production and perception of gestures. Firstly, we introduce a within-language factor, in that we vary the linguistic expressions for time conceptions within Chinese, by comparing gestures in utterances in which time is expressed by vertical spatial metaphors (e.g., “上周”/“shàng zhōu”, “above week”, meaning “last week”) with utterances that do not contain such a spatial metaphor (neutral words such as “昨天”/zuótiān, meaning “yesterday”). This will allow us to see to what extent the type and frequency of specific gestures are affected by the mere presence of specific words that express this vertical time conception. If such a lexical trigger would be the determining factor for the gestural representation of time, one would expect relatively few vertical gestures in utterances that do not contain an explicit vertical spatial metaphor.

Secondly, we make a comparison between two languages, by exploring the gestural expression of time in Chinese and English by Chinese–English bilinguals, given that time conceptions with Chinese vertical spatial metaphors have different, non-vertical, lexical correlates in English (e.g., “above week” in Chinese, “last week” in English). If the vertical mental representation of time in Chinese speakers is the most important determining factor for the choice of gestures, and assuming everyone can only have one conceptual scheme (e.g., Kellerman & Van Hoof, 2003; Negueruela *et al.*, 2004; Stam, 2006), then one would predict that Chinese–English bilinguals will also gesture vertically even when speaking English. That means their vertical gesturing will be unaffected by the language itself. Alternatively, if gestures are more strongly caused by linguistic choices, one would expect speakers to gesture more vertically when speaking Chinese than English, especially for words with a lexical trigger in Chinese.

These questions are addressed both from the perspective of a speaker who spontaneously produces gestures while speaking (Experiment 1), and the perspective of an addressee who processes another person’s co-speech gestures (Experiments 2 and 3).

By researching the gestural representations of time in Chinese–English bilinguals, we can provide a better understanding of the cognitive processing of the production and perception of co-speech gestures, and we can shed light on the respective roles of lexical choices and mental representations in bilingual language processing.

2.2 Experiment 1

In the production experiment, we address two questions: (1) In Chinese, will verbally producing time conceptions with vertical spatial metaphors (“above week”, “below month”, etc.) lead to more vertical gestures than in the case of verbally producing time conceptions without a spatial metaphor (e.g., neither in Chinese nor in English are “yesterday” and “tomorrow” spatial expressions with reference to time)? (2) Given the fact that English and Chinese speakers may think of time differently (Boroditsky, 2001), will Chinese–English bilinguals produce more vertical gestures in Chinese than in English?

2.2.1 Method

Participants

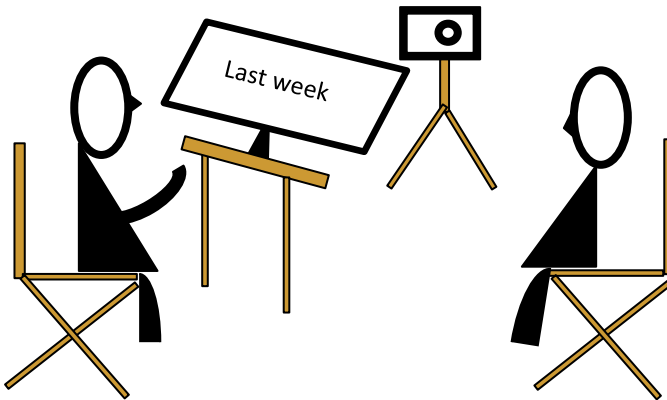
Forty-six late Chinese–English bilinguals (L1 = Chinese; 35 F and 11 M; mean age = 24 yrs, ranged from 19 to 38 yrs, $SD = 3.8$ yrs) were paid for participation. They were students attending English-taught international programmes at Tilburg University (the Netherlands), who originally came from China. Bilinguals were defined as sequential bilinguals, who first acquired Mandarin as the L1 and then English as the L2 (Average age of acquisition = 11 yrs). Their English proficiency was between intermediate and advanced, as assessed by a Quick Placement Test (UCLES, 2001) and a 5-point-scale (1 for beginner and 5 for very advanced) self-report ($M = 3.53$, $SD = .64$).

Stimuli

Eleven Chinese wordlists were constructed for a word definition task. Four wordlists were relevant for the current study, which in total consisted of eleven expressions that conveyed time conceptions. The number of expressions in each wordlist ranged from two to four (Table 2.1). Wordlists (1) and (2) were time references containing words with vertical spatial metaphors (“上”/shàng, *above*, and “下”/xià, *below*) to indicate the conceptions of “early” and “late”. By contrast, words in wordlists (3) and (4) did not contain explicit lexical references to vertical (“shàng”, *above* or “xià”, *below*), or sagittal (“前”/qián, *front* or “后”/hòu, *back*) space dimensions.

Table 2.1 Wordlists of targeted time referents.

Chinese	English
(1) 上周, 下周 (vertical) shàng zhōu, xià zhōu	last week, next week (neutral English translations of vertical)
(2) 上辈子, 下辈子 (vertical) shàng bèi zi, xià bèi zi	previous life, next life (neutral English translations of vertical)
(3) 昨天, 今天, 明天 (neutral) zuó tiān, jīn tiān, míng tiān	yesterday, today, tomorrow (neutral)
(4) 早晨, 晌午, 傍晚, 深夜 (neutral) zǎo chén, shǎng wǔ, bàng wǎn, shēn yè	morning, noon, evening, late at night (neutral)

Procedure**Figure 2.2.** Schematic illustration of the experimental set-up.

Each participant was tested individually, in interactions with an unknown addressee who would not become a participant (speaker) afterwards. The experiment was ostensibly set up as a language and memory test, in which the speaker's short-term memory and the addressee's long-term memory would be tested. They sat face-to-face in a quiet room, where a monitor was placed in front of the speaker. The wordlists were presented in the centre of the monitor and could only be seen by the speaker (Figure 2.2). Each wordlist consisted of several expressions that were thematically related (e.g., "last week" and "next week"). The expressions within a wordlist were shown on separate slides to avoid that they would be presented

laterally or vertically and thus suggesting a specific axis, but each word within an expression was presented laterally. Furthermore, the speaker was told that s/he would have to remember the wordlists shortly after having seen them twice, find the relationship between the expressions within a wordlist and explain the definitions of the expressions to the addressee as clearly as possible. Note that it was not a word-guessing game, as speakers were allowed to tell the expressions in the wordlists. The addressee was told to remember the speaker's descriptions as much as possible for a memory test afterwards, and s/he was allowed to ask the speaker clarification questions. After the task, the addressee was taken to another room for the memory test, which s/he did not actually need to complete.

All participants took part twice in the experiment, once in Chinese and once in English. The instructions were given in the language of the experiment. The testing order of the languages was counterbalanced and the interval between the 2 tests was approximately 10 days (to reduce possible learning effects). The addressees were native speakers of Chinese for the Chinese task, and Dutch–English/English–Dutch bilinguals for the English task. The entire experiment was videotaped with participants' consent. There was no mentioning of gestures at any point during the experiment, and speakers were not explicitly informed to gesture during the production task. After the second session of the experiment, participants were given a questionnaire to fill in some background information such as the age of acquisition, length of residence in the Netherlands, and writing experiences. Debriefing responses indicated that participants had not been aware that the purpose of the study was to investigate speakers' gestures.

Coding and Measurements

The temporal gestures accompanying the speech that described the target wordlists were annotated in ELAN (Lausberg & Sloetjes, 2009). A first coder (the first author) performed an initial coding, viewing the entire video with the accompanying audio. The planes of gestures were categorised as vertical, lateral, or sagittal, and the directionality of each plane was also indicated (Casasanto & Jasmin, 2012). When a wordlist was produced with gestures of no codable direction or no/ non-temporal gestures, it was coded as "other".

A participant could explain a wordlist by using temporal gestures from several planes, which were coded in each plane accordingly. The present study focused on vertical temporal gestures, so wordlists with sagittal or lateral temporal gestures and

with “other” gestures were all treated as “non-vertical” in the later analyses⁶. Each wordlist got one binary score: Containing a vertical gesture or not. Four participants did not produce any gestures in Chinese or in English for all target wordlists and one participant did not finish the experiment. Data from these five people were excluded from the analysis.

The reliability of the annotation was established by having 15% of the data coded by a second coder, who was naïve to the research question at the time of coding. The two coders agreed on the gesture plane judgement on 91.1% of the tokens ($N = 56$), Cohen’s Kappa = 0.85 (referring to “Excellent” agreement). In cases of disagreement, the two coders discussed and reached agreement on the labels, which were used for the final analysis.

In the subsequent analyses, the wordlist-type (vertical and neutral) and the language factor (Chinese and English) were the independent variables. The type of a temporal gesture (vertical, non-vertical) accompanying the description of a wordlist was the binary dependent variable.

2.2.2 Results and Discussion

Participants produced a total of 328 ($41 \times 4 \times 2$) target wordlists for both languages, 269 (82.0%) of which were accompanied by clear temporal gestures [128 (78.0%) for Chinese and 140 (85.4%) for English]. The remaining wordlists (18%) were produced either with gestures having no codable direction or no/non-temporal gestures. The average number of temporal gestures per wordlist in English ($M = 3.51$, $SD = .71$) was significantly higher than in Chinese ($M = 3.14$, $SD = 1.06$), $t(40) = 1.95$, $p = .029$, $r = .30$. This is to be expected, because late bilingual speakers have been shown to gesture more often in their second language than in their first language (Gullberg, 1998).

Based on the binary coding, each wordlist was accompanied with either a “vertical” or “non-vertical” gesture. The proportion of vertical temporal gestures for each type of time references was computed as the total number of wordlists that were accompanied by vertical gestures divided by the total number of wordlists. As shown in Figure 2.3, vertical gestures were produced for both types of wordlists in both Chinese and English. The fact that vertical gestures were produced for time references with neutral words in Chinese and English suggests that Chinese–English

⁶ When wordlists with “others” were excluded in the analysis, the results remained similar.

bilinguals can employ a vertical conceptualisation of time, even when switching to a second language (cf. Boroditsky, 2001).

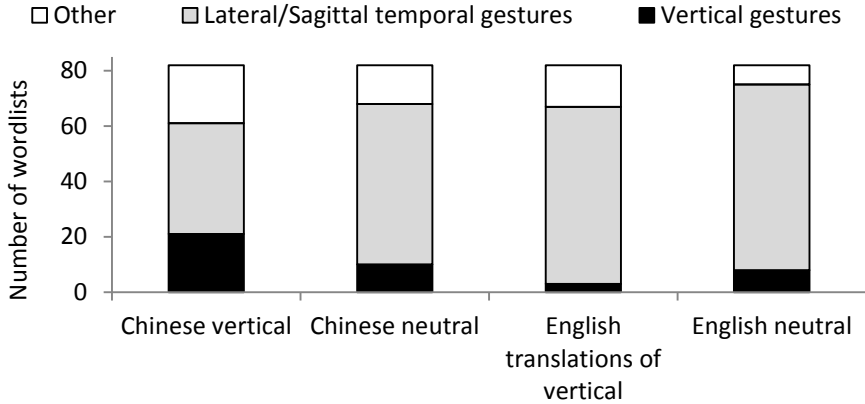


Figure 2.3. The proportion of wordlists that were accompanied by vertical gestures for the four types of time references (82 for each type). Chinese vertical/English translations of vertical = wordlists 1 and 2; Chinese neutral/English neutral = wordlists 3 and 4 (Table 2.1.).

The proportion of vertical gestures was compared as a function of Wordlist-type (vertical, neutral) and Language (Chinese, English) using a random effects binary logistic regression⁷. This model considers multiple responses from the same participants and takes individual differences (random effects) into account.

First, Chinese wordlists with vertical spatial metaphors were accompanied by a significantly higher proportion of vertical gestures than the neutral Chinese wordlists ($\beta = -1.11$, Wald $\chi^2 = 6.04$, $df = 1$, $p = .0014$) (Table 2.2). This indicates that producing time references with vertical spatial metaphors had an online effect on the production of vertical gestures. By contrast, the difference between the two types of wordlists was not statistically significant in English ($\beta = 1.16$, Wald $\chi^2 =$

⁷ This model is equivalent to the generalized linear-mixed model (using a logistic link function and the probability density function for the logistic) for the binary outcome. As robustness checks, both a random effects count data regression and a 2×2 repeated measures ANOVA yield the same effects, when the dependent variable was coded as the number of vertical gestures for each wordlist-type.

2.51, $df = 1$, $p = .113$). This shows that the production of vertical temporal gestures was sensitive to the linguistic choices.

Additionally, as for the comparisons between languages, firstly, the proportion of vertical gestures for wordlists with vertical spatial metaphors was significantly higher in Chinese than in the English translations ($\beta = -2.68$, Wald $\chi^2 = 15.12$, $df = 1$, $p = .0001$). One may explain this as the result of simply having two different language-specific conceptualisations of time, which are predetermined by Chinese and English. If this is true, we would expect the same pattern in the case of wordlists with neutral words. However, for the neutral wordlists, there was no significant difference in the proportion of vertical gestures between the two languages ($\beta = -.41$, Wald $\chi^2 = .61$, $df = 1$, $p = .433$). This is supported by finding a significant interaction between language and wordlist-type ($\beta = 2.27$, Wald $\chi^2 = 6.87$, $df = 1$, $p = .0087$) (Table 2.2).

Table 2.2. Summary of the results by a random effects binary logistic regression.

Comparisons	Coefficients		$\chi^2(1)$	p -value	Marginal effects
Chinese vertical vs. Chinese neutral	$\beta_{neutral}$	-1.11	6.04	0.014	-18.25%
Chinese vertical vs. English translations of vertical	$\beta_{english}$	-2.68	15.12	0.01	-35.81%
English translations of vertical vs. English neutral	$\beta_{neutral} + \beta_{interaction}$	1.16	2.51	0.11	
English neutral vs. Chinese neutral	$\beta_{english} + \beta_{interaction}$	-0.41	0.61	0.43	
Language \times wordlist-type interaction	$\beta_{interaction}$	2.27	6.87	0.01	

Notes: $\beta_{interaction}$ is the estimated coefficient of the interaction term of language and wordlist type. Marginal effects corresponding to $\beta_{neutral}$: For an average person, given s/he speaks Chinese, if the wordlist-type changes from vertical to neutral, then s/he is 18.25% less likely to perform vertical gestures. Marginal effects corresponding to $\beta_{english}$: For an average person, given s/he speaks Chinese vertical wordlists (or English translation of vertical), if his/her language changes from Chinese to English, then s/he is 35.81% less likely to perform vertical gestures.

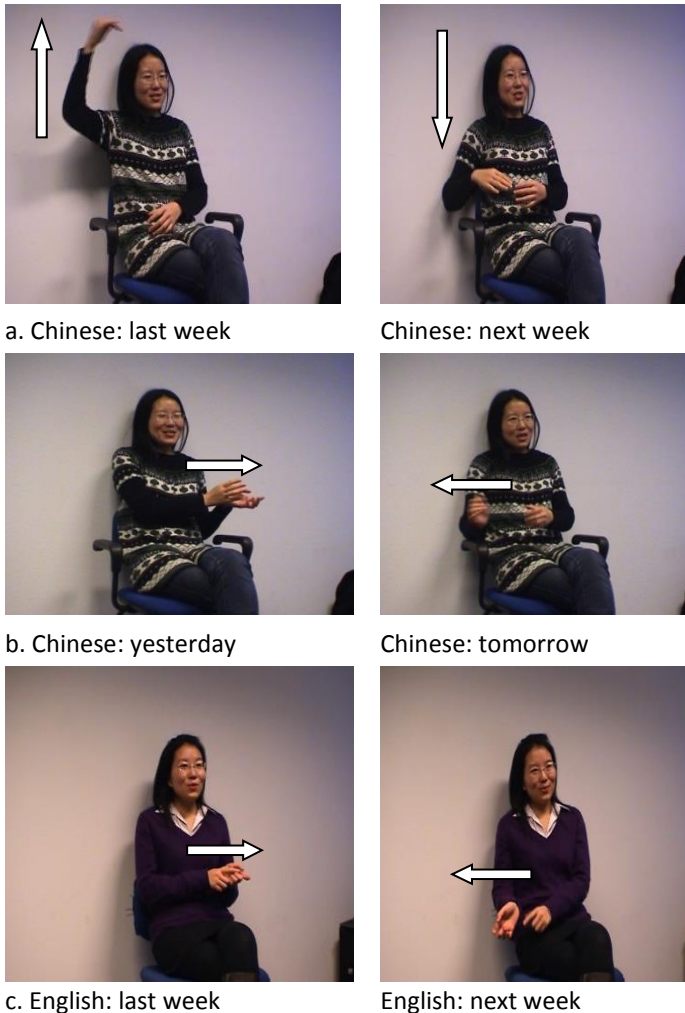


Figure 2.4. Gestures of *last week* and *next week* in Chinese, and *yesterday* and *tomorrow* in Chinese, and *last week* and *next week* in English by the same participant.

Why did the temporal gestures of the two types of time references (vertical and neutral) display such differences across languages? It seems that apart from the spatio-motoric thinking (the stable vertical spatial-temporal mappings), there is another force – the force from the linguistic encoding possibilities, resulting in the increase in vertical gestures for time references with vertical spatial metaphors in

Chinese as compared to time references with neutral spatial metaphors in Chinese. In other words, the increase in vertical gesturing for time conceptions with vertical spatial metaphors in Chinese can be triggered by the specific online lexical expressions.

To illustrate the effect of within and between-language linguistic choices, Figure 2.4 shows a participant producing vertical gestures for time references of “last week” and “next week” in Chinese, while producing lateral gestures for “yesterday” and “tomorrow” in Chinese and for “last week” and “next week” in English.

In theory, it could be that, in our experiment, factors such as L2 proficiency levels, age of acquisition, culture exposure and writing experiences may have influenced the production of vertical gestures. However, when we put all these factors into the model, the effect of linguistic choices (within-language comparisons of two types of Chinese wordlists and between-language comparisons of vertical wordlists in Chinese and English translations) remained still highly significant, even after controlling for the proficiency levels of L2 English, age of L2 acquisition, length of living in the Netherlands, and vertical experience (writing and reading) (all *ns.*). Furthermore, we included task order as a factor, which revealed no evidence for a possible effect that participants who did the task first in Chinese were more likely to produce vertical gestures in English, compared to those participants who did the task first in English ($\beta = .009$, Wald $\chi^2 = .0$, $df = 1$, $p = .99$).

In summary, our results show that Chinese–English bilinguals’ vertical gesturing about time is not only shaped by the stable vertical conceptualisation (Figure 2.3), but also by the online linguistic choices. We discuss this more in general discussion.

2.3 Experiment 2

An increasing number of studies show that the production and the perception of speech and gesture are interconnected (Pickering & Garrod, 2013). For instance, perceiving gestures automatically activates the brain areas involved in producing these corresponding actions (Hostetter & Alibali, 2008; Mashal, Andric, & Small, 2011). Additionally, studies have shown that there is an on-line integration of semantic information from speech and gesture. That is, co-occurring speech and gestures are integrated simultaneously into a preceding sentence context (e.g., Özyürek, Willems, Kita, & Hagoort, 2007). This raises the question whether the perception of vertical gestures about time by the Chinese–English bilinguals is also influenced by the linguistic encoding possibilities.

In Experiment 2, we address two questions: (1) In Chinese, will observers prefer vertical gestures for phrases with explicit vertical spatial metaphors (e.g., “above week”) over vertical gestures for phrases that do not have such an explicit spatial indicator (so words without having either a vertical or sagittal spatial metaphor)? (2) Will there be perceptual differences in that respect between Chinese and English?

If one’s perception of gesture is also sensitive to the online linguistic choices, then, firstly, Chinese–English bilinguals are likely to prefer vertical gestures to lateral ones for time references with Chinese vertical spatial metaphors. Also, Chinese–English bilinguals are likely to prefer vertical gestures for time references with vertical spatial metaphors compared to neutral words. Moreover, we expect there to be less of a preference for a vertical gesture plane in English than in Chinese, especially for Chinese time references with vertical spatial metaphors (since in English the Chinese vertical wordlists were translated into neutral words). To test these hypotheses, Chinese–English bilinguals were asked to do a rating task.

2.3.1 Method

Participants

Hundred and nine Mandarin-English sequential bilinguals (L1 = Chinese; 52 F and 57 M; mean age = 18 yrs) from Nanjing University, China were paid to participate in the experiment.

Stimuli

Thirty items, consisting of 8 target items of time references and 22 fillers were performed by an actor. Each item consisted of a sentence which was followed by a silent video clip of the seated actor (visible from shoulders to upper legs) who made specific gestures. To avoid possible distractions due to some culture-specific facial expressions, the face was hidden by a digitally inserted black square on the face. This also enabled the same stimuli to be used both in the English and Chinese version.

For instance, a sentence was shown as “The person is asked to perform body languages that indicate the time directions of last week and next week symbolically”. The clip underneath the sentence showed an 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” (Figure 2.5). The direction of the movements (from left to right on the lateral axis, from top to bottom

on the vertical axis, both from the speaker’s perspective) was determined by observations in the production study, where these movements were much more likely than their counterparts (right to left, bottom to top). The exact same video clips were used in English and Chinese and the format of sentence instruction was consistent for all the target time references; the only thing that varied was the instructions in either English or Chinese.

The person is asked to perform body languages that indicate the *time directions* of “last week” and “next week” symbolically.

The person is asked to perform body languages that indicate the *time directions* of “last week” and “next week” symbolically.



1=very poor; 2=poor;
3=unsatisfactory; ★★★★★☆ 5
4=fair;
5=good; 6=very good;
7=excellent

1=very poor; 2=poor;
3=unsatisfactory; ★★★★★☆ 5
4=fair;
5=good; 6=very good;
7=excellent

Figure 2.5. An example, of a gesture clip. Stills from the two gestures that were used as a stimulus of *last week* and *next week* (the vertical plane).

To prevent participants from being too conscious of the many repetitive judgements of temporal gestures, only eight sentences had time references among all the item instructions. As shown in Table 2.3, half of time references (1–4) contained vertical spatial metaphors, and the other half were literally neutral (no spatial metaphors) in Chinese. Half of the time references [(1) and (2); (5) and (6)] in the sentences were performed in the vertical gesture plane and the other half were performed in the lateral plane. These references were counterbalanced in gesture planes by creating a second version.

Additionally, 11 fillers (unrelated to time conceptions) had incongruent gestures with the sentence instructions (e.g., an incongruent gesture for the concept of “over there” was presented as pointing to the actor’s own body), and the other 11 fillers were congruent. The text was created in Chinese and the English text was a translation of the Chinese. Note that wordlists (1), (2), (3) and (4) in the sentences were again neutral English translations of vertical words.

Table 2.3. Time references with vertical spatial metaphors and time references with neutral words, as used in the perception experiment.

	Chinese	English
(1)	上周, 下周 (vertical) shàng zhōu, xià zhōu	last week, next week (neutral English translations of vertical)
(2)	上午, 下午 (vertical) shàng wǔ, xià wǔ	a.m., p.m. (neutral English translations of vertical)
(3)	上月, 下月 (vertical) shàng yuè, xià yuè	last month, next month (neutral English translations of vertical)
(4)	上学期, 下学期 (vertical) shàng xué qī, xià xué qī	last semester/term next semester /term (neutral English translations of vertical)
(5)	昨天, 明天 (neutral) zuó tiān, míng tiān	yesterday, tomorrow (neutral)
(6)	早晨, 傍晚 (neutral) zǎo chén, bàng wǎn	morning, evening (neutral)
(7)	去年, 明年 (neutral) qù nián, míng nián	last year, next year (neutral)
(8)	早春, 晚春 (neutral) zǎo chūn, wǎn chūn	early spring, late spring (neutral)

Procedure

Participants took part twice in the experiment, once in Chinese and once in English, with an interval of one week. The sequence of the languages tested was counterbalanced. In the first test, participants were randomly assigned to one of the two versions (counterbalanced in gesture planes) to fill out a 1-7-Likert scale rating task in a large computer classroom. They were shown the sentence instructions and the silent video clips. Participants were asked to judge the extent to which the gestures in the clip expressed the instruction correctly, with 1 meaning “very poor” and 7 meaning “excellent” (see Figure 2.5). Data from 30 participants were excluded because they either did not show up for the second part of the experiment

(19), or failed to comply with the instructions (11)⁸. All data were collected via a survey programme Qualtrics.

2.3.2 Results and Discussion

There was no significant difference between the two versions in counterbalancing gesture planes, $F(1, 77) = .031$, $p = .86$, $\eta_p^2 = .00$, so the data from the two versions was merged for further analyses. A $2 \times 2 \times 2$ repeated measures ANOVA with Wordlist-type (vertical and neutral) \times Gesture plane (lateral and vertical) \times Language (Chinese and English) as within subject factors, and rating scores as dependent variable revealed that there were main effects of wordlist-type, $F(1, 78) = 37.11$, $p < .001$, $\eta_p^2 = .32$ and gesture plane, $F(1, 78) = 23.65$, $p < .001$, $\eta_p^2 = .22$, but there was no main effect of language, $F(1, 78) = 1.83$, $p = .18$, $\eta_p^2 = .02$. Furthermore, there was a significant interaction between wordlist-type and gesture plane, $F(1, 78) = 17.08$, $p < .001$, $\eta_p^2 = .18$, and a significant interaction between wordlist-type and language, $F(1, 78) = 4.26$, $p = .042$, $\eta_p^2 = .052$ (see Figure 2.6 for mean rating scores).

Follow-up Bonferroni adjusted t -tests (with alpha level corrected) were conducted. Firstly, for Chinese wordlists containing vertical spatial metaphors (Chinese vertical), participants preferred vertical gestures ($M = 3.40$, $SD = 1.38$) to lateral gestures ($M = 2.82$, $SD = 1.27$), $t(78) = 5.53$, $p < .001$, $r = .53$, 95% CI = (.37, .79). At first sight, this might suggest a Chinese speakers' general preference of vertical gestures over lateral ones. However, there were no such preferences in time references with neutral words (Chinese neutral), $t(78) = .13$, $p = .90$, $r = .01$, 95% CI = (-.18, .20). Also, participants rated vertical gestures for "Chinese vertical" wordlists ($M = 3.40$, $SD = 1.38$) higher than those for "Chinese neutral" wordlists ($M = 2.71$, $SD = 1.17$), $t(78) = 8.20$, $p < .001$, $r = .68$, 95% CI = (.52, .86), but they did not rate the lateral gestures significantly different for the two type of wordlists, $t(78) = 1.25$, $p = .21$, $r = .14$, 95% CI = (-.07, .31) (Chinese-English speakers in Figure 2.6). Assuming that the neutral and metaphoric time references share the same conceptualisation of time within a language, the major discrepancy between the two is the difference in linguistic choices. This indicates that the vertical spatial

⁸ The counter-balance design was still achieved in the remaining 79 participants (there were 39 participants for version A, in which 19 participants first did the Chinese task and the other 20 first did the English task; there were 40 participants for version B, in which 18 participants first did the Chinese task and the other 22 first did the English task).

metaphor of time has an online influence on perceiving the vertical temporal gestures.

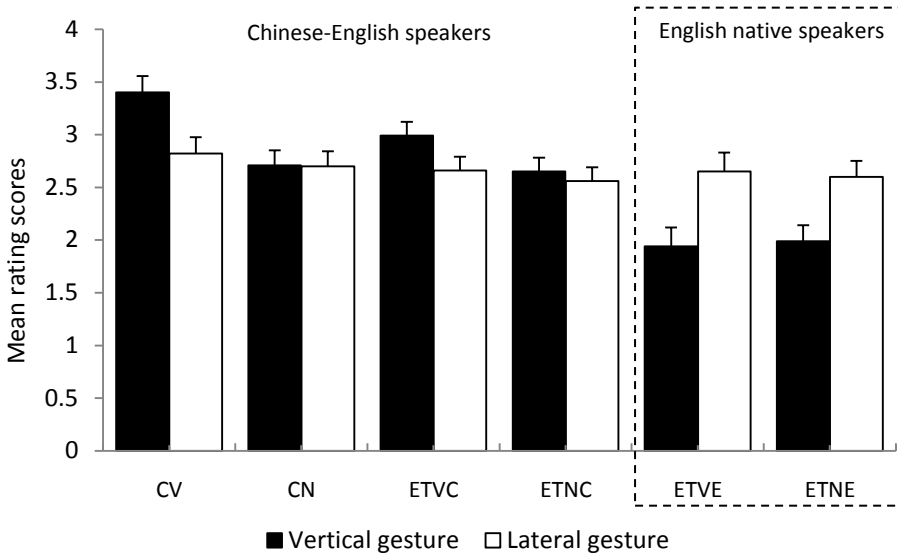


Figure 2.6. The mean rating scores and standard errors of the two types of time references (words with vertical spatial metaphors and with neutral words) in Chinese and in English by Chinese–English observers, and in English by native English observers. *Notes:* CV = Chinese vertical, CN = Chinese neutral, ETVC = English translations of vertical for Chinese, ETNC = English translations of neutral for Chinese, ETVE = English translations of vertical for English, ETNE = English translations of neutral for English.

With respect to English stimuli, the pattern of results was quite similar to that in Chinese. For the English translations of Chinese vertical spatial metaphors (ETVC), participants also preferred vertical gestures ($M = 2.99$, $SD = 1.32$) to lateral gestures ($M = 2.66$, $SD = 1.13$), $t(78) = 2.90$, $p = .005$, $r = .31$, 95% CI = (.10, .56), but they did not have such a preference for wordlists without spatial metaphors (English translations of neutral) (even though all these translations no longer contained explicit lexical markers of space). Also, vertical gestures for “English translations of vertical (ETVC)” ($M = 2.99$, $SD = 1.32$) were rated significantly higher than vertical gestures for the “English translations of neutral (ETNC)” wordlists ($M = 2.65$, $SD = 1.06$), $t(78) = 8.20$, $p < .001$, $r = .68$, 95% CI = (.16, .53).

Further comparisons between Chinese and English revealed that participants rated vertical gestures with a higher score when perceiving Chinese wordlists containing vertical spatial metaphors ($M = 3.40$, $SD = 1.38$) than when perceiving the English translations of the wordlists ($M = 2.99$, $SD = 1.32$), $t(78) = 2.05$, $p = .022$, $r = .23$, 95% CI = (.11, .81), but the bias towards vertical gestures in Chinese no longer existed when it came to wordlists with neutral words, $t(78) = .43$, $p = .67$, $r = .05$, 95% CI = (-.21, .35) (black bars for Chinese–English bilinguals in Figure 2.6). As for the rating score for the lateral gestures, the difference between the two languages was not significant for either type of wordlist (white bars). In short, only when perceiving the “Chinese vertical” and the corresponding “English vertical translations”, did participants prefer vertical gestures in Chinese over those in English.

The similar pattern of results from the L1 and L2 may seem to suggest that Chinese speakers still thought in their first language when perceiving the English words. If Chinese speakers used L1 as a mediating factor in the L2 English for the translations of vertical wordlists, we would expect that participants with a lower L2 proficiency were more likely to translate the words from Chinese than participants with a higher L2 proficiency, and thus would be influenced more by the Chinese vertical linguistic choices and would therefore be more in favour of the vertical axis. Participants’ 5-point-self-assessment of English proficiency showed that their proficiency levels were between intermediate and advanced, $M = 2.7$, $SD = 0.84$. Further analysis on the correlation between the scores of English vertical translations and L2 proficiency showed that the rating of verticality was not related to the L2 English proficiency, $r = -.005$, $p = .97$. Thus the similar pattern of L1 and L2 results suggests that Chinese vertical spatial metaphors were activated in the English context, which is consistent with Wu and Thierry’s (2010) proposal that languages are co-activated in a bilingual speaker, even if only one language is contextually relevant.

However, it could be that a subjective self-assessment of L2 proficiency is uninformative, and an objective language proficiency test is recommended in future studies. Another possibility could be that participants, when doing the English test, have translated the sentences internally into their native language, Chinese. It is still possible that the translation process for these frequent and salient abstract concepts is so pervasive and automatic that it is unaffected by the bilingual’s self-reported proficiency level.

To sum up, the results from this perception study show that firstly, in Chinese, the bilingual speakers preferred vertical gestures for time references with vertical

spatial words to vertical gestures for neutral words. Secondly, when perceiving time references with vertical spatial metaphors, they preferred vertical gestures to lateral gestures. Additionally, participants preferred vertical gestures for time references containing vertical spatial metaphor in Chinese to vertical gestures for the English translations.

However, as the lateral temporal gestures took the speakers' perspective, the left-right mapping onto to a timeline was mirrored (right-left) for the addressees. It could have been difficult for the addressee to deal with the mirror effect whereas describing expressions by vertical gesture is unambiguous for the addressee, as top and bottom are similar for speakers and addressees. This may also be a reason why vertical gestures are preferred over lateral gestures. To rule out the possibility of a vertical preference that is brought about by some general non-linguistic factors, we did another perception experiment, with native speakers of English.

2.4 Experiment 3

2.4.1 Method

Participants

73 American English speakers (40 F and 33 M; mean age = 39 yrs) were paid to take part in this experiment via Crowd-Flower, a crowdsourcing service similar to Amazon Mechanical Turk. The validity of this method for behavioural studies has been previously tested and studies assessing data quality have been positive about using crowdsourcing as an alternative to more traditional approaches of participant recruitment (e.g., Buhrmester, Kwang, & Gosling, 2011; Crump, McDonnell, & Gureckis, 2013). Data from 19 respondents were excluded from the analyses because they were not native English speakers (5), or did not finish the task in a proper way (15) (e.g., finished the task in less than two minutes, clicked the same choice for the whole task or misunderstood the task).

Procedure

Participants were instructed to do the same rating task as that in Experiment 2. The Qualtrics links were provided via CrowdFlower.

2.4.2 Results and Discussion

A 2×2 repeated measures ANOVA with Wordlist-type (vertical and neutral) \times Gesture plane (lateral and vertical) as within subject factors, and rating scores as dependent variable revealed that there was no main effect of wordlist-type, $F(1, 53) = .003$, $p = .96$, $\eta_p^2 = .00$, but there was a main effect of gesture plane, $F(1, 78) =$

23.65, $p < .001$, $\eta_p^2 = .32$. Furthermore, there was no interaction between wordlist-type and gesture plane, $F(1, 53) = .34$, $p = .56$, $\eta_p^2 = .006$. The results show that English native speakers preferred lateral gestures to vertical gestures for both types of time references (English translations of Chinese vertical time references for English, ETVE: $M = 2.65$, $SD = 1.52$ vs. $M = 1.94$, $SD = 1.07$; English translations of Chinese neutral time references for English, ETNE: $M = 2.58$, $SD = 1.36$ vs. $M = 1.99$, $SD = 1.07$, Figure 2.6).

The pattern is very different from that of Chinese–English speakers. First, English speakers did not rate the vertical gesturing differently for two types of time references whereas Chinese–English speakers rated the vertical gesturing for English translations of vertical time reference with a higher score than that for the English translations of neutral time references. This indicates that Chinese–English speakers' vertical tendency in time references with vertical spatial metaphors was not due to some general non-linguistic factors, but to the activation of L1 Chinese lexicons in the L2.

Second, for the English translations of Chinese neutral time reference, English speakers preferred the lateral axis to vertical axis whereas Chinese–English speakers rated the vertical axis the same as the lateral axis. Presumably, this discrepancy is due to their differences in time conceptualisations, in that Chinese speakers can think of time vertically (Boroditsky, 2001).

2.5 General Discussion

In Experiment 1 we observed that Chinese–English bilinguals produced vertical temporal gestures, both in Chinese and in English. The between-language and within-language comparisons showed that Chinese–English bilinguals produced more vertical gestures when talking about Chinese time references with vertical spatial metaphors than (1) when talking about time conceptions in the English translations, and than (2) in the case of Chinese time references with no spatial metaphors. In Experiment 2, we showed that Chinese–English bilinguals preferred vertical gestures to lateral gestures when perceiving time references with vertical spatial metaphors. This bias towards vertical gestures still existed when they perceived them in English, though to a lesser extent. Nevertheless, there was no such bias towards vertical gestures when perceiving time references with no spatial metaphors. Results of Experiment 3 showed that English speakers had a different preference of temporal gestures from the Chinese–English bilinguals, and also indicated that the vertical tendency in Chinese–English bilinguals was not due to

some general non-linguistic factors. We discuss these results in terms of production and perception of gestures, respectively.

With respect to gesture production, the findings suggest that the production of vertical gestures by Chinese–English bilinguals can be influenced by both the habitual vertical conceptualisation of time and the online lexical form of the expressions they produce when speaking. On the one hand, participants' generation of vertical gestures for neutral time references in both Chinese (even without using vertical wording) and English indicate that they can employ a vertical conceptualisation of time (Boroditsky, 2001). As the number of vertical gestures for these neutral time references was not different between the two languages, the gesture production pattern implied that the vertical gesturing was likely to be influenced by a Chinese vertical time conceptualisation.

On the other hand, the extent to which vertical gestures were produced also depended on the linguistic choices. Firstly, participants produced more vertical gestures for time references with Chinese vertical spatial metaphors than for the English translations of Chinese vertical spatial metaphors. One may argue that the difference was due to the effect of the addressee, as speakers may take the perspective of the addressee and were aware that vertical gestures were not helpful when the addressee was English. If so, we would also find less vertical gesturing in the case of time references with neutral words, but there was no significant difference between the two languages in the number of vertical gestures produced with neutral words.

It could be argued that in Chinese, vertical spatial language is more strongly associated with time units such as weeks than with days (Chen, 2007), and thus wordlists could potentially confound the verticality of the stimulus with the time unit treated in the stimulus. However, the effect that we found in the production experiment is unlikely due to this, because, first, the between languages comparison of wordlists with vertical spatial metaphors showed that even for the same time units (e.g., last week), the number of vertical gestures was significantly higher in Chinese than in the English translations. Second, participants performed vertical gestures when using vertical wording to explain the vertical wordlists, and sometimes they also explained the same conceptions with non-vertical wording (e.g., “The expressions are last week and next week. So they are about two weeks, namely the previous week and the following week/seven days ago, and seven days later. Etc”). We further checked the temporal gestures of vertical wordlists which accompanied these cases of non-vertical wording. The proportion of vertical gesturing was significantly higher (90%) when accompanying vertical wording than when

accompanying non-vertical wording (20%) (McNemar test, $p = .039$). This indicates that even for identical time conceptions within a particular wordlist in the same language, verbally producing a vertical spatial metaphor for a time reference immediately led to an increase in the production of vertical gestures. This piece of evidence, together with the findings from the within and between languages comparisons of the two types of time references provides strong evidence to support the fact that linguistic choices of vertical wording can also have an influence on participants' production of vertical gesturing.

Another alternative explanation for our findings could be related to the claim that the greater number of vertical gestures in Chinese context was superficial, because speakers simply produced vertical gestures so that the addressees could figure out the vertical spatial words to be reported in a led-to-believe and end-of-game test. This is unlikely. First, the task was not a word-guessing game and participants were not instructed to use gestures at all. Second, the lexical form of “shàng” (above) alone does not necessarily result in many vertical gestures. We looked at a filler (shàng bān, on duty; xià bān, off duty) which also contained the identical morphemes of “shàng” and “xià”. However, when describing the filler, participants far less often performed vertical gestures compared to that of “shàng zhōu” (last week) and “xià zhōu” (next week)⁹. This fact also indicates that the vertical gesturing in time references were unlikely due to a matter of preference on the part of the participants or by a priming of the trials.

Our results are consistent with previous studies on forced gesturing about time. When participants were asked explicitly to point to space for time conceptions, Chinese speakers were more likely to point vertically for time conceptions with vertical spatial metaphors than for those with non-vertical spatial metaphors, or without any spatial metaphor (Fuhrman *et al.*, 2011; Lai & Boroditsky, 2013). Furthermore, by comparing the temporal gestures for the same time conceptions produced by Chinese–English bilinguals, we provide new evidence for the effect of

⁹ One possible explanation is that “shàng zhōu” (last week) and “shàng bān” (on duty) have different levels of semantic transparency. Such a difference is essentially associated with the different word conceptions. Regarding Chinese morphological processing, different meanings of an ambiguous morpheme are activated during word recognition (e.g., Tsang & Chen, 2013; Tseng, Wong, Huang & Chen, 2014). In the context of “shàng zhōu” (last week), the morpheme form “shàng” activates the lemma “above” more than that in the context of “shàng bān” (on duty), according to their corresponding context-consistent meaning. Therefore, given the same lexicon form of “shàng”, the ultimate activation of vertical spatial metaphors plays a role in shaping vertical gestures.

cross-linguistic choices on gesture production. These results are in line with a model that states that gestures are not only the result of a pre-determined language-specific conceptual scheme (vertical conceptualisations of time) (Boroditsky, 2001), but are also shaped by the interface between spatio-motoric thinking (imagistic representation) and speaking, in which spatial imagery is adjusted to fit the verbalisation (Kita & Özyürek, 2003). The production study provides unique new evidence supporting the Interface Hypothesis (Kita, 2000; Kita & Özyürek, 2003), and further contributes to the theory by suggesting that gesture production is dynamic and sensitive to linguistic encoding possibilities, even for abstract concepts and in a bilingual context.

With respect to the perception experiments, we found that the interpretation of temporal gestures was not only influenced by general time conceptualisations but also by linguistic choices. First, for neutral time references, English speakers preferred lateral gestures whereas Chinese–English speakers also accepted vertical gestures. The differences are likely due to the fact that Chinese speakers can think of time vertically (Boroditsky, 2001). Secondly, in comparison to the lateral gesture plane, for Chinese–English speakers, the vertical gesture plane was preferred for time references with vertical spatial metaphors, but not for time references with neutral words. Since the extent to which English speakers preferred the vertical gestures was not different in both types of wordlists, the differences in the Chinese–English group were not caused by some general non-linguistic factors. Thus the perception of temporal gestures can also be affected by vertical spatial metaphors, in that sense being evidence that supports the findings of the production experiment.

Perhaps the most striking observation is the finding that Chinese–English speakers still preferred vertical gestures to lateral gestures for the English translations of time conceptions with vertical spatial metaphors. Since we did not find a correlation between the vertical tendency and L2 English proficiency, it may suggest that languages are co-activated in a bilingual speaker, even if only one language is contextually relevant (e.g., Brown & Gullberg, 2008; Wu & Thierry, 2010). In this case, the Chinese vertical spatial metaphors are also activated in a Chinese–English bilingual’s mind, even in the English context. Future studies can focus on English learners of Chinese to find out whether this is due to L1 mediated translations: If English speakers’ vertical mapping in L2 Chinese is still activated in their L1 English, then it is likely that the vertical mapping is due to the activation of a stable representation of that mapping, since it is quite unlikely that English speakers translate the Chinese words into English when they are tested in the English mother tongue.

Interestingly, comparing the production and the perception studies on Chinese–English bilinguals, we saw that, although we used both implicit and explicit approaches to investigate gestures, the pattern of results from the production and the perception experiments show great similarity, especially in L1 Chinese. This parallel between the production and perception data seems to suggest that in addition to the stable conceptualisation, the online linguistic encoding possibilities of time conceptions also have an influence on the perception of temporal gestures.

Admittedly, in both experiments there was a linguistic input to which the participants had to react. Participants may be primed from the task instruction (vertical/non-vertical time wordlists), such that the pattern of results may come from the implicit priming of the spatial morpheme (e.g., “above”) in the target wordlist (e.g., “above week”). In fact, participants often produced more than one temporal gesture when explaining a target wordlist in the production experiment. Within each Chinese wordlist, we further coded co-occurring spoken words accompanied with each temporal gesture (binary coding of co-occurring words: with/without vertical lexicon).

In total, we obtained 588 lexicon-gesture tokens, which included 148 vertical words and 440 non-vertical words, and 101 vertical gestures and 487 non-vertical gestures. There was a significant effect of vertical lexicon on the vertical gesturing ($\beta = 2.36$, Wald $\chi^2 = 32.15$, $df = 1$, $p < .0001$), even after controlling for wordlist-type and other factors. This indicated that within a wordlist (regardless of neutral or vertical priming), participants were more likely to produce vertical gestures when their co-occurring words were vertical lexicons. Furthermore, among the vertical gestures, 50 vertical gestures were produced with vertical lexicons whereas 51 vertical gestures were produced with non-vertical words. The fact that half of the vertical gestures were produced with non-vertical temporal expressions indicated that Chinese people can conceptualise time vertically, even when the wording did not have vertical spatial metaphors. Together, these additional analyses show that the pattern of results is not simply due to a priming effect¹⁰, but a consequence of both lexical and conceptual effects.

¹⁰ If this priming also took place when the Chinese participants produced gestures for the English counterpart, we would expect that Chinese participants with lower English proficiency were more likely to translate the neutral English word into Chinese, being more primed to produce/prefer vertical gestures than Chinese participants with higher English proficiency. However, we did not find any evidence for this, as the variable of English proficiency was not significant in both production and perception experiments. Additionally, according to a similar previous study on

The population of Chinese–English bilinguals in Experiment 1 (production) was different from the population in Experiment 2 (perception) in terms of context in which they were tested (the Netherlands vs. China). One possible concern is that the Chinese–English bilinguals for the production experiment had been away from China for a certain period of time (Mean = 20 months) and might have been immersed in an “English-taught international programme”. Yet, in this study we did not find strong evidence supporting this concern, as the length of staying in the Netherlands was not found to be a significant factor ($\beta = -0.068$, Wald $\chi^2 = .14$, $df = 1$, $p = .71$).

Additionally, the similar pattern of results exhibited in the production and perception studies not only suggests the effect of linguistic choice on the production and perception of co-speech gestures, but also provides new evidence for the interconnection between production and perception (Pickering & Garrod, 2013) from the perspective of gestures.

2.6 Conclusions

In the present study we investigated whether and why Chinese–English bilinguals produce vertical gestures about time and how different factors interact with each other in the bilingual language processing. We addressed these questions by investigating Chinese–English bilingual speakers’ production and perception of gestures for temporal expressions. The findings of this study contribute to theories accounting for the speech–gesture relationship, bilingual mental lexicons and embodied cognition. First, the results of gesture production experiment support the claim that gestures are not only shaped by the language-specific conceptual schema, but also by the linguistic encoding possibilities (Kita & Özyürek, 2003). Moreover, we extend the Interface model, which was proposed and tested predominantly based on motion events, to abstract concepts such as time, and to a bilingual context. Second, we are the first to propose that the linguistic encoding possibilities influence the perception of gestures as well. Future studies can test this hypothesis using a more implicit approach. Furthermore, our gesture data provide evidence for the view that languages are co-activated in a bilingual (e.g., Brown & Gullberg, 2008; Wu & Thierry, 2010). Finally, this study also provides insight into Chinese speakers’ implicit and explicit understanding of time. If gestures are a visible embodiment of

English speakers’ time gestures, an implicit priming of the spatial morpheme alone (e.g., “ahead”) is insufficient to elicit systematically congruent temporal gesture (Casasanto & Jasmin, 2012), because temporal gestures also reveal an implicit spatial conceptualisation of time that may not be inferred from the language.

cognition (Hostetter & Alibali, 2008), then the production of vertical temporal gestures for time by Chinese–English bilinguals offers empirical support for the idea that Chinese speakers can employ a vertical conceptualisation of time (Boroditsky, 2001). To further explore this idea, future work can study different samples of Chinese speakers. For instance, we can study the temporal gestures by learners of Chinese as a second language to see whether their temporal gestures change after learning Chinese; we can also investigate the spatio-temporal reasoning of Chinese deaf signers, an atypical population of Chinese speakers in the Chinese culture, who differ from Mandarin speakers in spatial metaphors for time linguistically (see Chapter 5). This sample may provide a unique opportunity to study the effect of linguistic force on spatio-temporal thinking within the culture. Additionally, these studies can examine to what extent the cross-linguistic differences in mental lexicons cause the differences in conceptualisation.

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Which is in front of Chinese people, Past or Future? The effect of language and culture on temporal gestures and spatial conceptions of time

Abstract

The *temporal-focus hypothesis* claims that whether people conceptualise the past or the future as in front of them depends on their cultural attitudes towards time; such conceptualisations have been argued to be independent from the space-time metaphors expressed through language. In this paper, we study how Chinese people conceptualise time on the sagittal axis to find out the respective influences of language and culture on mental space-time mappings. An examination of Mandarin speakers' co-speech gestures shows that some Chinese spontaneously perform past-in-front/future-at-back (besides future-in-front/past-at-back) gestures, especially when gestures are accompanying past-in-front/future-at-back space-time metaphors (Experiment 1). Using a temporal performance task, the study confirms that Chinese can conceptualise the future as behind and the past as in front of them, and that such space-time mappings are affected by the different expressions of Mandarin space-time metaphors (Experiment 2). Furthermore, a survey shows that Chinese tend to focus more on the future than on the past, and the results of Experiment 2 are replicated even after controlling for participants' cultural temporal values (Experiment 3). Finally, a cross-cultural comparison of space-time mappings between Chinese, Moroccans, and Spaniards shows that there are both long-term effects of cultural attitudes on the spatialisation of time, and immediate effects of the linguistic space-time metaphors that probe people's mental representations (Experiment 4). The findings not only provide a better understanding of Chinese people's sagittal temporal orientation, but advocate a modification of the *temporal-focus hypothesis*, with additional implications for theories on the relationship between language and thought, and the production of metaphoric gesture.

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3.1 Introduction

Across cultures people use space to represent time (Bottini *et al.*, 2015; Casasanto & Boroditsky, 2008; see reviews Bender & Beller, 2014; Núñez & Cooperrider, 2013). The concepts of future and past are often linguistically expressed by the use of spatial metaphors. For instance, in English, we look *forward* to the bright future lying *ahead*, or look *back* to the hard times *behind* (e.g., Calbris, 2008; Evans, 2004, 2013; Lakoff & Johnson, 1980; Moore, 2014; Traugott, 1978). Interestingly, studies have shown that many people not only talk about time using a front-back axis, but also tend to think about time this way, i.e., the past is mentally “behind”, and the future “ahead” of the speaker (Boroditsky, 2000; Miles, Nind, & Macrae, 2010; Ulrich *et al.*, 2012). This particular conceptualisation seems to be consistent with the bodily experience of walking in a certain direction, so that the path that we have passed by is the past and the place that we are heading towards is the future (e.g., Clark, 1973).

Despite this general tendency in languages like English, speakers of other languages may exhibit opposite sagittal space-time mappings than the one explained above. For example, Aymara speakers can conceptualise the past as seen events in front of them, and the future as yet unseen events behind them, which is reflected in the observation that their words for *past* and *future* also mean *front/seen* and *back/unseen* (e.g., *front year* means *last year*). This past-in-front mapping is also apparent from Aymara’s temporal gestures (Núñez & Sweetser, 2006).

Somewhat similar to Aymara is Mandarin Chinese, in which sagittal words for spatial “front” (前/qián) and “back” (后/hòu) are also used as temporal conceptions of “before/past” and “after/future”. Such sagittal spatial metaphors for time suggest past-in-front/future-at-back space-time mappings (e.g., “后天/hòu-tiān”, “back day”, the day after tomorrow; “今后/jīn-hòu”, “today back”, from now on). However, how Mandarin speakers conceptualise or gesture about time using the front-back space is barely known (Yu, 2012). Based on the first attempt by Fuhrman *et al.* (2011), Xiao, Zhao and Chen (2017)’s recent study provides a comprehensive picture of the psychological reality of time by Mandarin speakers.

Xiao, Zhao and Chen (2017) (also Yu, 2012) propose that, like English, there are two kinds of time perspective-taking for Chinese people, related to a moving-ego and moving-time perspective (e.g., Gentner, Imai, & Boroditsky, 2002; Moore, 2011; Núñez, Motz, & Teuscher, 2006; Walker, Bergen, & Núñez, 2017). They argue that for the Mandarin temporal expressions such as “前天/qián -tiān” (“front day”, the day before yesterday) and “后天/hòu-tiān” (“back day”, the day after tomorrow), the

reference point is not the observer but time (i.e., today) (earlier-times in-front-of later-times metaphor). By contrast, temporal expressions such as “过去/guò qù” (pass go, past) and “未/将来/wèi/jiāng lái” (hasn’t come yet/will come, future) take the observer as a reference point, suggesting that future is ahead of and the past behind the ego (Yu, 2012) (front-to-the-future metaphor).

Xiao, Zhao and Chen (2017) used an illustrative example of a train to explain the sagittal temporal representation of Mandarin speakers based on linguistic analyses (Figure 3.1). Time in this visualisation would be analogous to a moving train with a number of carriages. The moving-time perspective (the train) refers to the relation among time points (carriages), whereby earlier time points (e.g., carriages 1 and 2) are in front of later time points (e.g., carriages 4 and 5, from the perspective of the train). The ego-moving time perspective refers to the relation between the ego (observer) and the time points, with a direction of the future (e.g., carriage 5) in front of the ego.

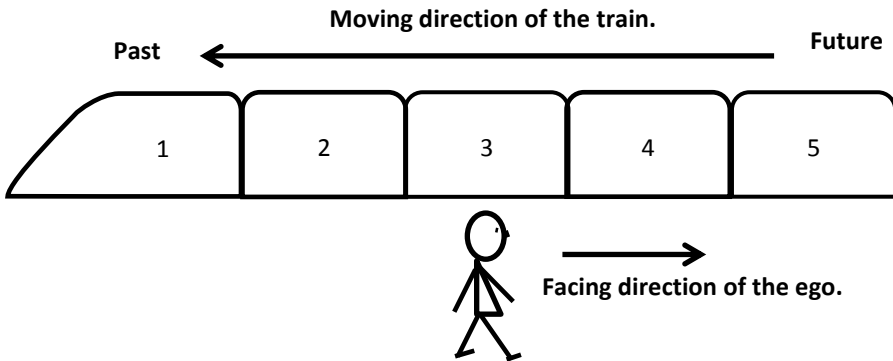


Figure 3.1. According to Xiao, Zhao and Chen (2017), time can be perceived as moving from the future to the past, where the ego faces the future (carriage 3 is now): From the time-reference-point perspective, earlier events (e.g., carriages 1 and 2) are in front of later events (e.g., carriages 4 and 5), thus the past is in the front of the timeline; from the ego-reference-point perspective (*stationary* or *moving*), earlier events are behind the ego, so the past is at the back of the ego.

Studies have shown that Mandarin space-time metaphors not only suggest different temporal perspectives, but may also have an impact on Mandarin speakers’ front-back mental space-time mappings (Fuhrman *et al.*, 2011; Lai & Boroditsky, 2013). For instance, the Mandarin Chinese lexicon contains both words suggesting

past-at-back/future-in-front and past-in-front/future-at-back space-time mappings, whereas the sagittal lexical signs of CSL do not show this variation as they represent only past-at-back/future-in-front space-time mappings (Wu & Li, 2012; Zheng, 2009). Interestingly, deaf signers of CSL appear to display a different spatio-temporal reasoning than Mandarin speakers, and deaf signers with higher Mandarin proficiency are more likely to have past-in-front/future-at-back space-time mappings than signers with lower Mandarin proficiency (see more information in Chapter 5).

Regardless of any effect of linguistic space-time metaphors on temporal perspectives, Xiao, Zhao, and Chen (2017) believe that the ego of a Mandarin speaker *always* faces the future. However, there are also alternative views regarding the metaphorical sagittal orientation of time by Chinese people. For example, some believe that the ego faces the past (Alverson, 1994), whereas others believe that the ego can face both the past and the future (Ahrens & Huang, 2002). Given that an increasing number of studies have shown that human's mental space-time mappings can be influenced by different factors (e.g., Casasanto & Bottini, 2014; Duffy, Feist, & McCarthy, 2014; Duffy & Evans, 2017; Santiago *et al.*, 2007; Saj *et al.*, 2014; Torralbo, Santiago, & Lupáñez, 2006), it is possible that Chinese people's mental orientation of sagittal time may not only be shaped by linguistic space-time metaphors but may also be affected by additional influences such as culture.

Indeed, de la Fuente, Santiago, Román, Dumitrache and Casasanto (2014) propose that people's sagittal mental space-time mappings are not necessarily the exclusive result of the sagittal space-time metaphors expressed in the language, as they can also be influenced more generally by the specific way cultures associate space to time. For instance, despite the fact that front-back time lexical metaphors in Arabic are similar to those in Spanish and English (future-in-front mappings), Moroccans have a stronger tendency for past-in-front mapping whereas most Spaniards have future-in-front mappings. The different space-time mappings between Moroccans and Spaniards have been argued to be related to cross-cultural differences in temporal focus (*temporal-focus hypothesis*). It is claimed that people who are past-focused metaphorically should have a tendency to place the past in front of them, "in the location where they could focus on the past literally with their eyes if past events were physical objects that could be seen" (de la Fuente *et al.*, 2014, p.1684). Given that Moroccans focus more on past times and the old generation (past-oriented), and place more value on tradition than Spaniards (future-oriented), they are more likely to put the past in front than Spaniards.

According to the *temporal-focus hypothesis*, people conceptualise either the future or the past as in front of them to the extent that their culture (or subculture) is

future oriented or past oriented. Thus space-time mappings in people's minds are conditioned by their cultural attitudes towards time, which are dependent on attentional focus and can be independent of the way space-time mappings are lexically expressed in language (de la Fuente *et al.*, 2014).

Inspired by the *temporal-focus hypothesis*, when seeking evidence for how Chinese cultural values towards time can influence Chinese people's sagittal space-time mappings, there are also surprisingly contradictory findings regarding the temporal focus of Chinese culture. Some studies have suggested that Chinese people show a tendency to be future-oriented (e.g., Brislin & Kim, 2003), but others argue that Chinese are primarily past-oriented (e.g., Ji, Guo, Zhang, & Messervey, 2009). Evidence for the latter would be that Chinese perceive objects in the past as being much more valuable than Americans do (Guo, Ji, Spina, & Zhang, 2012). Nevertheless, how exactly a Chinese cultural temporal-focus of attention influences their space-time mapping is still unclear. In short, studies on Mandarin speakers' mental sagittal space-time mappings seem to be inconclusive.

Given the fact that Mandarin speakers' mental space-time mappings are quite sensitive to the temporal orientation or perspective-taking suggested by the space-time metaphors (e.g., Gu, Hoetjes, Mol, & Swerts, 2017; Lai & Boroditsky, 2013; Xiao, Zhao, & Chen, 2017), and given that cultural attitude towards time is a rather stable value (which can be independent of linguistic space-time metaphor, see e.g., Moroccans), it is theoretically interesting to examine how the two different lines of theories will work in the Chinese case: Such research can not only provide a better understanding on Chinese people's metaphorical sagittal temporal orientation, but may also contribute to the theory on the mental spatialisation of time. Additionally, it can shed light on the respective roles of language and culture in shaping people's mental space-time mappings, and in that respect, has important implications for theories on the relationship between language, culture, and thought. However, to the best of our knowledge, so far no study has investigated the questions as to how both the Mandarin linguistic space-time metaphors and Chinese cultural values towards time (temporal-focus of attention) can influence Chinese people's sagittal space-time mappings.

To address this general research question sketched above, in the current study we will study how Chinese people conceptualise time on the front-back axis, i.e., whether they conceptualise the past as in front of or behind them. In particular, we conducted a survey on Chinese cultural values towards time (temporal-focus of attention), and several experiments to investigate Chinese people's spontaneous

temporal gestures and action performances in space-time mappings, while taking different sagittal temporal metaphors into consideration.

First, in Experiment 1, we will look at spontaneous gestures, as these can be seen as a “vivid and naturalistic source of evidence for the use of space in abstract reasoning” (e.g., Cienki, 1998; Casasanto & Jasmin, 2012; Cooperrider & Núñez, 2009; Cooperrider, Gentner, & Goldin-Meadow, 2016; Núñez & Sweetser, 2006), and can provide a window into spatial cognition (Chapter 2, Goldin-Meadow, 2003; Kita, Danziger, & Stolz, 2001; Walker & Cooperrider, 2016). A previous case study described how a Mandarin speaker employs the sagittal axis to gesture about time (Chui, 2011), but that was an observation from one participant only. The present study will do a quantitative research on a larger, more representative sample of Chinese speakers’ sagittal temporal gestures.

Second, to corroborate the patterns of space-time mappings observed from spontaneous gestures, we will adopt a temporal performance task in Experiment 2, which has been used in several previous studies to explicitly test people’s mental space-time mappings (e.g., de la Fuente *et al.*, 2014; Li & Cao, 2018). Particularly, we are interested in whether these mappings are affected by different space-time metaphors. Third, with a survey on Chinese people’s temporal focus of attention, we will investigate the influence of language on spatial-temporal mappings while controlling for Chinese attitude towards time (Experiment 3). And fourth and finally, we will perform a cross-cultural comparison in space-time mappings among Chinese, Moroccans, and Spaniards (Experiment 4).

3.2 Experiment 1: Do Chinese Spontaneously Gesture the Past to the front?

As spontaneous gestures have been argued to provide a window into people’s mental space-time mappings (e.g., Casasanto & Jasmin, 2012), in Experiment 1, we used a word definition task that has previously been used in Chapter 2 to elicit Chinese people’s speech accompanying gestures about time. This task also enabled us to study the possible effect of temporal language on co-speech temporal gestures. The goal of this experiment is twofold: (1) we will investigate whether Mandarin speakers systematically produce sagittal gestures and examine the temporal orientation of the sagittal temporal gestures (e.g., whether the past is gestured to front or back); and (2) we will try to further explore the relationship between the temporal orientation of sagittal gestures and the accompanying temporal language.

3.2.1 Method

Participants

34 monolingual Mandarin speakers ($M_{\text{age}} = 33.79$ yrs, $SD = 7.58$, 12 Males) participated as speakers in an experiment conducted in Rizhao, China. Three participants were excluded in the later analyses as they did not produce any gestures. Participants' self-reported education level was about middle to senior high school ($M = 2.55$, $SD = .96$, 1-primary school; 2-middle school; 3-high school; 4-college; 5-university).

Materials and Procedure

We constructed 12 wordlists, each containing two to four expressions that were thematically related (e.g. “yesterday”, “today” and “tomorrow”). Five wordlists were about time conceptions, which in total consisted of 13 temporal expressions (see Appendix 3.1); the rest were fillers. The experiment was ostensibly set up as a test of speakers' short-term memory and addressees' long-term memory. As speakers, participants were asked to remember each wordlist shortly after they had seen them twice; they had to tell and explain the words as explicitly as possible to addressees who could ask them clarification questions (for more details, see Figure 2.2, Chapter 2, p.35). The addressees were told to “remember as many descriptions of the speaker as possible for a later memory test” (the test, in fact, did not take place). Gestures were not mentioned at any moment. The experiment was audio-video recorded after participants had explicitly given their informed consent. Debriefing responses indicated that participants had not been aware that the study was about speakers' gestures.

Coding of the Data

Temporal gestures were annotated in ELAN (Lausberg & Sloetjes, 2009). A first coder performed an initial coding, viewing the entire video with the accompanying audio. The axes of gestures were coded as vertical, lateral, or sagittal, and the temporal orientation of each axis was indicated (Casasanto & Jasmin, 2012; Chapter 2). The time words accompanying temporal gestures were also transcribed.

The present study focused on sagittal temporal gestures; of course, people can also use the lateral and vertical axes to position time in space (e.g., Boroditsky, 2001; Fuhrman *et al.*, 2011), also in Chinese, but this will not be addressed here (see a more detailed discussion about Chinese people's lateral and vertical temporal gestures in Chapter 2 and Gu *et al.*, 2013). Therefore, vertical or lateral gestures were all treated as “non-sagittal” in the later analyses of this study. Accordingly, the temporal expressions were coded as sagittal or non-sagittal. Sagittal words included temporal words explicitly having overt sagittal spatial references to “front” (前/qián)

and “back” (后/hòu) (e.g., “后年/hòu-ni ǎn”, literally “back year”, meaning “the year after next year”). All the other temporal words were coded as non-sagittal. Thus we obtained binary scores for the axis of each temporal gesture (sagittal or non-sagittal), for the temporal orientation of each sagittal gesture (a future-in-front/past-at-back or past-in-front/future-at-back mapping), and for the lexically expressed references to time accompanying each temporal gesture (sagittal or non-sagittal words).

In total, we obtained 507 temporal word-gesture tokens that contained both a word and a gesture. The inter-coder reliability of the annotation was established by having a naïve second person code videos of 10 randomly chosen participants (37.7% of all temporal gesture data). The two coders agreed on the gesture axes judgement on 91.1% of the tokens ($N = 191$), Cohen’s Kappa = 0.84 (referring to “Excellent” agreement). In cases of disagreement, the two coders discussed and reached agreement on the labels, which were then used for the final analysis.

3.2.2 Results and Discussion

First, we found that Chinese people produced sagittal temporal gestures spontaneously ($N = 104$), which accounted for 20.51% of all temporal gestures. Interestingly, as shown in Figure 3.2, when participants were uttering sagittal temporal words, almost half of their co-speech temporal gestures (46.15%) were produced on the sagittal axis. However, the proportion of sagittal gestures decreased to 13.90% when participants were uttering non-sagittal temporal words.

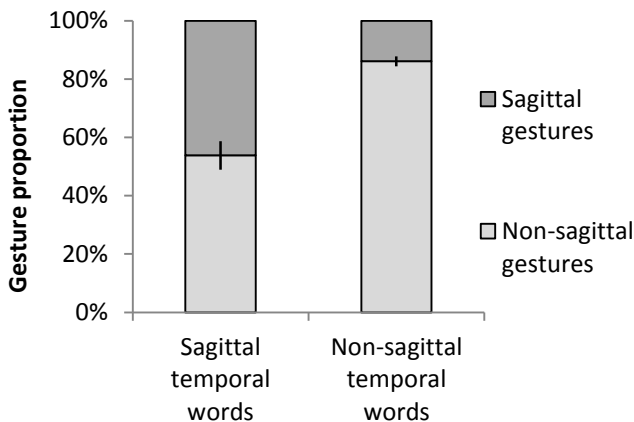


Figure 3.2. The proportion of sagittal and non-sagittal temporal gestures (with SE error bars) when accompanying sagittal and non-sagittal temporal words.

The proportion of sagittal gestures was analysed as a function of sagittal temporal words using a binary logistic regression for panel data, which considered multiple responses from the same participants and took individual differences, like age, education, and gender into account. The results showed that participants were more likely to produce sagittal temporal gestures when speaking sagittal temporal words than when speaking non-sagittal temporal words, $\chi^2(1) = 27.63$, $N = 507$, $p < .001$, $\beta = 1.81$, 95% CI = [1.14, 2.49], while controlling for age, education, and gender. This indicated that sagittal gestures are influenced by the accompanying temporal words.

Furthermore, when focusing on the temporal orientation of sagittal gestures, the results showed that apart from gesturing the future to the front and the past to the back (future-in-front/past-at-back gestures) (50.96%), Chinese people gestured the past to the front and the future to the back (past-in-front/future-at-back gestures) (49.04%). In comparison to previous studies on English speakers, the proportion of past-in-front/future-at-back gestures by Mandarin speakers is surprisingly high, because on the sagittal axis, English speakers instead will predominantly produce temporal gestures with future-in-front/past-at-back mappings (about 80%, Casasanto & Jasmin, 2012). Based on such gestural behavior, and based on the claim that temporal gestures can reveal people's conceptualisation of time (e.g., Casasanto & Jasmin, 2012; Cienki, 1998; Núñez & Sweetser, 2006), this finding suggests that Chinese sometimes can visualise time in space as the Aymara do (past-in-front/future-at-back).

Interestingly, the temporal orientation of sagittal temporal gestures seems to be associated with the accompanying temporal words. In our study, 70.83% of the sagittal gestures were past-in-front/future-at-back when participants were uttering overt sagittal temporal words, whereas the proportion dropped to only 30.36% when speaking other temporal words (Figure 3.3).

This was born out by the analysis, because a regression ($N = 104$) of sagittal gesture orientation on sagittal temporal words showed that the temporal orientation of sagittal gestures was influenced by the accompanying temporal words. Specifically, on the sagittal axis, participants were more likely to perform past-in-front/future-at-back gestures when speaking sagittal temporal words than when speaking other temporal words, $\chi^2(1) = 6.64$, $p = .01$ (two-tailed), $\beta = 5.57$, 95% CI = [1.33, 9.80], while controlling for age, education, and gender. This was different from the pattern of temporal gestures by English speakers according to a previous study, in which there was no significant effect of the metaphorical spatial words on temporal gesture orientation (Casasanto & Jasmin, 2012).

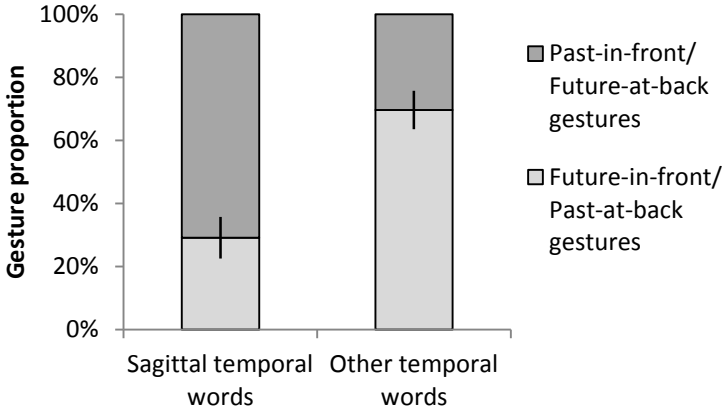


Figure 3.3. The temporal orientation of sagittal temporal gestures (with SE error bars) and the corresponding accompanying temporal words.

The result that Chinese people’s past-in-front/future-at-back gestures were more often associated with sagittal temporal words (unlike English) may be due to the use of past-in-front/future-at-back space-time metaphors. Given that Mandarin sagittal words for spatial “front” (前/qián) and “back” (后/hòu) are also used as temporal conceptions of “before/past” and “after/future”, the sagittal spatial metaphors for time can suggest past-in-front/future-at-back space-time mappings (e.g., “后天/hòu-tiān”, “back day”, the day after tomorrow; “今后/jīn-hòu”, “today back”, from now on)¹¹, and therefore can significantly influence the temporal orientation of sagittal temporal gestures.

However, as mentioned in the introduction, 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, in this way being similar to speakers of other future-in-front languages (e.g., English and Spanish). For example, “过去/guò qù” (pass go, past) and “未/将来/wèi/jiāng lái” (hasn’t come yet/will come, future) are also common translations of past and future. These metaphors suggest future-in-front/past-at-back mappings (Yu, 2012; Xiao, Zhao, & Chen, 2017; Example 5, p.8).

¹¹ By contrast, the use of “前/qián” (front) and “后/hòu” (back) to convey “future” and “past” conceptions is rather rare. For instance, according to a corpus survey, only 2.75% of temporal use of “后/hou” refers to “early/before” (Peng, 2012). In this study, all sagittal temporal words produced by participants were the past-in-front/future-at-back spatial metaphors for time.

Additionally, some temporal expressions consist of words that do not contain spatial metaphors (neutral words, like “yesterday”, “later”). If it is the case that there is a direct effect of sagittal temporal words on the temporal orientation of sagittal gestures (as shown above), then compared to when uttering past-in-front/future-at-back metaphors, Chinese people are expected to perform fewer past-in-front/future-at-back gestures when they are uttering future-in-front/past-at-back metaphors, or neutral temporal words.

To further confirm this assumption, we sorted sagittal gestures that co-occurred with temporal words of past-in-front/future-at-back, neutral words, and future-in-front/past-at-back metaphors (Figure 3.4) and ran a regression ($N = 97$) of sagittal gesture temporal orientation on sagittal temporal metaphors (Focusing on the analysis of sagittal axis, the few cases of vertical temporal words ($N = 7$) were dropped rather than merged to any category as they were neither sagittal spatial metaphors for time nor neutral wordings. It is also inappropriate to make the few cases to a new category). As predicted, the proportion of past-in-front/future-at-back gestures uttered with past-in-front/future-at-back metaphors (72.34%) was significantly higher than the proportion of gestures uttered with neutral words (31.25%, $\chi^2(1) = 5.59$, $\beta_{neutral} = -7.83$, $p = .018$, 95% CI = [-14.32, -1.34]) and future-in-front/past-at-back metaphors (22.22%, $\chi^2(1) = 8.20$, $\beta_{future_front} = -12.64$, $p = .004$, 95% CI = [-21.29, -3.99]), while controlling for age, gender, and education.

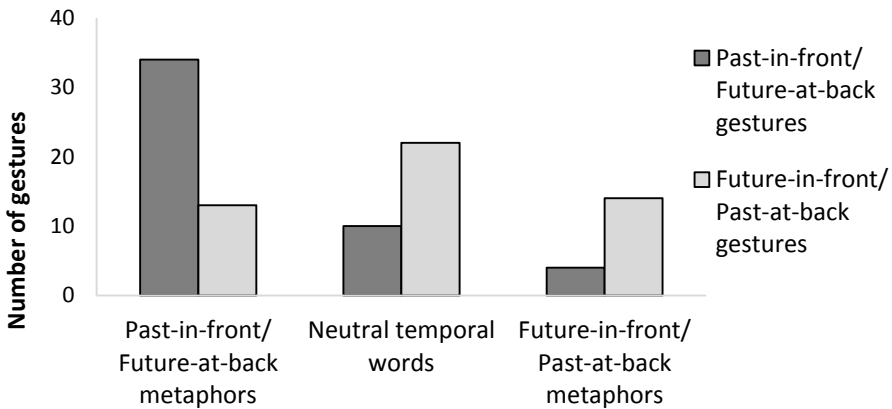


Figure 3.4. The number of past-in-front/future-at-back gestures and future-in-front/past-at-back gestures in the past-in-front/future-at-back metaphors, neutral words, and future-in-front/past-at-back metaphors conditions.

In short, the results of this study showed that Chinese speakers can produce sagittal gestures not only directing the past to their back but also to their front. The extent to which they performed past-in-front/future-at-back gestures was influenced by the accompanying temporal words (i.e., past-in-front/future-at-back metaphors; neutral words; future-in-front/past-at-back metaphors). Nevertheless, in Experiment 1, due to the fact that co-speech gestures were spontaneously produced on the fly, the number of total gestures in each metaphor condition could be rather unbalanced (see Figure 3.4). In Experiment 2, we used a more controlled and explicit approach to corroborate this first set of findings.

3.3 Experiment 2: Do Chinese People Place Past Events in front?

A temporal performance task, adapted from de la Fuente *et al.* (2014)'s temporal diagram task, was used to examine Chinese people's space-time mappings. This task has been shown to be an efficient and reliable paradigm to test people's sagittal mental space-time mappings in several cross-cultural studies (e.g., Casasanto, 2009; de la Fuente *et al.*, 2014; Li & Cao, 2018), and is more explicit than our gesture study in Experiment 1 about people's mental representations.

3.3.1 Method

Participants

114 Mandarin monolinguals ($M_{\text{age}} = 23.6$ years, $SD = 8.0$, 56 Females) were assigned to three different (between-subject) temporal word conditions (cf. Experiment 1 had three but within-subject conditions): 38 in neutral word condition, 37 in past-in-front metaphor/future-at back condition, and 39 in the future-in-front/past-at-back metaphor condition. Each participant was tested individually in Rizhao, China. The mean education level of participants was between senior high school to college ($M = 3.58$, $SD = .83$, 1-primary school; 2-middle school; 3-high school; 4-college; 5-university).

Materials and Procedure

Participants sat at a table on which they viewed on the sagittal axis a toy doll (named Xiaoming) positioned between two boxes. Participants and the character faced the same sagittal direction (Figure 3.5). The instruction presented to the participants was the same across three conditions, except, as explained below, that the wordings of temporal expressions were manipulated with the use of (1) neutral words, (2) past-in-front/future-at-back metaphors, and (3) future-in-front/past-at-back metaphors. All materials were in Mandarin.

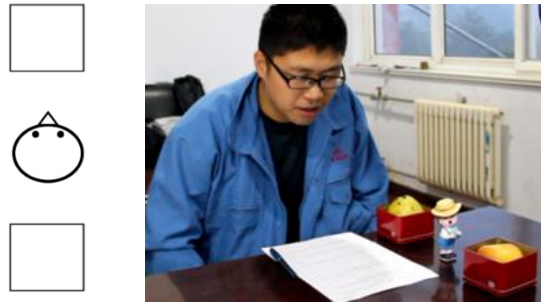


Figure 3.5. de la Fuente *et al.* (2014)'s temporal diagram task (left); setup of Experiment. 2 (right).

For the neutral word condition, participants read that *yesterday* (昨天, *zuó-tiān*) Xiaoming went to visit a friend who liked eating apples, and *tomorrow* (明天, *míng-tiān*) he would be going to visit a friend who likes eating pears (or vice versa). Participants were given an apple and a pear and were instructed to put the *apple* in the box that corresponded to what happened at *an earlier time* and the *pear* in the box that corresponded to what would happen at *a later time*. The temporal expressions (e.g., yesterday, later) in the instructions consisted of neutral words that did not contain any lexical cues referring to space. The mentioning order of the apples and pears was counterbalanced (same for other conditions), as well as the way they were paired with temporal expressions *yesterday* and *tomorrow*.

For the past-in-front/future-at-back metaphor condition, however, the expressions about time in the instruction were changed from neutral words to explicit past-in-front/future-at-back spatial metaphors: *The day before yesterday* (前天/*qián-tiān*, front day) Xiaoming went to visit a friend who liked eating apples, and *the day after tomorrow* (后天/*hòu-tiān*, back day) he would be going to visit a friend who likes eating pears. Participants were instructed to put the *apple* in the box that corresponded to the *past* (以前/*yǐ-qǐán*, to front, before) events and the *pear* in the box that corresponded to the *future* (今后/*jīn-hòu*, now back, from now on) events. Note that the new pair of temporal constructs (*the day before yesterday* and *the day after tomorrow*) had a similar period of time unit as the pair of *yesterday* and *tomorrow* in the neutral word condition, both being one or two days away from the *now* moment.

For the future-in-front/past-at-back metaphor condition, the instruction was the same as that in the neutral word condition except that the neutral wording of *an earlier time* and *a later time* in the instruction were replaced with future-in-front/past-at-back metaphors. Specifically, participants were instructed to put the *apple* in the box that corresponded to *past* (过去/guò-qù, *pass go*) events, and the *pear* in the box that corresponded to *future* (未来/wèi-lái, *will/not yet come*) events.

We made two adjustments to de la Fuente *et al.* (2014)'s paradigm. First, de la Fuente *et al.* (2014) used the entities of “plant” and “animal” to represent the conceptions of “past” and “future”, whereas we used “apple” and “pear” to reduce the possible temporal thinking of evolutionary sequence (plants came earlier than animals). Second, as Chinese people can conceptualise time vertically with “up” as “early” and “down” as “late” (e.g., Boroditsky, 2001; Chapter 2), we had participants do the task with real entities rather than letting them write on paper, in this way minimising the potential projection of vertical timelines into the sagittal dimension. After this temporal performance task, we had also asked participants why they had such placements. The results were addressed in the general discussion.

3.3.2 Results and Discussion

In the neutral word condition, 36.8% of participants placed the fruits representing the past in front of the character and the future behind it. Even though they were still a minority, the result suggests that some Chinese indeed conceptualise the past as in front of them.

Interestingly, the participants' responses towards space-time mappings were sensitive to the different lexical conditions (Figure 3.6). Specifically, in the past-in-front/future-at-back metaphor condition (PFMC), the proportion of past-in-front responses was 20% higher than in the neutral word condition (56.8% vs. 36.8%, $\chi^2(1) = 2.95$, $N = 75$, $p = .0917$ (two tailed; but we had a directional hypothesis, so $p = .046$, one-tailed), OR = 4.0, 95% CI = [.80, 20.04]), while controlling for age ($p = .39$) in a binary logistic regression. By contrast, in the future-in-front/past-at-back metaphor condition (FFMC), only 10.3% of participants performed past-in-front/future-at-back mappings, which was significantly lower than that of the 36.8% in the neutral condition ($\chi^2(1) = 6.80$, $p = .009$, OR = 5.12, 95% CI = [1.50, 17.45]), and the 56.8% in the PFMC ($\chi^2(1) = 10.76$, $p = .001$, OR = 20.30, 95% CI = [3.36, 112.46]), controlling for age ($p = .39$) in the regression ($N = 114$).

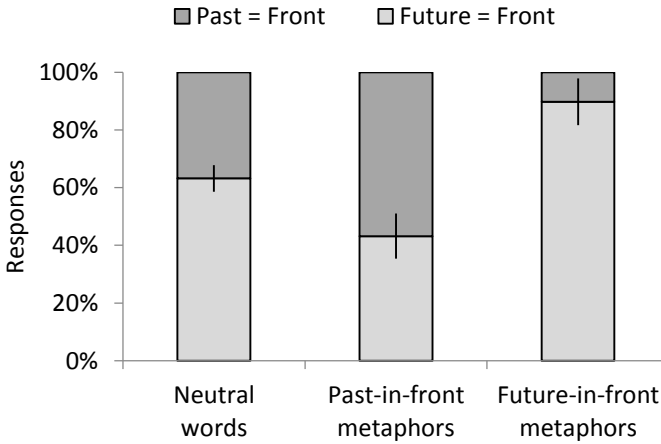


Figure 3.6. Percentage of past-in-front and future-in-front responses with SE error bars: Chinese neutral word condition, past-in-front/future-at-back metaphor condition (PFMC), and future-in-front/past-at-back metaphor condition (FFMC).

Furthermore, we recoded the temporal words of three conditions according to the extent to which they hinted to past-in-front/future-at-back mappings (= 1 if FFMC; = 2 if neutral wording; = 3 if PFMC) and ran a regression ($N = 114$) of space-time mappings on temporal words. The results showed that temporal wording was a significant factor in predicting the probabilities that participants would perform past-in-front/future-at-back mappings ($\chi^2(1) = 12.20, p = .0005, OR = 4.64, 95\% CI = [1.96, 10.96]$), controlling for age ($p = .226$). It indicated that the more temporal expressions conveyed past-in-front/future-at-back mappings, the more likely Chinese would conceptualise the past as in front/future as at back. This again demonstrated an effect of spatial metaphors on people's mental representation of time within the Chinese culture. The results are consistent with the findings of Experiment 1 on Mandarin speakers' spontaneous gestures.

3.4 Experiment 3: Language vs. Cultural Attitudes towards Time

In Experiment 2, we found that linguistic space-time metaphors have a direct influence on people's mental representation of time. However, previous research claims that space-time mappings in people's minds are also conditioned by their cultural attitudes towards time, which are dependent on attentional focus (de la Fuente *et al.*, 2014). In Experiment 3, we investigated the roles of cultural temporal-focus of attention and of the linguistic metaphors in shaping Chinese

people's space-time mappings in a survey on Chinese people's temporal performances (a replication study of Experiment 2) and cultural attitudes towards time (temporal-focus of attention).

3.4.1 Method

Participants

Another 206 Mandarin speakers ($M_{\text{age}} = 30.0$, $SD = 7.2$; 61 males, 130 females and 15 gender unknown) were assigned to fulfil a 3D temporal diagram task (adapted from Experiment 2) combined with a survey of their cultural attitudes towards time (temporal-focus of attention), both written in Mandarin Chinese. Participants' education level was about university bachelor ($M = 3.11$, $SD = .56$; 1-junior; 2-high school; 3-bachelor; 4-master).

We could not ensure that participants in this experiment were monolinguals as they were recruited via social networking and their personal backgrounds were less known than participants in other experiments. Therefore, we also collected participants' English proficiency levels ($M = 2.97$, $SD = 0.87$, 5-point-self-assessment), in case that Mandarin speakers' L2 English proficiency may influence their conceptualisation of time (e.g., Lai & Boroditsky, 2013).

Materials and Procedure

First, we conducted a replication study of Experiment 2. Participants saw a 3D animated clip of a character named Xiaoming with one box behind and one box in front of him (the clip can be viewed at <https://gifyu.com/image/SYjp>). Participants were randomly assigned to one of the three instruction conditions (neutral, past-in-front, and future-in-front metaphor conditions, cf. Experiment 2), and were requested to put the *apple* and *pear* in the corresponding boxes. On the next webpage, there was a test question asking participants to recall the axis (sagittal; vertical; lateral) on which the boxes were positioned with respect to the character in the clip. Those who did not indicate a sagittal axis (24 participants) were excluded from the analysis related to space-time mappings.

Next, participants were asked to fill in a temporal-focus questionnaire to survey the cultural values towards time. Although there are alternative measurements of cultural temporal-focus of attention (see discussions in Stolarski, Fieulaine, & van Beek, 2015; Szpunar, Spreng, & Schacter, 2014), we used the same questionnaire as de la Fuente *et al.* (2014)'s Experiment 4 because it would allow us to make a direct comparison of our results to their results with Spanish and Moroccan participants. The questionnaire was translated to Chinese and was double-checked by a backward

translation. It consisted of 21 statements denoting opinions about the past and the future (e.g., past-focused: Traditions and old customs are very important for me; future-focused: Social and cultural changes will make people happier) (Appendix 3.2). Participants indicated the extent to which they agreed with the statements on a 5-point Likert scale. Those who did not complete the questionnaire (10 participants) or did not provide their age (5 participants) were excluded from the analyses that required these data. The data were collected via the survey programme Qualtrics.

3.4.2 Results and Discussion

First, the results of the 3D temporal diagram task showed that the proportions of past-in-front/future-at-back responses in the past-in-front (PFMC), neutral, and future-in-front metaphor (FFMC) conditions displayed a descending order (52.1%, 39.7%, and 24.6%), in that sense replicating the results from Experiment 2.

Second, according to the results from the temporal-focus questionnaire, the Chinese participants tended to focus more on the future than on the past. On average, the past-focused statements ($M = 2.92$, $SD = .42$) were rated significantly lower than the future-focused statements ($M = 3.16$, $SD = .34$), $t(195) = -5.72$, $p < 0.001$, Cohen's $d = .63$, 95% CI = $[-.31, -.15]$. Following de la Fuente *et al.* (2014)'s proposal, for each participant, we calculated a Temporal-focus Index [TFI = (mean of future-focused items – mean of past-focused items)/(mean of future-focused items + mean of past-focused items)], which yielded a modest future-orientation TFI ($M = .04$, $SD = .10$) that was significantly different from 0 ($p = .0001$, Cohen's $d = .4$). The TFI has a scale from -1 , strong past focus, to $+1$, strong future focus).

We linked the participants' TFIs to their responses towards space-time mappings (3D temporal diagram task) across three word conditions. A logistic regression ($N = 167$) of space-time mappings (dependent variable) on word conditions, keeping the TFIs constant, showed that, compared to the participants in the future-in-front metaphor condition (FFMC), participants in the past-in-front metaphor condition (PFMC) ($\chi^2(1) = 8.3$, $p = .004$, OR = 3.55, 95% CI = [1.50, 8.39]) and participants in the neutral condition ($\chi^2(1) = 4.3$, $p = .038$ (two-tailed), OR = 2.43, 95% CI = [1.05, 5.63]) responded significantly more with past-in-front/future-at-back mappings in the 3D temporal diagram task, while controlling for age, gender, education, English proficiency, and the instruction sequence (the order of mentioning “yesterday” first and then “tomorrow” or vice versa). However, the analysis of the influence of TFI on participants' performances in the 3D diagram task showed no significant differences, $\chi^2(1) = .48$, $p = .49$, OR = .29, 95% CI = [.009, 9.67], keeping other control variables constant.

The results replicated the findings in Experiment 2, showing that spatial metaphors of time have direct influences on Chinese people's space-time mappings, even after controlling for their cultural attitude towards time (temporal-focus of attention). Moreover, we did not find within-cultural evidence to support the claim that temporal-focus of attention influences Chinese participant's space-time mappings.

The results showed that the Chinese participants had a slightly stronger future than past orientation. However, previous studies have shown that Chinese are more past-oriented than Canadians or Americans (e.g., Ji, Guo, Zhang, & Messervey, 2009; Guo, Ji, Spina, & Zhang, 2012). If Chinese are indeed more past-focused than Westerners, and if the cross-cultural differences in temporal focus predict different space-time mappings (*temporal-focus hypothesis*, de la Fuente *et al.*, 2014), we would expect that, at the cross-cultural level, Chinese people are more likely to have past-in-front/future-at-back mappings than Westerners, in line with the previous findings of Moroccans. In Experiment 4, we compare Chinese data with the data of Moroccans and Spaniards in de la Fuente *et al.* (2014)'s study to further scrutinize the effects of the cultural attitudes towards time and of the linguistic spatial metaphors on space-time mappings in a cross-cultural context.

3.5 Experiment 4: Linguistic Space-Time Metaphors vs. Cultural Attitudes towards Time: A Cross-Cultural Study

3.5.1 Method

Participants

For this study, we used data from de la Fuente *et al.* (2014) to see how their results relate to the findings we obtained in Experiment 3 with Chinese participants. More specifically, we used data from 93 Moroccans ($M_{\text{age}} = 28.6$ yrs, $SD = 5.7$), 55 Spaniards¹² ($M_{\text{age}} = 20.2$ yrs, $SD = 2.7$), and the 206 Chinese participants in Experiment 3. All participants had some university education.

¹² There were two groups of Spaniards (younger group, $M_{\text{age}} = 20$ yrs, and older group, $M_{\text{age}} = 74$ yrs) in de la Fuente *et al.*'s (2014) study (Experiment 4). We used the data of the younger Spaniards group for cross-cultural comparisons, as they were more comparable to that of the Moroccan ($M_{\text{age}} = 29$ yrs) and Chinese ($M_{\text{age}} = 30$ yrs) samples. The main results still held when the old Spaniards were included.

Procedure

All participants had followed a similar procedure to complete the temporal diagram task and the survey of cultural attitudes towards time (temporal-focus of attention questionnaire) as described in Experiments 2 and 3.

3.5.2 Results and Discussion

First, according to the results of the temporal-focus questionnaire, we found that there were indeed cross-cultural differences in attitudes towards time (Figure 3.7). Using a regression ($N = 339$) of TFI (Temporal-focus Index) on country, controlling for age, we found that, in comparisons to Chinese ($M = .04, SD = .10$), Moroccans ($M = -.17, SD = .22$) had a significantly lower TFI ($F(1, 335) = 142.77, p < .001, \beta = -.22$), and Spaniards ($M = .17, SD = .13$) had a significantly higher TFI ($F(1, 335) = 8.68, p = .003, \beta = .07$). Furthermore, age was significantly negative ($F(1, 335) = 17.62, p < .001, \beta = -.005$), which was consistent with past research (de la Fuente *et al.*, 2014) that older participants were less future-oriented than younger participants. In short, the results suggest that Chinese are more past-focused than Spaniards but less past-focused than Moroccans in their cultural attitude towards time.

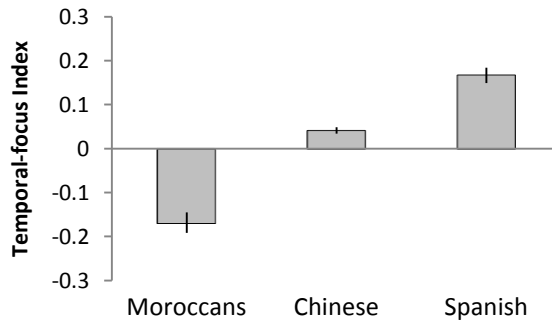


Figure 3.7. Cross-cultural differences in normalised temporal-focus of attention (TFI) with SE error bars. The TFI has a scale from -1 (strong past focus) to $+1$ (strong future focus).

Second, as for the performances in the temporal diagram task (Figure 3.8), a logistic regression of space-time mappings on country group showed that there were also cross-cultural differences in responses towards space-time mappings ($\chi^2(4) = 73.58, p < .001, N = 315$), which appeared from comparisons of Moroccans with

Spaniards ($p < .001$), Chinese past-in-front group ($p = .003$), Chinese neutral word group ($p < .001$), and Chinese future-in-front group ($p < .001$). Furthermore, Chinese in the neutral group were more likely to place the past in front than Spaniards (39.7% vs. 16.4%), $\chi^2(1) = 7.16, p = .0074, \Delta\beta = 1.21$, but were less likely to do so than Moroccans (39.7% vs. 77.4%), $\chi^2(1) = 20.43, p < .001, \beta = -1.65$.

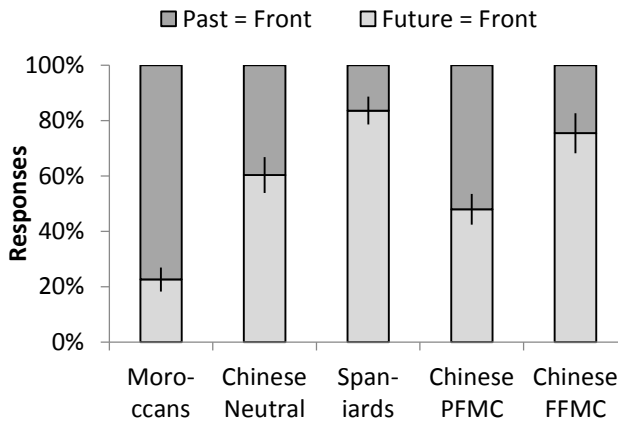


Figure 3.8. Percentage of past-in-front and future-in-front responses with SE error bars: Separately for Moroccans, Spaniards (de la Fuente *et al.*, 2014, Exp 4), Chinese neutral word condition, past-in-front metaphor condition (PFMC), and future-in-front metaphor condition (FFMC).

However, after controlling for TFI (Temporal-focus Index) in the regression model ($\chi^2(1) = 55.65, p < .0001, OR = .00015, 95\% CI = [.00001, .00148]$), most group differences were *not* significant any more (Spaniards, $p = .11$; Chinese neutral, $p = .21$; Chinese past-in-front, $p = .96$)¹³. For instance, while keeping TFI constant, Chinese in the neutral group no longer performed significantly different from Moroccans ($p = .21$) or Spaniards ($p = .50$). The significant TFI and these insignificant group differences indicated that the cross-cultural differences in space-time mappings were mostly shaped by the cultural-specific temporal focus.

¹³ To eliminate the potential multicollinearity between TFI and age, age was excluded in the model; the results were similar if age was additionally controlled for.

However, surprisingly, the effect of Mandarin spatial metaphors for time on space-time mappings still existed in the cross-cultural context. Chinese in the past-in-front group were still more likely to have past-in-front/future-at-back mappings than Spaniards ($\chi^2(1) = 3.11, p = .078$ (two tailed), $\Delta\beta = .35$), and Chinese in the future-in-front group were still less likely to have past-in-front/future-at-back mappings than Moroccans ($\chi^2(1) = 6.18, p = .013, \beta = -1.24$), keeping TFI constant. This suggested that the group differences were also influenced by spatial metaphors for time even when cultural attitudes towards time were controlled for. In sum, the results showed that space-time mappings appear to be the combined result of a general culture-specific temporal focus and lexical effects of temporal words that refer to space.

3.6 General Discussion

In this study, we aimed to find out how linguistic space-time metaphors and cultural values towards time influence Mandarin speakers' sagittal space-time mappings. We first studied spontaneous co-speech gestures to investigate Chinese people's implicit sagittal space-time mappings. It was found that, in addition to future-in-front/past-at-back gestures that are commonly also observed in the expressions of native speakers of English, some Chinese people produce gestures to associate the past to the front and the future to the back of them, especially in cases where they also used spatial words that put the past in front and the future at the back (Experiment 1).

Then we used a temporal performance task (Experiment 2) to more explicitly test Chinese people's mental space-time mappings. The results confirmed that some Chinese people conceptualise the past in front and the future as behind them, and such mappings are affected by the different words of Mandarin space-time metaphors, in that sense being consistent with the results revealed in Experiment 1 by gestures.

Furthermore, we conducted a survey on Chinese people's cultural attitudes towards time (temporal-focus of attention) together with a 3D temporal diagram task to investigate the respective roles of the linguistic metaphors and of the Chinese cultural temporal-focus of attention in shaping Chinese people's space-time mappings. The survey showed that our Chinese participants tended to focus a little bit more on the future than on the past. In addition, we replicated the findings of Experiment 2 that some Chinese people conceptualise the past in front and the future as behind them, and the extent to which they have such mappings is affected by the different words of Mandarin space-time metaphors, even though participants' temporal-focus of attention has been controlled for (Experiment 3).

Finally, with a cross-cultural comparison in space-time mappings between Chinese, Moroccans, and Spaniards, we found that Chinese more often have past-in-front/future-at-back mappings than Spaniards and less often than Moroccans. More importantly, we found that Chinese people's space-time mappings appeared to be the combined effect of lexical cues to space-time mappings and a culture-specific temporal-focus of attention (Experiment 4). The findings have several important theoretical implications to be discussed below.

3.6.1 Implications for Sagittal Metaphorical Temporal Orientation in Chinese People

Our study reveals how Chinese people conceptualise time on the front-back axis. While some Chinese conceptualise the future as being ahead of them and the past behind them, others show the opposite pattern, and view the past as something ahead of them. More specifically, Chinese people reveal gestures and actions that reflect past-in-front/future-at-back mappings, which appear to be related to the lexically expressed space-time metaphors used in language. These past-in-front/future-at-back mappings are peculiar, as pointing gestures referring the past to the front and the future to the back have so far only been reported in Aymara (Núñez & Sweetser, 2006).

One may argue that the Chinese past-in-front/future-at-back mappings are merely due to the lexical effect of Mandarin past-in-front/future-at-back sagittal words (e.g., 前/qián, front/before; 后/hòu, back/after). However, this is unlikely since Chinese people can still make past-in-front/future-at-back gestures when uttering temporal words that do not contain past-in-front/future-at-back references (e.g., yesterday, tomorrow, earlier, later) (Experiment 1), whereas English speakers do not spontaneously perform such sagittal temporal gestures at all (Casasanto & Jasmin, 2012). Additionally, even when reading an instruction in which temporal expressions consisted of future-in-front/past-at-back metaphors, still about one-fourth of the participants positioned the past in front (Experiment 3). Note that typical Westerners such as English and Spaniards would be quite unlikely to put the entity representing “future” to their back (de la Fuente *et al.*, 2014; Lakoff & Johnson, 1980).

The results of the study contribute to the theory on Chinese people's mental orientation of time on the sagittal axis. According to Xiao, Zhao and Chen (2017)'s proposal, time in Chinese minds can be perceived as moving from the future to the past, where the ego faces the future (see Figure 3.1). Both “early” events and “future” events are in “front”, depending on whether the perspective is taken from a

time-reference-point or an ego-reference-point. From the time-reference-point perspective, earlier events are in front of later events, thus the past is in the front of the timeline; from the ego-reference-point perspective (stationary or moving), earlier events are behind the ego, and as such the past is at the back of the ego. Therefore, “early” is in front of “late” but is *behind* the ego. Xiao, Zhao and Chen (2017)’s model can well explain most of our results. For instance, the time perspective in past-in-front/future-at-back metaphors (yǐ-qí án; jīn-hòu) and neutral words (zǎo, early; wǎn, late) conditions can be considered as a time-reference-point perspective whereas the future-in-front/past-at-back metaphor condition can be considered as an ego-reference-point perspective. Chinese participants were more likely to gesture and perform past-in-front/future-at-back mappings when the space-time metaphors encouraged a time-reference-point perspective than when the space-time metaphors encouraged an ego-reference-point perspective.

However, some of the empirical results in the present study may not fit into the temporal reference frames proposed by Xiao, Zhao and Chen (2017). For instance, some Mandarin speakers gestured the past events in front of the ego and future events behind the ego (Experiment 1), and some also explicitly indicated that they felt the past to be in front of them, and the future behind them (Experiment 2). According to post-hoc interviews with 37 participants who performed past-in-front/future-at-back mappings in Experiment 2, the majority of them (29/37) explained that they had such placements because they indeed believed that the past should be in front, four of whom, similar to Aymara, argued that it was because that past is known and seen and the future yet unknown and unseen (cf. Núñez & Sweetser, 2006).

These explanations, together with the fact of past-in-front/future-at-back spontaneous gestures may suggest that the ego of some Chinese people can be facing the past (Ahrens & Huang, 2002; Alverson, 1994). If time is analogous to a moving train with a number of carriages, it is possible that a Chinese observer is standing still and facing the past, and the moving train is passing from the back to the front of the observer (Figure 3.9). Taking the moment when the train passes the observer as the time reference point of “now”, the carriages that have passed the observer (e.g., carriages 1 and 2) become the past, and the carriages that have not passed the person (e.g., carriages 4 and 5) are future events. There is also some linguistic evidence in Mandarin Chinese for this conjecture, such as in (7) and (8).

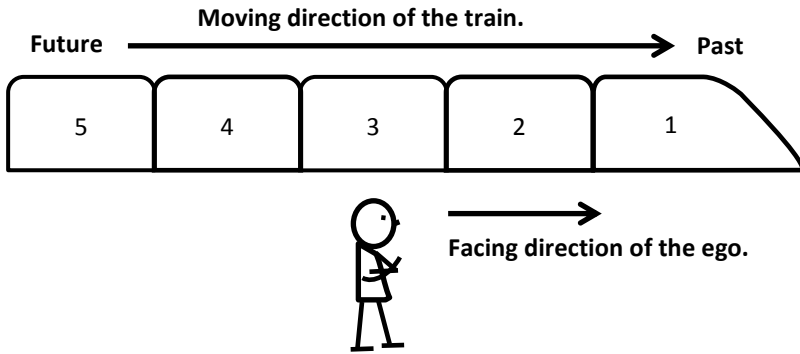


Figure 3.9. Time moves from the future to the past, but the ego stands stationary and faces the *past* (carriage 3 is now): From the time-reference-point perspective, earlier events (e.g., carriages 1 and 2) are in front of later events (e.g., carriages 4 and 5), thus the past is in the front of the timeline; however, different from Figure 3.1, from the ego-reference-point perspective, earlier events are *in front* of the ego as well, and the past is *in front* of the ego.

- (7) 直视自己的过去 (zhí shì zì jǐ de guò qù)
 straight forward look my past go
 gaze forward towards my past
- (8) 准备自己的后事 (zhǔn bèi zì jǐ de hòu shì)
 prepare for own back event
 prepare for one's own future funeral

In the above proposal, the ego is static while time is moving (Figure 3.9). It shows that early/past events can be in front of an observer even when an ego is involved in the time sequence. However, despite the fact that some Mandarin speakers believe that “early” is *in front* of the ego, and “late” is *at the back* of the ego, at the same time they may not deny that they also conceptualise the “future” as *ahead* and the “past” as *behind* themselves. This seemingly contradictory observation regarding mental timelines cannot fully be explained by the assumptions shown in Figure 3.1 or Figure 3.9.

For those Chinese people who have a mixed mental timeline, it is likely that there is both an internal human sequence timeline and an external ego-moving timeline (Yu, 1998, 2012; Ng *et al.* 2017; Xiao, Zhao, & Chen, 2017). Yu (1998,

2012) first proposes that the spatial conceptualisation of temporal order of humans is similar to a human’s queuing experience. In other words, it is consistent with the human’s psychological reality of sequential time (Gauthier & van Wassenhove, 2016; Gentner, Imai, & Boroditsky, 2002; Moore, 2011). For instance, in a queue, people who are in or near first position will be served earlier than those who are behind them (Núñez, Motz, & Teuscher, 2006; Walker, Bergen, & Núñez, 2015, 2017). Specifically, suppose I am lining up in a queue (e.g., C), then within the line, the earlier people (e.g., A and B) are in front of me, and later people (e.g., D and E) are behind me. However, for myself, as well as for all other people in the queue, the “future” is in front of me, as the path leading to the destination ahead, whereas the “past” is behind me, as the path I have taken to arrive at my current position (“now”) (Figure 3.10). As such, both “earlier” and “future” can be in front of the ego, and both “late” and “past” can be behind the ego. Thus the present study provides the first experimental evidence for this proposal.

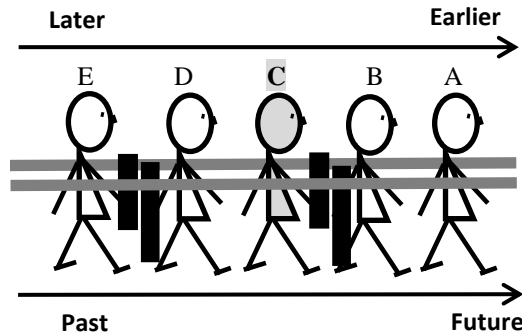


Figure 3.10. In Yu (1998, 2012)’s proposal, the ego faces the future: From the ego-reference-point perspective, earlier people (...A, B) are *in front of* the ego (C), later people (D, E...) are *behind* the ego. However, the destination/future is also *in front of* the ego, and the past is *behind* the ego.

3.6.2 Implications for Theoretical Accounts of Space-Time Mappings

This study extends our knowledge on cross-cultural differences in space-time mappings. The results that Chinese more often have past-in-front/future-at-back mappings than Spaniards and less often than Moroccans can largely be explained by the differences in culture-specific temporal-focus of attention. That is, in

comparison to Chinese culture, Moroccans are more past-focused whereas Spaniards are more future-focused. This provides new evidence supporting the *temporal-focus hypothesis*, which proposes that space-time mappings in people's minds are conditioned by their cultural attitudes towards time (attentional focus) (de la Fuente *et al.*, 2014).

Moreover, the study contributes to the development of the existing theories on mental space-time mappings. According to de la Fuente *et al.* (2014)'s *temporal-focus hypothesis*, whether people conceptualise the past as behind and the future as ahead of them depends on the extent to which their (sub) culture is future-oriented or past-oriented. Importantly, the authors claim that such conceptualisations can vary independently from the way time is linguistically expressed in terms of spatial metaphors. However, within the Chinese culture, the propensity of past-in-front/future-at-back mappings is sensitive to the wording of Mandarin space-time metaphors, irrespective of people's temporal-focus of attention. Such linguistic differences even contribute to the explanation of cross-cultural differences in space-time mappings. Therefore, we propose a modification of the *temporal-focus hypothesis*: Whether people conceptualise the past as behind and the future as ahead of them is not only influenced by cultural attitudes towards time, but also, directly, by the space-time metaphors used in the language.

3.6.3 Implications for Theories on the Relation between Language and Thought

The findings of this study provide some new insights into the relation between language and thought, especially for the online influence of linguistic context on thinking (e.g., Bylund, & Athanasopoulos, 2017; Lai & Boroditsky, 2013; Slobin, 1996). As mentioned above, results from our study of spontaneous gestures and of the temporal performance task show that there is a direct effect of linguistic metaphors on people's reasoning about time. In particular, such linguistic effect was persistently significant even after controlling for factors of culture-specific temporal-focus of attention, age, education, and English proficiency (Experiment 3).

Nevertheless, our results are still in line with previous findings that temporal language and temporal thinking "may not go hand in hand" (e.g., Casasanto, 2016). Past studies have examined spontaneous gestures that accompany temporal language to reveal English speakers' temporal thinking. Although in English space-time metaphors suggest that the future is ahead of the speaker and the past is behind, English speakers often laterally gesture the past to the left and the future to the right (see discussions e.g., Casasanto & Jasmin, 2012; Cooperrider & Núñez, 2009; Walker & Cooperrider, 2016). Similarly, in our Experiment 1, about half of sagittal

temporal words were accompanied by non-sagittal gestures. Additionally, in Experiment 3, about half of the participants tended to have future-in-front/past-at-back mappings even when instructed with past-in-front/future-at-back temporal language. Such facts indicate that past-in-front/future-at-back temporal language does not always lead to past-in-front /future-at-back gestures or space-time mappings (partially due to the cultural values towards time which can also play a role). However, the intriguing results from the current study are that, unlike in English (Casasanto & Jasmin, 2012), in Chinese, sagittal temporal language is *more* likely to activate sagittal gestures, and past-in-front/future-at-back sagittal temporal language (e.g., 前天/ qián tiān, front day) will *increase* the probability of past-in-front/future-at-back space-time mappings.

One may wonder why English speakers are hardly influenced by the linguistic past-in-front/future-at-back mappings, given that in English the temporal “before” and “after” can also be used as spatial “front” and “back”. However, English “before” and “after” are commonly used as temporal expressions, whereas “purely spatial uses of ‘before’ and ‘after’ are rare”¹⁴ (Casasanto, 2016, p. 70). In fact, to express the spatial concepts of *front* and *back* in English, it is more prevalent to use “front/back” or “ahead/behind” than to use “before” and “after”.

By contrast, in Mandarin, “前/qian” and “后/hou” are often used to express temporal concepts of “before/past” and “after/future”, while at the same time they are also the *only* words for the purely spatial use of “front” and “back” (no other option). According to a corpus survey, in Mandarin most words expressing temporal past and future consist of past-in-front/future-at-back metaphors (Chen, 2007; Peng, 2012). Given that past-in-front/future-at-back space-time metaphors are widely used to express Mandarin time (e.g., 前天/qián tiān, literally, *front day*, the day before yesterday) (Peng, 2012), given the frequent spatial use of “前/qián” and “后/hòu” (unlike the rarely spatial use of “before” and “after” in English), and given that people use space to conceptualise time, Mandarin speakers may well be more likely to establish the front-back space-time mappings than English speakers.

A further question is whether the past-in-front/future-at-back mappings in Mandarin will have an effect of habitual thinking on speakers’ conceptualisation of time. According to Slobin’s (1987) “thinking-for-speaking” hypothesis, habitual speech patterns may influence thinking online, during linguistic processing. When speakers use certain speech patterns repeatedly, they may form habitual language-

¹⁴ But see a counterexample: The priest stands behind the altar.

specific conceptual schemas. However, the results of the present study do not allow us to address this question directly.

Given that in Mandarin most words expressing temporal past and future consist of past-in-front/future-at-back metaphors (Chen, 2007; Peng, 2012), if habitual use of certain space-time metaphors can indeed influence one's time conceptions (Boroditsky, 2001; Hendricks & Boroditsky, 2017), one possibility is that, under the influence of past-in-front/future-at-back metaphors, Mandarin speakers may form past-in-front/future-at-back space-time mappings in the long-run. For example, a recent study on Chinese Sign Language found that, different from Mandarin speakers, on the sagittal axis, Chinese signers can only use future-in-front/past-at-back space-time metaphors. Interestingly, Chinese deaf signers also displayed a different spatio-temporal reasoning than Mandarin speakers, where deaf signers gradually establish the past-in-front/future-at-back mappings as a function of an improved Mandarin proficiency (more details will be discussed in Chapter 5). That study suggests that, within the Chinese culture, sagittal space-time metaphors appear to have a long-term influence on people's spatio-temporal reasoning (cf. Lai & Boroditsky, 2013).

3.6.4 Implications for the Mechanism of Gesture Production and Abstract Reasoning

This study provides the first quantitative analyses of Chinese people's spontaneous sagittal temporal gestures, the results of which can provide a better understanding of the mechanism of the production of temporal gestures and abstract reasoning. Previous studies have shown that temporal gestures can be shaped by the reading and writing direction (Casasanto & Jasmin, 2012), culture-specific beliefs (Floyd, 2016; Le Guen & Balam, 2012; Núñez & Sweetser, 2006), geographical environment (Núñez *et al.*, 2012), use of cardinal frame of references (Boroditsky & Gaby, 2010), and even bodily experience of temporal signs of sign language (Chapter 4). All these studies provide evidence that, how people use gestures to visualise time in space relies heavily on how they think of using the body to interact with the physical environment (spatio-motoric thinking, see Kita, 2000). In other words, the way one thinks of time in space affects the temporal gestural representation. Furthermore, in line with a previous finding that Mandarin speakers are likely to produce vertical gestures for vertical space-time references in Chinese (Chapter 2), this study shows that sagittal temporal gestures can be affected by the use of sagittal spatial metaphors.

More generally, our results of the gesture study offer new insights into the *Interface Hypothesis* (Kita & Özyürek, 2003) that the contents of concurrent gesture and speech tend to converge because the iconic gesture production system and speech production system can exchange information and align their contents. The results of the present study extend the *Interface model* into metaphoric gestures that can encode the spatio-motoric representations of abstract concepts (cf. Argyriou, Mohr, & Kita, 2017; Kita, Alibali, & Chu, 2017). Thus, the ultimate production of temporal gestures is a result of the metaphoric spatio-motoric thinking and the linguistic wording.

Furthermore, our study provides empirical evidence for the hypothesis that gestures are generated from the same process that generates practical actions (Calbris, 2003; Chu & Kita, 2016; Kita, Alibali, & Chu, 2017). As *simulated actions* (Hostetter & Alibali, 2008), gestures have no physical consequence on the real world, but they seem to share some properties with actions. Interestingly, the findings of our gesture study are surprisingly convergent to that of action performances in the temporal performance task. As shown by the results from Experiment 1, the proportions of past-in-front/future-at-back gestures in the past-in-front/future-at-back, neutral, and future-in-front/past-at-back metaphor conditions displayed a similar descending order to the results from the temporal performance/diagram task (Experiments 2 & 3). The results support the claim that gestures are “actions in the virtual environment” (Kita, 2000, p. 165) or “a natural expression of the simulated actions” (Hostetter & Alibali, 2008, p. 504) (see more discussion in Chu & Kita, 2016)

Finally, the study of metaphorical mapping of time to space is a kind of study on people’s abstract reasoning (e.g., Cienki, 1998; Cooperrider, Gentner, & Goldin-Meadow, 2016), and the study of temporal gestures (Experiment 1) has methodological implications. Given that gestures have an inherent spatial property, they are a unique natural source of evidence for the use of space in abstract reasoning (Walker & Núñez, 2016), and can inform our understanding of analogy by investigating how analogical thinking is manifest in metaphoric gestures that represent relations (e.g., time) (Cooperrider & Goldin-Meadow, 2017).

3.7 Conclusion

In this study we investigated how Mandarin linguistic space-time metaphors and cultural attitudes towards time can influence Chinese people’s use of the front-back space to conceptualise time. We studied Chinese people’s spontaneous temporal gestures and action performances in space-time mappings, as well as surveyed their

cultural temporal values. The results of within-cultural and cross-cultural differences in spatial mappings of time demonstrate that the extent to which people conceptualise the past as behind and the future as ahead of them depends not only on their cultural attitudes towards time but also on the linguistic spatial metaphors for time. Thus, there are both long-term effects of cultural temporal-focus of attention and immediate effects of the space-time metaphors used to probe people's mental representations. Such findings provide a better understanding of Chinese people's mental sagittal temporal orientation and of cross/within-cultural differences in spatial-temporal thinking, with additional implications for the theories on the relationship between language and thought, and on the mechanism of gesture production and abstract reasoning.

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Appendix 3.1. Wordlists of Targeted Time Referents.

	Chinese	Meaning
(1)	上周, 下周 shàng zhōu, xià zhōu	last week, next week
(2)	昨天, 今天, 明天 zuó tiān, jīn tiān, míng tiān	yesterday, today, tomorrow
(3)	早晨, 晌午, 傍晚, 深夜 zǎo chén, shǎng wǔ, bàng wǎn, shēn yè	morning, noon, evening, late at night
(4)	上辈子, 下辈子 shàng bèi zi, xià bèi zi	previous life, next life
(5)	前年, 后年 qián nián, hòu nián	the year before last year, the year after next year

Appendix 3.2. Temporal – Focus Questionnaire

Original English Version (de la Fuente *et al.*, 2014):

1. Traditions and old customs are very important for me.
2. The young people must preserve the traditions.
3. I think that people were happier some decades ago than nowadays.
4. Present day youth need to keep the values of their parents and grandparents.
5. Older people know better than young people.
6. The right way to do things is the way in which I was taught to do them.
7. It is difficult for me to accept the cultural changes that are occurring in recent years.
8. The young people's way to have fun was better in the old times than now.
9. The traditional way of living is better than the modern way.
10. I think that the technological and economic advances in recent years are detrimental for society.
11. Respect for traditions has been lost, which is bad.
12. I understand that cultural beliefs change progressively and that we have to adapt to those changes.
13. The values and beliefs of my culture are becoming more modern, which is good.
14. I think that globalization is very positive.
15. Technological and economic advances are good for society.
16. The values and beliefs of the youth must be different from those of older people.
17. Young people do not need to learn from their elders.
18. Young people must think about the future, not in the past.
19. Traditions are not useful for the present and future society.
20. It is important to innovate and adapt to the new changes.
21. Social and cultural changes will make people happier.

Chinese Version:

1. 对我来说传统和老习俗很重要。
2. 年轻人应该保留传统。
3. 我觉得几十年前人们比现在更幸福。
4. 当今的年轻人需要保持他们父母和祖父母的价值观。
5. 长者（年长的人）比年轻人懂得更多。
6. 正确的做事方法是用我曾被教过（传授）的方法来做。
7. 这些年的文化变化让我难以接受。
8. 过去年轻人娱乐的方法比现在要好。
9. 传统的生活方式比现代的要好。
10. 我觉得近些年科技和经济的进步对社会有危害。
11. 人们对于传统的尊重已经丢失，这是很糟糕的。
12. 我知道文化信仰会逐渐发生变化，我们必须适应这些变化。
13. 人们的价值观和文化信仰正在变得更加现代化，这是很好的。
14. 我觉得全球一体化很好。
15. 科技和经济发展有利于社会。
16. 年轻人的价值观和信仰一定会和年长的人不同。
17. 年轻人不需要向他们的长辈学习。
18. 年轻人应该思考未来，而不是想着过去。
19. 传统对于当今和未来的社会没什么用。
20. 创新和适应新的变化很重要。
21. 社会和文化的变化会使人们更幸福。

Having a different *pointing* of view about the future: The effect of signs on co-speech gestures about time in Mandarin-CSL bimodal bilinguals

Abstract

Mandarin speakers often use *gestures* to represent time laterally, vertically, and sagittally. Chinese Sign Language (CSL) users also exploit *signs* for that purpose, and can differ from the gestures of Mandarin speakers in their choices of axes and direction of sagittal movements. The effects of sign language on co-speech gestures about time were investigated by comparing spontaneous temporal gestures of late bimodal bilinguals (Mandarin learners of CSL) and non-signing Mandarin speakers. Spontaneous gestures were elicited via a wordlist definition task. In addition to effects of temporal words on temporal gestures, results showed significant effects of sign. Compared with non-signers, late bimodal bilinguals (1) produced more sagittal but fewer lateral temporal gestures; and (2) exhibited a different temporal orientation of sagittal gestures, as they were more likely to gesture past events to their back. In conclusion, 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.

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4.1 Introduction

People use space to represent the abstract concept of time (e.g., Casasanto & Boroditsky, 2008; see reviews Bender & Beller, 2014; Núñez & Cooperrider, 2013). For instance, we often talk about time in terms of space such as in phrases like: “The future is lying *ahead*; the past is *behind* us” (Calbris, 2008; Clark, 1973; Evans, 2004, 2013; Lakoff & Johnson, 1980; Traugott, 1978). In addition, humans also tend to gesture to visually express time in space. English people may refer to the future by pointing to the front of their body and indicate the past by pointing to their back (also left-right for past-future) (Casasanto & Jasmin, 2012; Cooperrider & Núñez, 2009; Walker & Cooperrider, 2016). Such *temporal gestures* with the future-in-front and the past-at-back mappings sound common for many Westerners.

However, across cultures and languages, people may gesture about time vastly differently. Take the temporal gestures of *future*: for instance, residents of Pormpuraaw (Australia) point the future to the front of them only when they are facing the west, because they always arrange temporal order according to cardinal directions from east to west (Boroditsky & Gaby, 2010). Interestingly, Aymara speakers point the future to their back as they believe that the future is unseen/unknown (Núñez & Sweetser, 2006). Moroccans also have a strong tendency to gesturally position the past in the front and the future at their back, which is claimed to be shaped by their cultural attitude towards time as Moroccans focus on past times and place high value on tradition (people who are past-focused metaphorically should have a tendency to place the past in front of them, “in the location where they could focus on the past literally with their eyes if past events were physical objects that could be seen” (de la Fuente *et al.*, 2014, p.1684). Additionally, some Chinese people spontaneously direct their gestures to their front when referring to past events, but the extent to which they perform past-in-front gestures is influenced by the accompanying temporal words (Chapter 3). Furthermore, people can even gesture about the future in some other space dimensions such as *downwards*, or *uphill*, etc. (Chapter 2; Núñez, Cooperrider, Doan, & Wassmann, 2012).

Despite the fact that there are an increasing number of studies on the relation between speakers’ gestures and their spatialisation of time (e.g., Bostan, Börütecene, Özcan, & Göksun, 2016; Floyd, 2016; Kita, Danziger, & Stolz, 2001; Le Guen & Balam, 2012), we still have an incomplete understanding of why some communities gesture the future to the front whereas others gesture the past to the front. In the research reported here, we investigated this question by exploring the effect of temporal signs on temporal gestures in *bimodal bilinguals*, who know both a spoken

language and a signed language (Emmorey, Boorin, Thompson, & Gollan, 2008). To the best of our knowledge, no study has researched the temporal gestures by people who have experience of sign language, which, in the case of Chinese, would represent an interesting group, as Mandarin Chinese-Chinese Sign Language (CSL)¹⁵ bimodal bilinguals share a similar culture as non-signers, but have acquired CSL which exploits different time-space mappings than Mandarin (see review below). Particularly, we are interested in whether Mandarin-CSL bimodal bilinguals gesture differently about time than Mandarin speakers who do not know CSL.

4.1.1 Background

Mandarin Speakers' Temporal Gestures

It has been shown that Mandarin speakers make gestures on different axes in space to represent time. First, similar to English speakers, Chinese people most often produce lateral temporal gestures, with the past on the left and the future on the right side. However, different from most Westerners, Chinese can exploit a vertical axis as well to gesture about time, as they tend to spontaneously point *upwards* for the time conception of “last week” and *downwards* for “next week” (see Chapter 2).

Additionally, Mandarin speakers can perform sagittal gestures to express time. On the one hand, they can point the future to the front of their body and the past to the back, which is in line with the Mandarin future-in-front/past-at-back sagittal space-time metaphors (Table 4.1, Example 1). On the other hand, a Mandarin speaker can point to the front of his/her body to refer to the conception of temporal “before” (Chui, 2011). As revealed by the gesture study in Chapter 3 (Experiment 1), past-in-front/future-at-back gestures were more often associated with past-in-front/future-at-back space-time metaphors. As Example (2) shows, the sagittal

¹⁵ The sign languages used in mainland China are generally called Chinese Sign Language (CSL) (Fischer & Gong, 2010). CSL has different dialects such as the northern (Beijing) CSL and the southern (Shanghai) CSL, which sometimes can even be mutually unintelligible (Yang, 2005). The China Association of the Deaf has been making efforts to unify and standardise CSL since the late 1950s. An authorized dictionary, Chinese Sign Language (zhong-guo shou-yu) (China Association of the Deaf and Hard of Hearing, 2003) is used in China to standardise CSL. The dictionary has collected the signed forms of more than 5,000 Chinese words that are common in use in both Beijing and Shanghai (representing the northern and the southern varieties). This standard variety is learned by users of both dialects and it is now widely used in education, on television and by interpreters (Yang, 2015). Note that we will deal with only one variety, namely the Standard CSL, which was the language taught to the hearing L2 learners in our study.

words for spatial “front” (前/qián) and “back” (后/hòu) are also used as temporal conceptions of “before/past” and “after/future”. Such sagittal spatial metaphors for time suggest past-in-front/future-at-back space-time mappings, and, therefore, may significantly influence the direction of sagittal temporal gestures. Partially due to this lexical effect, some Mandarin speakers even explicitly report to believe the future to be positioned behind and the past in front of them (i.e., past-in-front/future-at-back space-time mappings) (Chapter 3).

Table 4.1. Examples of future-in-front/past-at-back and past-in-front/future-at-back mappings in Mandarin.

Example (1)	展/zhǎn 望/wàng 未/wěi 来/lái
	unfold gaze-into-distance hasn't come Looking far ahead/into the future.
	回/huí 首/shǒu 过/guò 去/qù
	turn-around head pass go Looking back to the past.
Example (2)	前/qián 天/tiān, 今/jīn 后/hòu
	front day, today back the day before yesterday, from now on

Temporal Signs in CSL

CSL users also make use of the lateral, vertical, and sagittal spatial representations to express the conception of time. In many sign languages, the lateral axis is often used to express a sequence timeline, which is parallel to the signers' body and extends from left to right, representing earlier to later time periods (e.g., Nilsson, 2016; Wilcox, 2002). It is used when signers refer to ordered events that are unrelated to the utterance time (Emmorey, 2001). Zheng (2009) finds that users of CSL are consistent in listing events that happened at a different time from the left to the right.

As for the vertical timeline, CSL signers make use of vertical spatial metaphors of “up” and “down” to represent time conceptions of “early” and “late”, or the sequence of events. For instance, the temporal conception of “future” can be signed “downwards” (Wu & Li, 2012; Zheng, 2009).

Furthermore, the sagittal axis is often used for what could be termed a deictic timeline. Similar to other sign languages in the world (e.g., Cabeza Pereiro &

Fernández Soneira, 2004; Maeder & Loncke, 1996; Schermer & Koolhof, 1990, see a review in Sinte, 2013), CSL signers' bodies are often referred to as a deictic reference point of the timeline, such that locations near the signers are often used for “now”, and the future is signed more to their front and the past to their back (Wu & Li, 2012; Zheng, 2009).

Time in Hands: Gestures vs. Signs

Interestingly, there are dramatic *differences* in the deictic sagittal timelines between CSL and Mandarin Chinese. As stated above, Mandarin Chinese contains space-time metaphors that suggest both future-in-front/past-at-back and past-in-front/future-at-back space-time mappings. Accordingly, Mandarin speakers can not only produce future-in-front/past-at-back temporal gestures, but also past-in-front/future-at-back gestures. However, the sagittal lexical signs of CSL do not show this variation, as they represent *only* future-in-front/past-at-back space-time mappings, in this way being different from Mandarin Chinese. For instance, the time conceptions of “the day before yesterday” and “the day after tomorrow” in Mandarin are expressed in a completely reversed manner from what is the case in CSL (Wu & Li, 2012; Zheng, 2009). That is, in Mandarin the direction of “the day before yesterday (前天/qián-tiān, *front day*)” is literally to the front, and “the day after tomorrow (后天/hòu-tiān, *back day*)” is literally to the back, which is often reflected in the directionality of the co-speech sagittal temporal gestures by Mandarin speakers (Chapter 3). By contrast, in CSL the temporal sign of “the day before yesterday” is signed to the back, whereas the temporal sign of “the day after tomorrow” is signed to the front (Zheng, 2009).

Additionally, although Mandarin speakers and CSL signers both use 3D manual movements to indicate time, the relative proportion of the three time axes may be different, since Mandarin speakers predominantly produce temporal gestures on the lateral axis (see results presented in Chapter 2) whereas an empirical survey showed that CSL deaf signers mostly produce temporal signs on the sagittal and vertical axes (Zheng, 2009).

Do Speakers' Gestures Change after Learning a Spoken or Signed Language?

There has been a long interest on whether speakers gesture differently after learning an L2, even when the existing studies provide mixed results (e.g., Brown & Gullberg, 2008; Casey & Emmorey, 2009; Özçalışkan, 2016; Pika, Nicoladis, & Marentette, 2006). For unimodal (non-bimodal) bilinguals, Brown and Gullberg

(2008) found that there were influences of an L2 on co-speech gestures of an L1. For instance, it was found that intermediate Japanese learners of English gestured slightly differently in their L1 Japanese than Japanese monolinguals when talking about motion events. Specifically, Japanese–English speakers (similar to English monolinguals) were less likely to perform a gesture that expressed manner of motion than monolingual Japanese, while their speech conveyed manner information. By contrast, Choi and Lantolf (2008) found that even advanced English learners of Korean as an L2 or Korean learners of an L2 English still retained their L1 co-speech gesture patterns when expressing manner of motion in their L1 language. Similarly, Özçalışkan (2016) found that Turkish-English bilinguals still followed L1 co-speech gesture patterns even when speaking L2.

As for bimodal bilinguals, the very few studies about their gestures reveal that there is probably an influence of a signed language on the co-speech gesture patterns in a first spoken language. For instance, an L2 sign language may affect the production of co-speech gestures or facial expressions when bimodal bilinguals speak in their L1 (Pyers & Emmorey, 2008). Additionally, two studies have shown that American Sign Language (ASL)-English bilinguals may have a higher co-speech iconic gesture rate than English non-signers (Casey & Emmorey, 2009; Casey, Emmorey, & Larrabee, 2012). These results seem to suggest 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, Nadolske, & Wolford, 2012; Emmorey *et al.*, 2008).

However, the studies on gestures discussed above, regardless of whether they were dealing with unimodal or bimodal bilinguals, predominantly have focused on how gestures for motion events or gesture frequency and form can be affected by knowing a second spoken/signed language. No studies have looked into how the *content* of gestures (e.g., the abstract concept of space-time mappings represented in gestures) can be affected by the experience of a signed language.

4.1.2 The Current Study

The current study aims to investigate whether the experience of CSL influences the production of co-speech gestures about time in bimodal bilinguals. We will explore firstly whether Mandarin-CSL bimodal bilinguals perform different patterns of temporal gesture than Mandarin speakers, in terms of the relative proportion of three axes. Second, focusing on the temporal orientation on the sagittal axis, we aim to find out whether hearing people who have learned CSL have a different direction of sagittal temporal gestures than Mandarin non-signers.

If it is the case (in line with previous studies) that gesture production and sign production systems are interconnected (e.g., Emmorey *et al.*, 2008) in a way that bimodal bilinguals are accustomed to perform manual movements in certain axes or directions, given the differences between temporal gestures and signs, we predict that bimodal bilinguals will have more sagittal and vertical temporal gestures but fewer lateral temporal gestures than Mandarin speakers who are non-signers. Additionally, Mandarin-CSL bilinguals are less likely to perform past-in-front/future-at-back gestural mappings than Mandarin speaking non-signers.

Furthermore, given that spontaneous gestures are a window into people's spatio-temporal thinking (e.g., Casasanto & Jasmin, 2012; Cienki, 1998; Núñez & Sweetser, 2006), providing a "vivid and naturalistic source of evidence for the use of space in abstract reasoning" (visualising thought) (Cooperrider, Gentner, & Goldin-Meadow, 2016; Tversky, 2011), the study of co-speech temporal gestures by late bimodal bilinguals may reveal the effect of cross-modal spatial metaphors of time on people's mental space-time mappings. Thus this study can show the cross-linguistic influence of an L2 on an L1 and may further help clarify the problem of the restructuring of temporal conceptualisation after learning an L2.

4.2 Method

Participants

Forty-four participants, including 10 hearing Mandarin-CSL late bimodal bilinguals (6 female; $M_{\text{age}} = 39.2$ yrs, $SD = 7.7$ yrs) and 34 Mandarin-speaking non-signers (22 females; $M_{\text{age}} = 33.79$ yrs, $SD = 7.58$ yrs), took part in the experiment in Rizhao, China. Three Mandarin-speaking non-signers were excluded from the analyses as they did not produce any gestures. The monolingual data were from a corpus collected in Chapter 3. We used part of the data to do different analyses so that they could be used as comparison materials in this study.

All late bimodal bilinguals were born into hearing families and acquired standard CSL as a second language later in their life (average age of acquisition = 20.6 yrs, $SD = 3.3$ yrs). They were fluent users of standard CSL with an average of 18.6 years of signing experience ($SD = 9.2$). Their CSL proficiency levels ($M = 8.6$, $SD = 1.07$, 10-point scales) were assessed by a CSL teacher from a school for special education. This assessment was done after all the participants had finished the experiment so that participants would not infer a focus on manual movements in the study. These bimodal bilinguals were teachers of deaf children, and none of them were interpreters.

Additionally, the English proficiency levels of participants of both groups were minimum ($M = 1.36$, $SD = .66$, 1 = hardly know any English; 2 = beginner to lower-intermediate), as reported on a 5-point-scales' self-assessment.

Materials and Procedure

A word definition task was used to elicit participants' spontaneous gestures, inspired by previous studies (e.g., Chapters 2 and 3; Núñez *et al.*, 2012) that showed the effectiveness of this method. We constructed twelve wordlists, which consisted of five wordlists of time conceptions and seven of fillers. Each wordlist had two to four expressions that were thematically related (e.g., “yesterday”, “today”, and “tomorrow”). In total, there were thirteen Mandarin temporal expressions (see Chapter 3, Appendix 3.1, p. 98).

The experiment was ostensibly set up as a study of speakers' short-term memory and addressees' long-term memory. All bimodal bilinguals and non-signers took the role of speakers to fulfil the word definition task in their native language, that is, spoken Mandarin (not in sign language). All participants were told that the task was in Mandarin and the addressees could only speak Mandarin Chinese. They were asked to remember each wordlist shortly after seeing it twice presented on screen. Then they had to tell and explain the words from each wordlist as explicitly as possible to Mandarin-speaking addressees who could ask them clarification questions (for more details see the same method in Chapter 2). The addressees were told to remember speakers' descriptions for a later memory test. However, the latter test actually did not take place as they were confederates. The experiment was videotaped after obtaining participants' written consent. Gestures or CSL were not mentioned at any moment and debriefing responses revealed that participants had not realised that the study was about speakers' gestures or manual movements.

Gesture Coding

Co-speech temporal gestures were annotated in ELAN (Lausberg & Sloetjes, 2009). A first coder did an initial coding, viewing the entire video with the audio. The axes of gestures were coded as vertical, lateral, or sagittal, with an indication of the directionality of each axis (Casasanto & Jasmin, 2012; Chapters 2 and 3). Additionally, although bimodal bilinguals were speaking to non-signers, they might still produce a small proportion of signs (e.g., about 3%, Casey & Emmorey, 2009). CSL temporal signs were noted when they were identifiable lexical signs, or hand movements that a non-signer would unlikely produce (Casey & Emmorey, 2009; Casey, Emmorey, & Larrabee, 2012). Six CSL temporal signs (about 2.8%) were

detected and were excluded from the analyses (e.g., a temporal sign of “morning” was produced when the Mandarin word “morning” was uttered, that is, a movement of one hand starts with a palm down horizontally in front of the chest, with four fingers and thumb pinched, and the hand moves up slowly with fingers gradually opened, indicating the sky is lighting up).

Furthermore, the temporal words accompanying temporal gestures were transcribed. These could contain temporal words explicitly having vertical spatial references to “up” and “down” (e.g., 上周/shàng zhōu, *above week*, “last week”), sagittal spatial references to “front” (前/qián) and “back” (后/hòu) (e.g., 前年/qián nián, *front year*, “the year before last year”), or words without having such lexical cues (e.g., 昨天/zuótiān, “yesterday”). These temporal words were coded in three categories (vertical; sagittal; neutral).

In total, we obtained 719 temporal word-gesture tokens, including 212 from late bimodal bilinguals, and 507 from Chinese non-signers. The average number of gestures by bimodal bilinguals ($M = 21.2$) tended to be significantly higher than that of non-signers ($M = 14.9$), $t = 1.52$, $p = .067$ (one-tailed with a directional hypothesis). The pattern of increased gesture production for bimodal bilinguals compared to non-signers is in line with previous results for ASL-English bilinguals (Casey & Emmorey, 2009; Casey, Emmorey, & Larrabee, 2012).

The reliability of the annotation of the gestures was established by having 53% of the data coded by a naïve second coder. The two coders agreed on the gesture axes judgement on 92.31% of the tokens ($N = 380$), Cohen’s Kappa = 0.87 (referring to “Excellent” agreement). In cases of disagreement, the two coders discussed and reached agreement on the labels, and these consensus labels were used for the final analysis.

Statistical Analyses

A mixed multinomial logit model for panel data was used (Croissant, 2012) to compare the gesture proportion of three axes, with *group* (late bimodal bilinguals vs. Mandarin-speaking non-signers) as a main independent variable and *temporal gesture axis* (L; V; S) as a dependent variable. We started with the maximal random effect structure, including random intercepts and random slopes for the crucial independent variable *group*. However, the standard deviations of random slopes on *group* were insignificant, so the random slopes were not used in the final model. Given that previous research has shown that temporal words can have an influence on gestures (e.g., Chapter 2), we also controlled for the type of temporal words

accompanying temporal gestures (vertical; sagittal; neutral). To compare the direction of sagittal temporal gestures, a binary logistic regression for panel data was used, with group as a main independent variable and the direction of sagittal gestures (past-in-front or future-in-front) as a dependent variable. Both models have taken individual differences into consideration and dealt with the repeated observations from the same individuals.

4.3 Results and Analyses

4.3.1 Temporal Gestures on the Lateral, Vertical, and Sagittal Axes

As Figure 4.1 shows, late bimodal bilinguals displayed a different distribution of temporal gestures on the three axes than the non-signers. Specifically, non-signers performed 48.72% of the temporal gestures on the lateral axis whereas late bimodal bilinguals performed only 29.72% of gestures on the lateral axis. Instead, late bimodal bilinguals performed 37.26% of the temporal gestures on the sagittal axis and 33.02% on the vertical axis, which, respectively, was 16.75% and 2.25% more than those of non-signers.

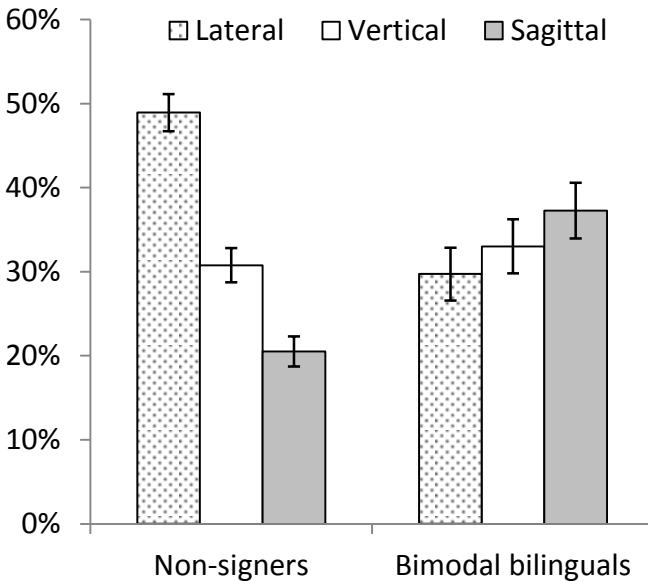


Figure 4.1. Distribution of temporal gestures on three axes by bimodal bilinguals and non-signers. Error bars show standard errors of the mean.

A mixed multinomial logit regression ($N = 719$) of gesture axes on group (baseline: vertical axis) showed that late bimodal bilinguals were significantly less likely to perform lateral temporal gestures ($t = -2.42, p = .016, \beta = -0.74$) but more likely to perform sagittal ones ($t = 4.13, p < .001, \beta = 1.98$) than the non-signers, controlling for the type of temporal words (vertical; sagittal; neutral) and age. The different distribution of axes between the two groups indicated that the production of temporal gestures can be influenced by the experience of learning temporal signs in CSL.

Additionally, as for the influence of the type of temporal words on temporal gestures, we found that participants were more likely to perform vertical temporal gestures when uttering vertical spatial metaphors for time than when uttering neutral temporal words, regardless of whether they were signers or non-signers, in that they would perform fewer lateral ($t = -10.21, p < .001, \beta = -2.89$) or sagittal temporal gestures ($t = -9.66, p < .001, \beta = -4.97$), controlling for group and age. Similarly, participants were more likely to produce sagittal temporal gestures when uttering sagittal spatial metaphors for time than when uttering neutral temporal words ($t = 2.26, p = .024, \beta = .87$). The results indicated that the concurrent temporal words also had an effect on the choice of temporal gesture axes.

4.3.2 Directionality of Sagittal Temporal Gestures

Focusing on the directionality of sagittal temporal gestures, non-signers performed about 49.04% of the sagittal temporal gestures with the past to the front and the future to their back (past-in-front/future-at-back gestures) and 50.96% with the future to the front and the past to the back (future-in-front/past-at-back gestures). However, the proportion of past-in-front/future-at-back gestures by late bimodal bilinguals was only 16.48%, and the proportion of future-in-front/past-at-back gestures was 83.52% (Figure 4.2).

A binary logistic regression ($N = 183$) of sagittal temporal gesture direction on group showed that late bimodal bilinguals performed a significantly lower proportion of past-in-front/ future-at-back temporal gestures than the non-signers, Wald $\chi^2(1) = 5.12, p = .024, \beta = -6.85, 95\% \text{ CI} = [-12.78, -.92]$, even after controlling for the type of temporal words co-occurring with gestures (vertical; sagittal; neutral). This indicated that after learning CSL, late bimodal bilinguals were more likely to have a future-in-front/past-at-back temporal orientation as visible in their sagittal temporal gestures.

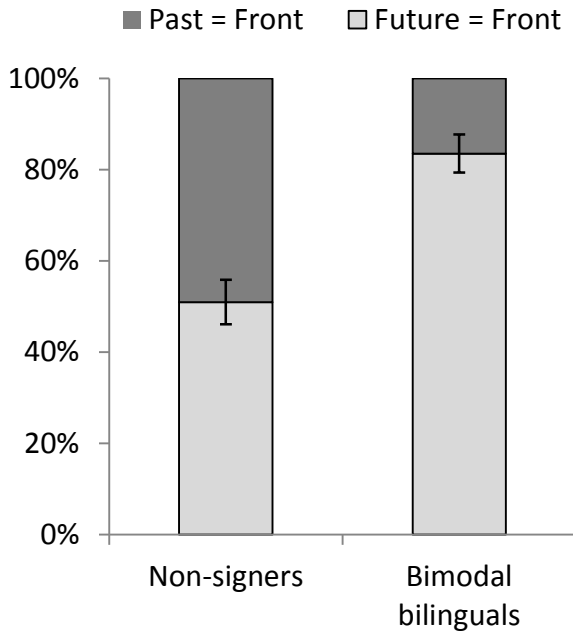


Figure 4.2. Orientation of sagittal temporal gestures by bimodal bilinguals and non-signers. Error bars show standard errors of the mean.

Furthermore, it has been claimed that Mandarin speakers' past-in-front temporal gestures are predominantly produced when speakers utter sagittal temporal words with past-in-front metaphors (e.g., *qián-tiān*/前天, *front day*, “the day before yesterday”) (Chapter 3; Lai & Boroditsky, 2013). For instance, in this study, when Mandarin-speaking non-signers uttered past-in-front metaphors, 72.34% of the sagittal temporal gestures were the past-in-front temporal gestures. However, in this case, the proportion by late bimodal bilinguals was only 22.22% (Figure 4.3), which was significantly smaller (Wald $\chi^2(1) = 54.16$, $N = 83$, $p < .001$, $\beta = -19.75$, 95% CI = [-25.01, -14.49]), and the majority of sagittal temporal gestures were instead produced according to the future-in-front mapping (77.78%). Thus, late bimodal bilinguals had a different direction of sagittal gestures than non-signers even when both groups were uttering the same overt past-in-front space-time metaphors (e.g.,

see Figure 4.4 and Figure 4.5). The results indicated that the experience of temporal signs influenced temporal gestures.

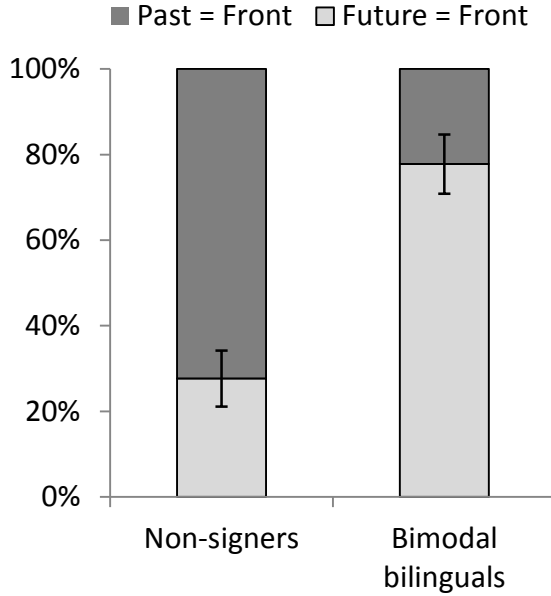


Figure 4.3. Orientation of sagittal temporal gestures accompanied by past-in-front temporal sagittal words. Error bars show standard errors of the mean.



Figure 4.4. Gestures of “this year”, “last year” and “the year before last year” in Chinese, by a Mandarin-speaking non-signer.

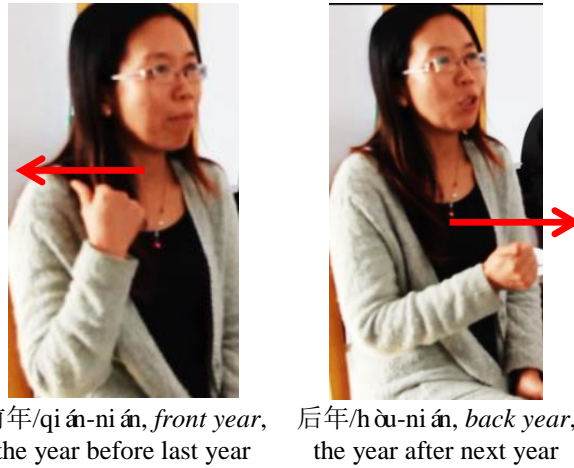


Figure 4.5. Gestures of “the year before last year”, and “the year after next year” in Chinese, by a late Mandarin-CSL bimodal bilingual.

4.4 Discussion

This study is the first that explored temporal gestures by bimodal bilinguals, and the first to look into effects of temporal signs on temporal gestures. Our results have shown that both Mandarin-speaking non-signers and Mandarin-CSL late bimodal bilinguals could perform spontaneous temporal gestures on the lateral, vertical, and sagittal axes. However, the two groups were significantly different in their use of temporal gestures on the three axes, as well as in their direction of sagittal temporal gestures. Although the results of this study were admittedly obtained based on a relative small number of bimodal bilinguals, these findings have a number of important theoretical implications.

First, our findings support the claim that there is an interconnection between the co-speech gesture production system and a sign language production system (Emmorey *et al.*, 2008). The few studies on this topic have mainly focused on the changes in gesture rate, character viewpoint, and handshape after learning American Sign Language (ASL). Although it has been observed in these studies that there was an increase of gesture rate in ASL learners, sometimes “these changes were not large enough to create significant group differences” in comparison to non-signers (Casey, Emmorey, & Larrabee, 2012) (Note in that study ASL learners had only one-year of ASL instruction). The present study, however, focusing on the study of temporal gestures, provides additional evidence that the knowledge and experience

of an L2 sign language can indeed impact the content and form of L1 co-speech gestures.

Second, these results point out that there may be cross-linguistic influences of the L2 on the L1 (e.g., Brown & Gullberg, 2008, 2011; Zou, 2012). Studies have shown that languages are co-activated in a bilingual mind (e.g., Van Hell & Dijkstra, 2002). For instance, there is an unconscious access to the sound form of Chinese words when Chinese-English bilinguals read or listen to English words (Wu & Thierry, 2010). Such cross-language interactions can even occur across modalities (e.g., Emmorey *et al.*, 2005; Giezen & Emmorey, 2016; Ortega & Morgan, 2015). For example, Morford (2010) found that ASL–English bilingual deaf readers activate the ASL translations of written words in English even when the task does not explicitly require the use of ASL. Recent ERP research also reveals that there is an implicit co-activation of ASL in deaf readers (Meade, Midgley, Sevcikova Sehyr, Holcomb, & Emmorey, 2017). In our study, late bimodal bilinguals produced significantly more sagittal temporal gestures than non-signers. Given that CSL mostly makes use of the sagittal spatial metaphors for time (Zheng, 2009), a speculative explanation for the result can be that even when Mandarin is the target language for production, the detailed spatial information for temporal expressions in CSL is still activated, which may prime the action production system that generates temporal gestures (Casey & Emmorey, 2009).

One possible concern is that these manual movements produced by bimodal bilinguals were not co-speech gestures but CSL signs. This is quite unlikely because even native bimodal bilinguals only produce very few signs when interacting with non-signers (e.g., only 3%, Casey & Emmorey, 2009), and in our study participants were late bimodal bilinguals and their signs have been excluded in the analyses. Additionally, it was also visible by the number of fingers in the gestures. For example, the concept of “the day before yesterday” in CSL is expressed by the use of the index and middle fingers to point to the back once, whereas the gestures we obtained did not show such a pattern.

Furthermore, our results also suggest that the acquisition of a signed language may have an impact beyond the nature of gestures that accompany the native spoken language (cf. Casey, Emmorey & Larrabee, 2012; Emmorey, Giezen, & Gollan, 2016). For instance, an intriguing result is that Mandarin-CSL late bilinguals were highly unlikely to perform past-in-front/future-at-back temporal gestures as opposed to Chinese non-signers who would often do so. In other words, the future-in-front/past-at-back mappings were activated to a greater extent in bimodal bilinguals than in Mandarin non-signers. Strikingly, even when the sagittal temporal gestures

were accompanied by the sagittal past-in-front words, a situation in which the gesture direction would most likely be influenced by the uttering of such overt words, late bimodal bilinguals still rarely directed the past to their front. If spontaneous gestures are a visible embodiment of cognition (Alibali, 2005; Hostetter & Alibali, 2008) which provide a window into people's mental space-time mapping (e.g., Casasanto & Jasmin, 2012; Cienki, 1998; Núñez & Sweetser, 2006; Walker & Cooperrider, 2016), it is likely that learning CSL changes Mandarin speakers' conceptualisations of space-time mappings.

Such differences in sagittal space-time mappings may be explained in terms of differences in time perspective-taking¹⁶, related to two possible systems of space-time metaphor in language. There are two types of time perspectives, i.e., moving-ego and moving-time (e.g., Moore, 2011; Núñez, Motz, & Teuscher, 2006; Walker, Bergen, & Núñez, 2017). When a person takes an ego-moving perspective, s/he moves forward in the timeline, from past to future, e.g., "We look *forward* to the future *ahead*". When that person takes a time-moving perspective (e.g., "Christmas is coming"), s/he still faces the future, but time is conceived of as a river or conveyor belt on which events are moving from the future to the past (Gentner, Imai, & Boroditsky, 2002). In this perspective, the *front* of a timeline can be assigned to a past (earlier) event (e.g., in the timeline May is before (in front of) June).

According to previous studies, English speakers usually take an ego-moving perspective, whereas Mandarin speakers mostly take a time-moving perspective (e.g., Gentner, Imai, & Boroditsky, 2002; Xiao, Zhao, & Chen, 2017; Yu, 2012). For example, Mandarin-English speakers were influenced by the English time perspective even when they were speaking Mandarin, such that Mandarin-English speakers were less likely to take a time-moving perspective than Mandarin monolinguals (Lai & Boroditsky, 2013). Similarly, given that signers of CSL mainly take the ego-moving time perspective (the deictic of time in CSL is moving ego, Wu & Li, 2012), late bimodal bilinguals may be influenced by the CSL time perspective even in a non-signing context.

¹⁶ One reviewer pointed out that the cross-linguistic differences in time-space mappings are unlikely raised from the moving-ego vs. moving-time perspectives. When an ego is involved in the timeline, in both perspectives, the future is ahead and the past is behind; neither presents a scenario in which the past is ahead (because this would be characterised by a reverse moving time perspective, in which time moves from behind forward). More studies are needed to better understand the psychological realisation of Chinese sagittal space-time mappings.

One may further ascribe such differences in spatio-temporal reasoning to the different uses of spatial metaphors for time between Mandarin Chinese and CSL, given that Mandarin Chinese contains both lexicon words suggesting future-in-front/past-at-back and past-in-front/future-at-back space-time mappings, whereas the sagittal lexical signs of CSL do not show this variation as they represent only future-in-front/past-at-back space-time mappings (Wu & Li, 2012; Zheng, 2009). For instance, a recent study has shown that Chinese deaf signers display a different spatio-temporal reasoning than Mandarin speakers. Specifically, participants were asked to fulfil a Mandarin temporal performance task, in which they had to label the Mandarin past and the future concepts in front-back space. The results revealed that CSL deaf signers with higher Mandarin proficiency were more likely to perform past-in-front/future-at-back space-time mappings than signers with lower Mandarin proficiency (it will be discussed in Chapter 5).

Given that a body of evidence has shown that space-time metaphors can influence people's mental representation of time (e.g., Boroditsky, 2000, 2001; Bylund & Athanasopoulos, 2017; Hendricks & Boroditsky, 2017), it is plausible that the learning of cross-modal spatio-temporal metaphors of CSL can also impact learners' time conceptualisations. For instance, Mandarin-CSL bilinguals "learn" to reconstruct the sagittal mental space-time mappings with the "past-at-back/future-in-front" as the dominant mappings.

Then the question is raised as to whether the differences in sagittal space-time mappings between Mandarin speakers and late bimodal bilinguals were merely due to bimodal bilinguals' learning of an L2 (having a different space-time metaphor than Mandarin). If this were the case, we would expect that Mandarin-English bilinguals may also have a similar change in space-time mappings as revealed by their co-speech gestures (since English, like CSL, usually also does not use past-in-front mappings). However, previous studies did not show such a pattern (e.g., Fuhrman *et al.*, 2011; Gu, Hoetjes, & Swerts, in preparation), so that one can raise the question why Mandarin-English bilinguals still perform a large proportion of "past-in-front" temporal gestures while speaking Mandarin.

Apart from the possible influence of the L2 proficiency, this could be due to the fact that in English, these metaphoric gestures are not "learned" like CSL signs or emblematic gestures. Temporal conceptions are spatially more iconic in a signed language than a spoken language (e.g., CSL vs. English), as temporal signs are visually and physically salient in the signing movements. The acquisition of sign language requires the learner to linguistically make distinctions based on movement (Emmorey *et al.*, 2009), and can enhance one's visual-spatial ability. For instance,

habitual use of ASL may lead to enhanced memory for object orientation (Emmorey *et al.*, 1998). Therefore, if one learns a sign pointing to the back for the conception of past and keeps on signing like this on and on, day in and day out, it is imaginable that the person can form a habitual mapping of the past to the back. This is also in line with the *body-specificity hypothesis* (Casasanto, 2009) that particular patterns of bodily experience can give rise to corresponding habits of thinking, perceiving, and acting (Gibbs, 2003).

Furthermore, signs can be regarded as a special kind of action, representing the world linguistically by use of space whereas gestures are also claimed to generate from the same process that generates actions (Calbris, 2003; Chu & Kita, 2016; Kita & Özyürek, 2003; Streeck, 2009). Gestures can be regarded as *simulated actions* (Hostetter & Alibali, 2008), which have no physical consequence on the real world but share some properties with actions. Therefore, gesture and sign to some extent share the same action production system (e.g., Emmorey *et al.*, 2008). The *Gesture-for-conceptualisation hypothesis* proposes that performing actions or gestures can activate and change one's spatial thinking (Kita, Alibali, & Chu, 2017). We believe that signing, a special kind of action in space, may also activate and change one's spatial thinking. For example, when bimodal bilinguals are signing about abstract ideas (e.g., time), the spatial movements of their hands may activate different spatio-motoric information from that of non-signers, which may affect bimodal bilinguals' spatial thinking in the long run. Given that people use space to think about time (e.g., Casasanto & Boroditsky, 2008), a different/new spatial thinking may consequently bring certain changes in space-time mappings, as shown in bimodal bilinguals' temporal gestures. Thus the results of this study appear to show an effect of (sign) language on thinking about time within a culture (Boroditsky, 2001; Chapter 5).

Alternatively, the results could be explained by the possibility that signing in a manner consistent with a past-at-back/future-in-front frame of reference primes bimodal bilinguals to gesture in a similar manner. This possibility is consistent with the proposal of *Gesture as Simulated Action* (Hostetter & Alibali, 2008): The activation of the motor system according to the spatio-temporal mapping via CSL may have primed the activation of the gesture system on a similar axis, which results in the effects observed in this study. This priming does not necessarily indicate that the bimodal bilingual's actual representations of time have changed, unlike the neo-Whorfian account that mentioned above (Nevertheless, this priming possibility is

harder to reconcile with the findings concerning the relationship between the directionality of gesture and verbal expressions)¹⁷.

Furthermore, one can even argue that co-speech temporal gestures do not necessarily reflect one's online conceptualisations of time, because they may only reveal speakers' implicit space-time mappings. Given all the above, future studies can use non-linguistic tasks (e.g., Fuhrman & Boroditsky, 2010; Fuhrman *et al.*, 2011) to further examine this in bimodal bilinguals of different signing proficiency.

Finally, the study provides a better understanding on the variation of the production of temporal gestures. Previous studies have shown that temporal gestures can be shaped by the reading and writing direction (e.g., Casasanto & Jasmin, 2012; Cooperrider & Núñez, 2009; Walker & Cooperrider, 2016), linguistic space-time metaphors (Chapters 2 and 3; Lai & Boroditsky, 2013), cultural specific belief (Núñez & Sweetser, 2006), use of cardinal frame of references (Boroditsky & Gaby, 2010), and geographical environments (Núñez *et al.*, 2012).

This study, on the one hand, showed that temporal gestures can be shaped by the accompanying words that happen to be uttered, e.g., vertical/sagittal temporal words can lead to more vertical/sagittal temporal gestures. On the other hand, with a comparison between Mandarin-CSL late bilinguals and Mandarin-speaking non-signers, we discovered that temporal gestures can be affected by people's bodily experience of sign language which may influence CSL users' spatio-temporal thinking. Note that such differences in gesture production were unlikely due to the lexical effect of Mandarin temporal words, because both groups were speaking in the same L1 and the differences still existed even when the uttered words were identical. Therefore, the different temporal gestures may be due to their different thinking of using the body to interact with the physical environment (spatio-motoric thinking, Kita, 2000) to represent time in space. Overall, all this evidence suggests that the ultimate production of temporal gestures is a result of the linguistic words and the metaphoric spatio-motoric thinking (cf. Kita & Özyürek, 2003; Özçalışkan, 2016; Özçalışkan, Lucero, & Goldin-Meadow, 2016).

4.5 Conclusion

In this study we examined whether the experience of CSL influences the production of co-speech gestures about time in late bimodal bilinguals. The results showed that hearing people who have learned CSL performed differently in temporal gesture production than Mandarin speakers, both in terms of relative proportion of three

¹⁷ We thank one anonymous reviewer for pointing out this alternative possibility.

time axes, and of the temporal orientation of sagittal gestures. Based on the mechanism of a shared production system between gestures and signs (Emmorey *et al.*, 2008), and the *Gesture-for-conceptualisation hypothesis* (Kita, Alibali, & Chu, 2017), we believe that the learning of a signed language can not only have an impact on the nature of co-speech gestures but may also exert an influence on users' spatio-motoric thinking and their abstract reasoning such as space-time mappings. Although the study of space-time mappings in CSL has been somewhat neglected in the literature, this study could provide a first insight into a cross-modal influence of space-time metaphors on people's mental representations of time within a culture. Future research on this topic can adopt non-linguistic methods to corroborate our findings.

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The future *ahead* is changing: The effect of Mandarin sagittal space-time metaphors on Chinese deaf signers' spatio-temporal reasoning

Abstract

Chinese Sign Language (CSL) uses different sagittal spatial metaphors to express time than is the case in standard Mandarin: Chinese signers use future-in-front/past-at-back space-time metaphors whereas Mandarin speakers additionally exploit past-in-front/future-at-back metaphors. This paper aims to find out whether such linguistic differences lead Chinese deaf signers to having a different time conceptualisation than Mandarin speakers, and whether acquiring Mandarin sagittal space-time metaphors influences signers' spatio-temporal reasoning. Using a temporal performance task (Experiment 1), we tested Chinese deaf signers' sagittal space-time mappings; using a clock question paradigm (Experiment 2), we examined their interpretation of a Mandarin sagittal space-time metaphor. Results of both experiments were compared with those of analyses of hearing Mandarin speakers. The results showed that Chinese deaf signers displayed a different spatio-temporal reasoning than Mandarin speakers. We observed effects both of CSL on deaf signers' space-time mappings and understanding of time, and of proficiency in Mandarin Chinese. Signers with higher Mandarin proficiency were more inclined to interpret the Mandarin space-time metaphor as Mandarin speakers did. We also provide evidence that signers gradually establish the past-in-front mappings as a function of an improved Mandarin proficiency. These findings show the *cross-modal* influence of language on thought *within a culture*, which also have practical implications for linguistic education to the deaf.

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5.1 Introduction

It appears universally true that people use spatial representations to conceptualise time (e.g., Boroditsky, 2000; Bottini *et al.*, 2015; Casasanto & Boroditsky, 2008; see reviews by Bender & Beller, 2014; Núñez & Cooperrider, 2013). Most Westerners feel that the past is behind and the future is in front of them (e.g., Miles, Nind, & Macrae, 2010; Ulrich *et al.*, 2012). Such an intuition matches the human's experience of walking in a certain direction, which is usually forwarding to the front, so that the passed-by path is the past and the place ahead represents the future (e.g., Clark, 1973). Interestingly, in many languages, the future-in-front and past-at-back mappings are also reflected in the way speakers talk about time. For instance, in English, "We look *forward* to the New Year *ahead*, and look *back* to the hard times *behind*" (e.g., Calbris, 2008; Clark, 1973; Evans, 2004, 2013; Lakoff & Johnson, 1980; Traugott, 1978).

However, time and space can be differently mapped as well (e.g., Fuhrman & Boroditsky, 2010; Moore, 2014; Núñez, Cooperrider, Doan, & Wassmann, 2012; Sullivan & Bui). In particular, the way of conceptualising the past at the back and the future in the front does not generalise to all languages. For example, speakers of Aymara exhibit the opposite sagittal space-time mapping, with past things in front of them, and the future as yet unseen events behind them. This conceptual mapping is consistent with the way they produce co-speech temporal gestures, and with the spatial metaphors in their language, as "front year" in Aymara has the meaning of "last year" (Núñez & Sweetser, 2006).

Interestingly, Moroccans also have a strong tendency to place past events in front when explicitly instructed to do so in cognitive tasks, even though in Arabic the metaphoric expression of front/back time closely matches that of most future-in-front languages such as English and Spanish. It has been argued that the reason for Moroccans' past-in-front space-time mapping is related to the fact that, in their culture, tradition and old generations are more valued, and they are more past-focused (*temporal-focus hypothesis*, de la Fuente, Santiago, Román, Dumitrache, & Casasanto, 2014). According to this hypothesis, people who are past-focused metaphorically should have a tendency to place the past in front of them, "in the location where they could focus on the past literally with their eyes if past events were physical objects that could be seen" (p.1684). Thus space-time mappings in people's minds may also be conditioned by their cultural attitudes towards time (e.g., with a strong focus on past times and old generations), which could be independent from the space-time mappings expressed in language (de la Fuente *et al.*, 2014). Nevertheless, slightly different from what the *temporal-focus hypothesis* will predict,

recent research on Mandarin speakers shows that there is a combined effect of lexical cues to space-time mappings and a culture-specific temporal values on the spatialisation of time (Chapter 3).

Of course, space-time mappings can vary, depending on contextual influences and personal bodily experience (e.g., Santiago, Lup áñez, Pérez, & Funes, 2007; Saj, Fuhrman, Vuilleumier, & Boroditsky, 2014; Torralbo, Santiago, & Lup áñez, 2006). For instance, people's mental timelines can be reversed after brief exposure to mirror-reversed orthography (Casasanto & Bottini, 2014).

Despite the fact that a growing number of studies have shown that linguistic, cultural and individual differences have separate influences on people's spatial representation of time (e.g., Duffy, Feist, & McCarthy, 2014; Duffy & Evans, 2017), our knowledge on why some communities adopt future-in-front mappings whereas others use past-in-front mappings for time is still incomplete. An example in case is the spatio-temporal representation of time by deaf signers. Few studies have researched deaf signers' spatio-temporal reasoning, which, in the case of Chinese, would represent an interesting comparison group, as they share a similar culture as speakers of Mandarin Chinese, but use a language which exploits different front-back time-space mappings (see below). The present study aims to investigate the effect of such cross-linguistic influences on Chinese deaf signers' sagittal space-time mappings and examine whether deaf signers have a different spatial-temporal reasoning than Mandarin speakers.

5.1.1 Background

A Brief Introduction to Chinese Sign Language

Given that China has about 20.04 million deaf people (National Bureau of Statistics China, 2006), sign language plays a vital role in the communication among members of the deaf community. The Chinese Sign Language family includes the sign languages used in mainland China (CSL) and the Hong Kong Sign Language (HKSL) (Fischer & Gong, 2010). Similar to what is the case for spoken Chinese, CSL also has different dialects such as the northern (Beijing) CSL and the southern (Shanghai) CSL, which sometimes can even be mutually unintelligible (Yang, 2005). The main differences between the CSL variations are at the lexical level (Gong 2009; Lin, Gerner de Garc ía, & Pichler, 2009). That is, local deaf people create lexical signs (e.g., names of objects, colours, numbers, and kinship terms) in different sign representations of the same meaning (Yang, 2015).

HKSL is historically a variety of the southern CSL dialect, but it has developed into an independent sign language. The Taiwan Sign Language (TSL) is more

related to Japanese Sign Language and Korean Sign Language, which belong to the Japanese family (Fischer & Gong, 2010). And then there is the Tibetan Sign Language (TibSL), used in the Tibet area of China, which is vastly different from CSL (Li, Wu, & Wugenzhuoga, 2013).

The China Association of the Deaf has been making efforts to unify and standardise CSL since the late 1950s by publishing an authorized dictionary, (Standard) Chinese Sign Language (*zhong-guo shou-yu*) (China Association of the Deaf and Hard of Hearing, 2003), which is widely used in education, on television and by interpreters in China. It is important to point out that there are different Chinese sign languages, as we will only be dealing in this study with one variety, namely the Standard CSL.

Below we first present some background information on space-time metaphors in Mandarin, including speakers' gestures about time conceptions, and then we explain concepts related to space and time in Chinese Sign language.

Mandarin Space-time Metaphors and Temporal Gestures

Similar to other languages, Mandarin Chinese also has spatial language to metaphorically represent time. The most well-known one is the employment of vertical spatial metaphors of “上/shàng” (literally “above”) and “下/xià” (literally “below”) to indicate time conceptions of “early” and “late”. For example, “上周/shàng zhōu” (literally “above week”) means “last week”, while “下周/xià zhōu” (literally “below week”) refers to “next week”.

Interestingly, the use of spatial metaphors for time can also be linked to how people metaphorically gesture about time (*temporal gesture*) (e.g., Casasanto & Jasmin, 2012; Cienki, 1998; Cooperrider & Núñez, 2009). Despite the fact that quite a large proportion of temporal gestures are produced along the lateral axis, it has been shown that Mandarin speakers employ a vertical axis as well to gesture about time, as they tend to spontaneously point *upwards* for the time conception of “last week” and *downwards* for “next week” (Chapter 2), which is in line with the spatial language mentioned above.

Additionally, Mandarin speakers often use sagittal spatial metaphors for time. For example, some Mandarin metaphors can suggest future-in-front/past-at-back space-time mappings, while some other sagittal spatial metaphors for time can

linguistically represent the reverse, so with past-in-front and future-at-back mappings (see Chapter 4, p.105, Table 4.1, Examples (1) and (2), respectively)¹⁸.

As for the spatial metaphors implying past-in-front and future-at-back mappings, it is common that the expressions of the temporal conceptions of “past” and “future” contain lexical references to sagittal space, such as “前/qián” (literally “front”) and “后/hòu” (literally “back”). Such a space-time word as “前/qián” can indicate both the spatial concept of “forward/front” and the temporal concept of “early/before”, whereas “后/hòu” indicates both the spatial concept of “back/behind” and the temporal concept of “late/after”¹⁹. In this way the space-time words suggest past-in-front/future-at-back spatial metaphors to express time.

Mandarin speakers can also perform sagittal gestures to express time. In terms of the directionality of sagittal gestures, in addition to the “common” temporal gestures that point the past to the back of the body, a Mandarin speaker can point to the front of the body to refer to the concept of temporal “before”, as observed from one participant in a case study (Chui, 2011). Recent quantitative research on Mandarin speakers’ gestures further reveals that about half of sagittal temporal gestures (49%) were produced with the future behind and the past in front of the speakers (Chapter 3). Such past-in-front/future-at-back gestures are quite peculiar, as they have only been reported for Aymara (Núñez & Sweetser, 2006).

Furthermore, the majority of past-in-front/future-at-back gestures were accompanied by sagittal wordings of past-in-front/future-at-back space-time metaphors. Partially due to this lexical effect, some Mandarin speakers even explicitly report to believe the future to be positioned behind and the past in front of them (past-in-front space-time mapping) (Chapter 3).

¹⁸ According to Yu (2012) and Xiao, Zhao, and Chen (2017), Example 1 is classified as an ego-reference-point metaphor (future-in-front-of-ego), and Example 2 is classified as a time-reference-point metaphor (earlier-times-in-front-of-later-times).

¹⁹ Note that it is rather rare to use “前/qian” (front) to indicate “late/after” and “后/hou” (back) to indicate “early/before”. For instance, according to a corpus survey, only 2.75% of temporal use of “后/hou” refers to “early/before” (Peng, 2012). Additionally, in Mandarin, “前/qian” and “后/hou” are the *only* words for the purely spatial use of “front” and “back”. They are different from English “before” and “after” that are widely used as temporal expressions but rarely used as pure references to space (Casasanto, 2016) (of course, one can find a counterexample like “The priest stands before the altar”). Instead, English “front/back” and “ahead/behind” are more often used to refer to the space of “front” and “back”.

Given that gestures and signs can both be considered cases of spatial manual movements to express meaning, it would be interesting to survey how signers use space to indicate time conceptions.

Time, Space and Signs in Chinese Sign Language

Sign language users also tend to use spatio-temporal metaphors to express the concept of time (e.g., Nilsson, 2016; Wilcox, 2002). They mainly use the sequence timeline and the deictic timeline. The sequential timeline is parallel to signers' body and extends laterally (e.g., from left to right in American Sign Language, ASL), representing earlier to later time periods. It is used when signers refer to a sequence of ordered events that are unrelated to the utterance time (Emmorey, 2001). Similarly, in CSL, Zheng (2009) finds that users of CSL are consistent in listing events from the left to the right that happened at different time periods.

As for the deictic timeline, signers' bodies are often referred to as a deictic reference point of timeline, such that "now" is often associated with locations near the signers, and the future is signed to the front of their bodies and the past to the back (see a review in Sinte, 2013), e.g., ASL (Emmorey, 2001), Sign Language of the Netherlands, NGT (Schermer & Koolhof, 1990), French Sign Language (Maeder & Loncke, 1996), Spanish Sign Language (Cabeza Pereiro & Fernández Soneira, 2004) and CSL (Wu & Li, 2012; Zheng, 2009).

There are few studies having mentioned the existence of a vertical timeline²⁰. A rare case found in NGT is that days of the week are signed vertically, with Monday at the top and Sunday at the bottom of the line (Schermer & Koolhof, 1990). The reverse is found in Tibetan Sign Language (TibSL) (Li, Wu, & Wugenzhuoga, 2013). TibSL *commonly* makes use of the vertical timeline such as the verticality of a signer's head is used to sign the days of the week (Sunday is signed at the top of the head, Monday the forehead, Tuesday around the eye region, Wednesday the ear, Thursday the nose, Friday the mouth and Saturday the chin, Standard Tibetan Sign Language Dictionary, 2011, p.433-435).

CSL also exploits the vertical timeline and makes use of vertical spatial metaphors to represent time, in this sense being quite similar to Mandarin Chinese. For instance, both in Shanghai CSL and Northern CSL the temporal conceptions of "future" can be signed "downwards" (Wu & Li, 2012; Zheng, 2009). In the standard

²⁰ We only discuss the three most common timelines here. There are more timelines in some sign languages, e.g., NGT has five timelines, for more details see a review in Sinte (2013).

CSL dictionary, the sign of “year” goes from up to down, and the sign for “提前/tí qián” (shifting to an earlier time) is moving up (China Association of the Deaf and Hard of Hearing, 2003, Figure 5.1).

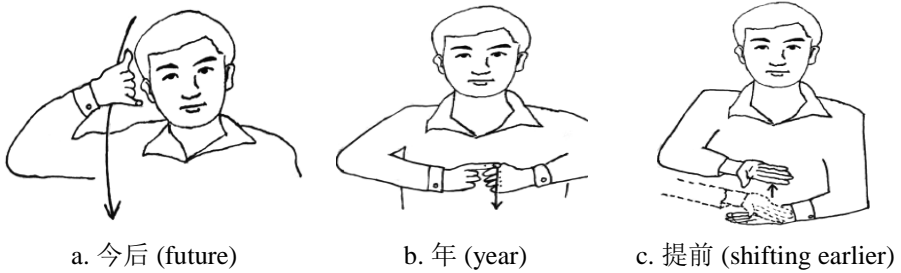


Figure 5.1. Lexical signs for “future”, “year”, and “shifting to an earlier time”.

Interestingly, there are dramatic *differences* in the deictic sagittal timelines between CSL and Mandarin Chinese. As stated above, Mandarin Chinese contains both future-in-front/past-at-back space-time mappings and past-in-front/future-at-back mappings. However, the sagittal lexical signs of CSL do not show this variation, as they represent *only* future-in-front/past-at-back space-time mappings, which is different from Mandarin Chinese (see examples in Figure 5.2, 5.3 and 5.4). For instance, the signs for past time conceptions such as “yesterday” and “the past” are directed to the back (Zheng, 2009) whereas the signs for future time conceptions such as “in a moment” and “future” are directed to the front of a signer (when signing on the sagittal axis) (Wu & Li, 2012).



Figure 5.2 过去/guò-qù “past”, signed by a CSL user



Figure 5.3 昨天/zūó-tiān, “yesterday”, signed by a CSL user

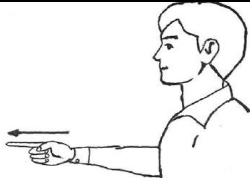





Figure 5.4 前天/qián-tiān, *front day*, “the day before yesterday”, signed by a CSL user

The fact that sagittal space-time mappings differ between CSL and Mandarin may be related to the different use of sagittal spatial metaphors for time. In Mandarin “前/qián” and “后/hòu” are the only words expressing the purely spatial concept of “front” and “back”, but they also actively have the temporal concepts of “before/past” and “after/future”, thus indicating past-in-front/future-at-back mappings. In CSL, however, there are no such past-in-front/future-at-back mappings, because the spatial “front” and the temporal “before” (also “back” and “after”) are signed differently. Specifically, the signs representing “front” and “back” are only

used for the spatial concept of “front” and “back”, whereas on the sagittal axis the temporal concepts of “before/past” and “after/future” are signed towards the “back” and “front”, respectively (e.g., China Association of the Deaf and Hard of Hearing, 2003; Zheng, 2009).

Table 5.2. Differences between Mandarin Chinese and CSL in sagittal space-time metaphors.

	<u>Mandarin Chinese</u>	<u>CSL</u>
Space: Front	前面 (<i>front surface</i>)	 <p>One hand, with the index finger extended, <i>points to the very front.</i></p>
Time: The day before yesterday	前天 (<i>front day</i>)	 <p>The index and middle fingers <i>point to the back</i> once.</p>
Space: Back	后面 (<i>back surface</i>)	 <p>One hand, with the index finger extended, points to the <i>back</i> of shoulder.</p>
Time: The day after tomorrow	后天 (<i>back day</i>)	 <p>The index and middle fingers <i>point forward.</i></p>

For instance, as shown in Table 5.2, the time conceptions of “the day before yesterday” and “the day after tomorrow” in Mandarin are expressed in a completely reversed manner from what is the case in CSL (Wu & Li, 2012; Zheng, 2009). That is, in Mandarin the direction of “the day before yesterday (前天/qián-tiān, *front day*)” is literally to the front and “the day after tomorrow (后天/hòu-tiān, *back day*)” is literally to the back, which is also reflected in the way Mandarin speakers gesture spontaneously when referring to time (Chapter 3). By contrast, in CSL the temporal sign of “the day before yesterday” is signed to the back and the temporal sign of “the day after tomorrow” is signed to the front (Zheng, 2009).

In short, Mandarin Chinese and CSL both make use of spatial metaphors for time²¹. The main differences seem to be in the direction of the sagittal timeline, in that CSL does not have past-in-front/future-at-back linguistic space-time mappings, whereas Mandarin allows both future-in-front/past-at-back and past-in-front/future-at-back mappings (Table 5.3).

Table 5.3. A comparison of main time lines between Mandarin Chinese and CSL.

	Mandarin Chinese	CSL
<u>Lateral axis</u>		
Left = Earlier/Past; Right = Later/Future	Yes ²²	Yes
<u>Vertical axis</u>		
Up = Earlier/Past; Down = Later/Future	Yes	Yes
<u>Sagittal axis</u>		
Front = Later/Future; Back = Earlier/Past	Yes	Yes
Front = Earlier/Past; Back = Later/Future	Yes	<i>No</i>

²¹ Past or future events can also be expressed with the use of tense in many languages. However, verbs in CSL do not have tense, similar to Mandarin Chinese. Although there is a possibility of signing a particle to indicate events that have happened (完了/wán-le, have ended) in CSL, the signs for verbs are the same no matter whether the event happened in the past or will happen in the future. For example, the sign for “ask” in “asked in the past” does not differ from that of “will ask in the future” (Zheng, 2009).

²² Left-right spatio-temporal metaphors are actually absent from Mandarin speech except that when talking about “being earlier/later than a certain time point (around that time)”, e.g., around one o’clock” can be said as “一点左右”/yī-diǎn zuo-yòu, literally “one o’clock left right”. However, Mandarin speakers do make use of the lateral time axis as shown by their temporal gestures. This lateral axis is likely due to the reading/writing direction (see discussions, in e.g., Casasanto & Jasmin, 2012).

5.1.2 The Current Study

Given the cross-linguistic differences in sagittal spatial metaphors for time between Mandarin Chinese and CSL, the current study is concerned with an investigation of sagittal space-time mappings in these two varieties. The motivation for the study firstly is to better understand how signers conceptualise time spatially, and more importantly to examine whether the language experience in one modality influences spatio-temporal reasoning in another language modality. In particular, we are interested to what extent such cross-linguistic differences across modalities in spatial metaphors for time affect deaf signers' conceptual space-time mappings over different Mandarin proficiency levels.

Previous studies have shown that languages are co-activated in a bilingual mind (e.g., Van Hell & Dijkstra, 2002). For instance, there is an unconscious access to the sound form of Chinese words when advanced Chinese-English bilinguals read or listen to English words (Wu & Thierry, 2010). Such cross-language interactions can even occur across modalities (Brown & Gullberg, 2008, 2011; Casey & Emmorey, 2009). For example, Morford (2010) found that ASL-English bilingual deaf readers activate the ASL translations of written words in English even when the task does not explicitly require the use of ASL. Recently, an ERP study also shows that there is an implicit co-activation of ASL in deaf readers (Meade, Midgley, Sevcikova Sehyr, Holcomb, & Emmorey, 2017).

Furthermore, signs can be regarded as a special kind of action in space, given that they can be seen as linguistic expressions that involve the use of space. Signing may also activate and change one's spatial thinking (Emmorey *et al.*, 1998), which in turn may influence one's spatialisation of time given that people use space to think about time (Chapter 4). For instance, if a signer performs a sign pointing to the back for the conception of past and keeps on signing like this for years, it is imaginable that the signer can form a habitual mapping of the past to the back. This is also in line with the *body-specificity hypothesis* (Casasanto, 2009) that particular patterns of bodily experience can give rise to corresponding habits of thinking, perceiving, and acting (e.g., Gibbs, 2003).

Therefore, it is interesting to study whether the differences in sagittal space-time metaphors between Mandarin Chinese and CSL cause Chinese deaf signers to have an understanding of time that differs from that of hearing Mandarin speakers. Additionally, we aim to find out, in the context of Chinese culture, whether the acquisition of cross-modal sagittal spatial metaphors (in particular, learning about the way time is expressed linguistically in standard Mandarin) leads Chinese deaf signers to change their sagittal spatio-temporal reasoning, given that

learning/speaking a new category of spatial-temporal metaphors may influence one's mental representation of time (Boroditsky, 2001; Bylund, & Athanasopoulos, 2017; Hendricks & Boroditsky, 2017).

Against this background, it is particularly worthwhile to investigate how Chinese deaf signers (who know written Mandarin) interpret the Mandarin space-time words “前/qián” (meaning spatial “front” or temporal “before”) and “后/hòu” (meaning spatial “back” or temporal “after”). Given that these Mandarin space-time words can express both space and time, CSL deaf readers can activate the CSL translation of these written Mandarin words in two ways: (1) activating the spatial signs in CSL, which is consistent with Mandarin spatial concepts (*front* and *back*); (2) activating the temporal sign of “before/past” and “after/future” in CSL, which can be reversed in sagittal direction in comparison to the front and back spatial signs (as shown in Table 5.2). It is reasonable to assume that the first activation may be more dominant than the second one, as the latter may be cognitively more demanding owing to the cross-linguistic differences, especially for deaf signers with relatively lower Mandarin proficiency.

To this end, we have conducted three experiments: in Experiment 1 a temporal performance task was used to examine Chinese deaf signers' and Mandarin speakers' sagittal space-time mappings; in Experiment 2 a clock question was used to explicitly test how Chinese deaf signers and Mandarin speakers interpreted the sagittal space-time word “前/qián” (spatial “front” or temporal “before”); in Experiment 3, a replication study of the control groups in Experiments 1 and 2 was conducted, mainly to see to what extent findings obtained through a between-subject design would hold in a within-subject design.

5.2 Experiment 1: A Temporal Performance Task

In Experiment 1, participants did a temporal performance task (known as *temporal diagram task*, see de la Fuente *et al.*, 2014), which has also been adapted and used in the study presented in Chapter 3. This paradigm has been used in previous studies to assess people's mental space-time mappings across cultures (e.g., de la Fuente *et al.*, 2014; Li & Cao, 2018). If the linguistic differences in sagittal space-time metaphors between CSL and Mandarin Chinese lead Chinese deaf signers to having a different time conceptualisation (i.e., different activations of the spatial *front* or temporal *before*) than Mandarin speakers, we expect that deaf signers and hearing Mandarin speakers may have different sagittal space-time mappings. Furthermore, within the deaf community, if acquiring Mandarin sagittal space-time metaphors influences

signers' spatio-temporal reasoning, we expect an effect of Mandarin proficiency on deaf signers' sagittal space-time mappings.

5.2.1 Method

Participants

52 participants, including 15 deaf signers and 37 Mandarin-speaking non-signers, took part in the experiment in Rizhao, China. The 37 non-signers came from Rizhao (15 females and 22 males, $Mean_{age} = 33.4$, $SD = 7.4$), who had no reported hearing deficits and no experience of CSL. These non-signers were participants in Experiment 2 of Chapter 3 (past-in-front word metaphor condition), whose data were used in the present study as comparison materials.

The 15 deaf signers (8 females and 7 males; $Mean_{age} = 17.6$, $SD = 2.8$) were from Rizhao Special Education School, who all became deaf at an early age: Seven were born deaf; four became deaf before 12-month old, three between 24 months to 48 months, and one at 60 months. The average hearing loss was moderate-severe, as reported by the deaf signers themselves and their teacher ($M = 3.8$, 1-slight, 2-mild, 3-moderate, 4-moderately severe, 5-severe, 6-profound). None of them reported to have any other health problems except for one participant who had a heart disease.

The deaf participants mainly came from families with a modest income ($M = 2.87$, $SD = .74$, 1-very low, 2-low, 3-modest, 4-high, 5-very high). Their parents generally had a low education level ($M = 1.6$, $SD = .51$, 1-primary school, 2-middle school, 3-high school, 4-vocational college, 5-university).

Deaf participants were all users of home sign or sign language dialects before school education. They were fluent users of standard CSL with a mean of 6.9 years' CSL experiences. Their CSL proficiency level was very high: $M = 9.26$, $SD = 1.03$, as assessed by their teacher on a 10-point scale. They studied in different grades at the school ($M = 7.5$, grade range 4-9). Deaf participants also learned written Mandarin at school, and they had to do their daily course assignments such as Math in written Mandarin. Permission was granted to the investigators to have access to the participants' Mandarin Chinese examination scores from the record of their last end-term exam. All participants signed a consent form to participate in the study, and after all the tasks they were given a small token of appreciation.

Materials and Procedure

Participants sat at a table and saw (from above) a toy doll (named Xiaoming) with one box behind and one box in front of it. Participants and the character faced the same sagittal direction (see the same paradigm in Figure 3.5, p.74, Chapter 3).

Participants were provided with a written Mandarin instruction in which they could read that *the day before yesterday* (前天/*qián-tiān*, “front day”) Xiaoming went to visit a friend who liked eating apples, and *the day after tomorrow* (后天/*hòu-tiān*, “back day”) he would be going to visit a friend who likes eating pears (or vice versa). Participants were given an apple and a pear and were instructed to put the *apple* in the box that corresponded to the *past* (以前/*yǐ-qǐán*, “to front”) and the *pear* in the box that corresponded to the *future* (今后/*jīn-hòu*, “now back”). The mentioning order of the “apple” and “pear” and the way they were paired with “the day before yesterday” and “the day after tomorrow” were counterbalanced.

Following the procedure in Chapter 3, with a written instruction, we instructed participants to perform the task with real entities rather than doing it on paper (cf. de la Fuente *et al.*, 2014; Li & Cao, 2018) to minimise the potential projection of Chinese vertical timelines into a sagittal one (as Chinese can conceptualise time vertically, mapping the “up” and “down” to the time conceptions of “early” and “late”, e.g., Boroditsky 2001; Chapter 2). Each participant did the task individually in a quiet room, and was accompanied by a teacher who did not interfere with the task itself. Participants were tested in Rizhao, China, and all instructions were not in sign language but in written Mandarin Chinese.

Data and Measurements

In total, data of 51 participants were used in the analysis (data from a fourth-grade signer were excluded as she was helped during the task). As for the comparison between the deaf and hearing participants, participants’ *group* (signers and non-signers) was defined as an independent variable. The dependent variable was the participants’ *responses* towards space-time mappings (past-in-front or past-at-back), that is, the placement of the two fruit in the boxes.

Furthermore, focusing on the group of deaf participants, we looked into possible factors that may moderate the responses within the deaf signers. The first and most important factor was deaf participants’ Mandarin proficiency level. It was mainly measured by the school grade level in which a deaf signer was studying (*grade*), as a deaf signer studying in a higher grade was expected to have a higher Mandarin proficiency level than a signer studying in a lower grade (This was also confirmed by the Mandarin teacher of the deaf participants). Second, signers’ Mandarin examination score (*exam_score*) was used to supplement the proficiency measurement, albeit that the examination papers and intrinsic difficulty of tests were different across grades. Additionally, given that age can influence individual’s

sagittal spatial-temporal reasoning (de la Fuente *et al.*, 2014), we controlled for *age* as a possible factor as well. Participants' *hearing_loss* and their parents' deafness (*deaf_parent*) were also considered to be factors that may influence participants' space-time mappings.

5.2.2 Results and Discussion

42.9% of deaf participants responded according to the past-in-front mapping, placing the fruit representing the past event in front of the character and the fruit representing the future event behind it. The proportion of past-in-front mappings by hearing Mandarin participants was about 14% more than that by deaf signers (56.8% vs. 42.9%), but the differences did not reach a statistical significance, $\chi^2(1, N = 51) = .79, p = .37, \text{Odds Ratio} = 1.75, 95\% \text{ CI} = [.51, 6.06]$.

We did not find evidence for the hypothesis that the deaf participants as a whole would be significantly different than hearing participants. However, this might not be so surprising because these deaf participants studied in different grades and varied in their proficiency levels of Mandarin. Given the fact that there are differences between Mandarin Chinese and CSL in sagittal space-time metaphors, if the lack of past-in-front space-time metaphors in CSL also discourages deaf users of CSL to have past-in-front mappings, it would be more appropriate to explore whether *monolingual* deaf users of CSL would be different from non-signing Mandarin speakers. Practically, it is impossible to find a group of deaf signers who do not know any written Mandarin.

Therefore, in a regression model we tried to use the existing information of signers' Mandarin proficiency (*signer's grade* and *signer's Mandarin exam*) to simulate the difference between Mandarin-speaking non-signers and a hypothetical group of Chinese deaf signers who do not know any Mandarin (monolingual deaf signers). We defined an independent variable *Mandarin_speaker*: either the participant was a Mandarin speaker or a monolingual deaf user of CSL. The result showed that *Mandarin_speaker* was significantly positive ($\beta = 2.83, p = .000$), controlling for *age*, *signer's grade*, and *signer's exam score* (Table 5.4). This indicated that theoretically a Mandarin speaking non-signer would more likely perform past-in-front space-time mappings than a deaf user of CSL who knows no Mandarin.

Table 5.4. Comparisons between Chinese deaf signers and Mandarin speakers in the temporal diagram task.

pastfront	Coef.	t	P>t	[95% CI]	
signer's grade	.292	4.90	.000****	.172	.41
signer's exam score	.005	1.78	.082*	-.0007	.011
Mandarin_speaker	2.83	6.47	.000****	1.95	3.72
age	-.012	-1.17	.25	-.032	.008
constant	-1.88	-4.96	.000	-2.64	-1.12

Note: $R^2 = .19$, * $p < .1$, ** $p < .05$, **** $p < .01$.

Furthermore, when focusing on the deaf signer's group, we examined the relationship between deaf signers' Mandarin proficiency and their responses towards space-time mappings. The results of a binary exact logistic regression showed that the factor *grade* was significant ($\beta = 1.14$, $p = .014$, Odds Ratio = 3.61). Assuming that deaf signers studying in higher grades were likely to have higher Mandarin proficiency levels than deaf signers studying in lower grades, the effect of *grade* suggested that Chinese deaf signers' Mandarin proficiency levels played a role in shaping their sagittal space-time mappings. The effect was still significant ($\beta = .34$, $p = .031$) after controlling for the factors *deaf_parent*, *age*, *exam_score*, and *hearing_loss*. This showed that deaf signers studying in higher grades had a stronger tendency to perform past-in-front mappings, keeping all other variables constant.

Likewise, the results of the regression analysis also showed that *exam_score* was significantly influencing deaf signers' space-time mappings (Table 5.5), suggesting that those who had higher Mandarin exam scores were more inclined to perform past-in-front mappings ($\beta = .008$, $p = .075$ (two-tailed, we had a directional hypothesis, so the one-tailed value was $p = .038$), 95% CI = [-.001, .017]), *ceteris paribus*. The results indicated that Mandarin proficiency has an effect on deaf signers' space-time mappings, both between different grades and within a grade. In other words, despite the fact that there are only past-at-back spatio-temporal signs in CSL, deaf signers can establish the Mandarin past-in-front space-time mappings during their learning process of Mandarin Chinese.

Additionally, those deaf signers whose parents were deaf were less likely to perform past-in-front mappings ($\beta = -.48$, $t = -2.04$, $p = .075$ (two-tailed, but given that we had a directional hypothesis, the one-tailed value was $p = .038$), 95% CI = [-1.015, .062]), *ceteris paribus*. The results suggested that deaf parents may influence

deaf children's space-time mappings. Plausibly, as deaf children may often be exposed to the past-at-back temporal signs performed by their deaf parents, they may be more likely to have past-at-back space-time mappings than their counterparts with non-deaf parents who often have past-in-front mappings in Mandarin.

Table 5.5. Results of the temporal diagram task for Chinese deaf signers.

pastfront	Coef.	t	P>t	[95% CI]	
grade	.340	2.61	.031**	.0391	.641
exam_score	.008	2.04	.075 *	-.001	.017
age	-.047	-1.53	.163	-.119	.024
deaf_parents	-.477	-2.04	.075*	-1.015	.062
hearing_loss	-.051	-.37	.724	-.372	.270
constant	-1.52	-4.38	.002	-2.32	-.722

*Note: $R^2 = .79$, * $p < .1$, ** $p < .05$.*

In general, the results of Experiment 1 provide some evidence for the effect of Mandarin proficiency on deaf signers' sagittal space-time mappings. The result that deaf and hearing participants were not significantly different may be due to the fact that the general level of signers' Mandarin proficiency has reached a certain level, such that the temporal performance task was not sensitive enough to detect possible differences (see more in general discussion). Therefore, in Experiment 2 we used a more explicit clock question paradigm to investigate Chinese deaf signers' understanding of time. This clock question has been used in previous studies to assess people's understanding of time, and is shown to be sensitive to the effect of participants' language background (e.g., Lai & Boroditsky, 2013).

5.3 Experiment 2: A Clock Question

The first goal of Experiment 2 was to more explicitly examine whether Chinese deaf signers and Mandarin speakers have a different understanding of time. We used Lai and Boroditsky (2013)'s clock question paradigm that has been used to test spatio-temporal reasoning of speakers from different language backgrounds (e.g., Mandarin monolinguals, Mandarin-English speakers and English speakers). Secondly, we aimed to investigate whether the effect of Mandarin proficiency can

also influence deaf signers' understanding of time (e.g., perspective-taking in mental timeline).

Table 5.6. The “clock” question in Mandarin and English.

假设	现在	下午	1点,		
Jia-she	xian-zai	xia-wu	yi-dian,		
suppose	now	afternoon	one o' clock,		
Suppose now it is 1 PM,					
时钟	往前拨	一小时	是	几点?	
Shi-zhong	wang-qian bo	yixiaoshi	shi	ji-dian?	
clock	forward front	one hour	is	which hour?	
what time is it if I would ask you to move the clock one hour forward/before (earlier)?					

As shown in Table 5.6, the sagittal space-time word “前/qián” (meaning spatial “front” or temporal “before”) in the clock question is somewhat ambiguous in meaning. Most Mandarin monolinguals will interpret this space-time word temporally as moving the clock one hour “before/earlier”, thus answering the question as 12 AM (termed a time-moving perspective in Lai and Boroditsky (2013)²³). If a deaf signer thinks of the space-time word as temporal “before/earlier”, which is consistent with the spatial metaphor for time in Mandarin (a time-moving perspective), then s/he is likely to give 12 AM as an answer. However, if a deaf signer thinks of the space-time word as spatial “front/forward” which is consistent with the sign for “front” in CSL, then s/he is likely to move the clock one hour “forward”, thus giving 2 PM as an answer (termed an ego-moving perspective in Lai and Boroditsky (2013)²⁴).

²³ When taking a time-moving perspective (e.g., The deadline is approaching.), a person stands still facing the future, and time is conceived of as a river or conveyor belt on which events are moving from the future to the past towards the observer (Gentner, Imai, & Boroditsky, 2002). In the perspective of time (without including the ego), the *front* of a timeline can be assigned to a past (earlier) event (e.g., in the timeline 12 AM is before (in front of) 1 PM).

²⁴ When taking an ego-moving perspective, a person moves forward in the timeline, from past to future, e.g., “We are running *ahead* to the future.”

Lai and Boroditsky (2013) found that when having to respond to the clock question, Mandarin monolinguals mostly reported to take the time-moving perspective (temporal “before”, thus answering 12 AM), whereas English speakers mostly take the ego-moving perspective (spatial “front”, thus answering 2 PM). This is because in Mandarin the spatial “front” can have a meaning of “past” (e.g., “front day”, the day before yesterday), but in English the spatial “front” usually does not have a meaning of temporal “before”. When Mandarin learners of English and Mandarin monolinguals were both asked to answer the same clock question even in *Mandarin*, Mandarin learners of English were significantly more likely to answer the question with an ego-moving perspective (spatial “front”: 2 PM) (affected by the L2 English). Thus Lai and Boroditsky (2013) claim that there is an effect of space-time metaphors on speakers’ spatio-temporal reasoning.

Similar as in English, in CSL the spatial “front” does not have a meaning of temporal “before”. If CSL signers mainly take the ego-moving time perspective in CSL (the deictic of time in CSL is moving ego, Wu & Li, 2012), they are likely to be influenced by the CSL time perspective when answering the clock question in Mandarin. That is, they will interpret the space-time word (“前/qián”) as spatial “front”, thus answering 2 PM. Alternatively, it is possible that they gradually gain the time-moving perspective after learning Mandarin Chinese, so that deaf signers of higher Mandarin proficiency levels are more likely to interpret the space-time word (“前/qián”) as a temporal concept of past (taking a time-moving perspective: Temporal “before”, thus 12 AM), in comparison with signers of lower Mandarin proficiency.

5.3.1 Method

Participants

All the deaf signers who initially participated in Experiment 1 took part in Experiment 2. We recruited a comparison group of 38 Mandarin speakers (15 females and 23 males, $Mean_{age} = 19.0$, $SD = .85$) from Rizhao Polytechnic for the clock question experiment. The Mandarin speakers had normal hearing and did not have experience of CSL.

Materials and Procedure

Deaf participants were given a questionnaire to obtain their personal information of gender, age, and deaf background (after the temporal diagram task in Experiment 1). Hearing participants did a questionnaire as well, but questions specific for deaf

signers were removed (e.g., hearing loss). The instructions were not in sign language but all materials were written in Mandarin Chinese.

In the middle of the questionnaire, there was a clock question (Table 5.6) “假设现在下午1点，时钟往前拨一小时是几点?” [Suppose now it is 1 PM. What time is it if I would ask you to move the clock one hour **front** (forward)/**before** (earlier)?].

Data and Measurements

Data of two deaf participants and one hearing participant were excluded from the analysis, as they did not fully complete the questionnaire. As for the comparison between the deaf and hearing groups (an independent variable), we counted the participants' responses to the clock question (12 AM or 2 PM) (a dependent variable).

Furthermore, we focused on the deaf group, and investigated possible factors that may moderate the responses within the deaf signers. As in Experiment 1, we defined the following factors: Participants' *grade*, *exam_score*, *age*, *hearing_loss*, and *deaf_parent*.

5.3.2 Results and Discussion

About 70% of the deaf participants (9 out of 13) responded according to the “spatial” understanding of the Mandarin sagittal space-time word “前/qián” (forward), giving 2 PM as an answer (an ego-moving time perspective). By contrast, only 8% of Mandarin speakers (3 out of 37) responded with an answer of 2 PM. The majority of Mandarin speakers (about 92%) instead responded according to the understanding of the word “前/qián” as temporal “before”, giving 12 AM as an answer (a time-moving perspective).

Thus, the deaf participants were significantly more likely to give an answer of 2 PM than hearing participants²⁵ (70% vs. 8%, Fisher exact test, $p < .001$, Odds Ratio = 25.50, 95% CI = [4.81, 135.13]). This indicated that deaf participants were still largely influenced by the signs of spatial “front” in their CSL when reading Mandarin, that they were more likely to take an ego-moving time perspective as suggested by CSL.

²⁵ The result was robust: in comparison to the Mandarin monolinguals (13%, 3 out of 24) in Lai and Boroditsky (2013)'s study, our Chinese deaf signers (70%) were significantly more likely to give an answer of 2 PM than Mandarin monolinguals in their study (Fisher exact test, $p = .001$, Odds Ratio = 15.75, 95% CI = [2.91, 85.22]).

Again we tried to use the existing information of signers' Mandarin proficiency (*signer's grade* and *signer's Mandarin exam*) to simulate the difference between Mandarin-speaking non-signers and a hypothetical group of Chinese signers who do not know any Mandarin (a virtue group of sign monolingual). We defined an independent variable *Mandarin_speaker*: Either the participant was a Mandarin speaker or a monolingual deaf user of CSL. The result showed that *Mandarin_speaker* was significant ($\beta = 2.64, p = .003$), controlling for *age*, *signer's grade*, and *signer's exam score*²⁶ (Table 5.7). This indicated that a Mandarin speaking non-signer would be more likely to give 12 AM as an answer than a deaf signer who do not know any Mandarin.

Table 5.7. Comparisons between CSL deaf signers and Mandarin speakers in the clock question.

clock	Coef.	t	P>t	[95% CI]	
signer's_grade	.257	3.35	.002**	.102	.412
signer's_exam	.0002	.03	.974	-.012	.012
Mandarin_speaker	2.643	3.56	.001****	1.15	4.14
age	-.014	-.42	.677	-.080	.052
constant	-1.46	-1.87	.067	-3.03	-.108

Note: $R^2 = .52$, * $p < .1$, ** $p < .05$, *** $p < .01$, **** $p < .001$

Furthermore, focusing on the deaf signer's group, we examined whether Mandarin proficiency had an influence on Chinese deaf signers' understanding of the space-time word (“前/qián”). The results of a binary exact logistic regression showed that the factor *grade* was significant ($\beta = 1.14, p = .042$, Odds Ratio = 3.13). This indicated that those who studied in higher grades were more inclined to interpret the space-time word (“前/qián”) as temporal “before” (a time-moving perspective, 12 AM). As deaf signers studying in higher grades were likely to have higher Mandarin proficiency levels than deaf signers studying in lower grades, the effect of *grade* suggested that Chinese deaf signers' Mandarin proficiency levels played a role in shaping their understanding of the conceptions of the space-time

²⁶ When the insignificant factor *signer's exam score* was dropped, the main effects remained the significance.

word (“前/qián”) (shifting from an ego-moving time perspective to a time-moving perspective). This effect was still significant ($\beta = .387, p = .020$), while controlling for the other factors *exam_score*, *age*, *deaf_parent* and *hearing_loss* (all $p > .05$, Table 5.8).

Table 5.8. Results of the clock question for Chinese deaf signers.

clock	Coef.	t	P>t	[95% CI]	
grade	.387	3.01	.02 **	.083	.691
exam_score	-.0002	-.02	.985	-.019	.019
age	-.029	-0.69	.515	-.129	.071
deaf_parents	-.176	-0.75	.479	-.731	.380
hearing_loss	-.231	-1.84	.108	-.528	.066
constant	-1.20	-1.76	.122	-2.83	.413

Note: $R^2 = .61$, * $p < .1$, ** $p < .05$.

5.4 Experiment 3: A Clock Question and a Temporal Diagram Task (Mandarin Speakers)

In Experiments 1 and 2, the control studies were conducted with two different samples of Mandarin speakers (i.e., it was a between-subject design). In Experiment 3 we further examined an aged-matched control using a within-subject design to corroborate our initial findings. At the same time, we can see whether the results from the one-shot paradigm are replicable in another hearing group.

5.4.1 Method

Participants

30 native speakers of Mandarin Chinese (10 females and 20 males, $Mean_{age} = 19.0$ yrs, $SD = .98$) from Rizhao Polytechnic participated in both the temporal diagram and the clock question experiment. All participants had normal hearing but no experience of CSL.

Materials and Procedure

Participants followed the same procedure as reported in Experiments 1 and 2, and the performing sequence of the two tasks was identical to the deaf signers.

5.4.2 Results and Discussion

The results of using a within-subject design were in line with that of Experiments 1 and 2. In the temporal diagram task, 50% of those hearing participants in the new group performed past-in-front/future-at-back mappings, which was similar to the 56.8% of hearing participants in Experiment 1 ($\chi^2(1, N = 67) = .30, p = .58$, Odds Ratio = .76, 95% CI = [.29., 2.0]). Likewise, the differences between the new group of Mandarin speakers and the deaf group were not statistically significant ($\chi^2(1, N = 44) = .20, p = .65$, Odds Ratio = .75, 95% CI = [.21, 2.69]). We again used signers' Mandarin proficiency information to simulate the differences between Mandarin speakers and the hypothetical sample of deaf monolinguals by including *Mandarin_speaker* in the regression model. It was estimated that Mandarin speakers more likely perform past-in-front/future-at-back space-time mappings than deaf signers who do *not* know any Mandarin ($\beta = 2.67, t = 2.94, p = .005$, 95% CI = [.84, 4.5]), controlling for *age* and *signer's grade* ($p = .004$). Note that this significance is not referring to the differences between the deaf and hearing participants in our sample, but is an estimation of the differences between Mandarin speakers and the hypothetical sample of deaf monolinguals.

As for the clock question, the proportion of Mandarin speakers who responded according to the understanding of the space-time word “前/qián” as temporal “before” (a time-moving perspective: 12 AM) was about the same between this new group of participants (97%) and the Mandarin speakers in Experiment 2) (92%) (Fisher exact test, $N = 67, p = .62$, Odds Ratio = 2.56, 95% CI = [.25, 25.95]). Additionally, in comparison to the responses by Mandarin speakers in this new group, the deaf participants were still significantly more likely to give an answer of 2 PM than hearing participants (70% vs. 3%, Fisher exact test, $p < .001$, Odds Ratio = 65.25, 95% CI = [6.44, 660.94]). Furthermore, we included *Mandarin_speaker* in the regression model and used signers' Mandarin proficiency information to simulate the differences between Mandarin speakers and the hypothetical sample of deaf monolinguals. The results showed that Mandarin speakers are more likely to give 12 AM as an answer than deaf signers who know little Mandarin ($\beta = 2.3, t = 4.6, p < .001$, 95% CI = [1.30, 3.33]), controlling for *age* and *signer's grade* ($p = .005$). In short, the findings of Experiments 1 and 2 were replicated, that there was an effect of Mandarin sagittal space-time metaphor on deaf signers' temporal spatial reasoning.

5.5 General Discussion

In this study we aimed to find out whether there is any evidence showing that deaf users of CSL would conceptualise time differently from Mandarin speakers due to differences in use of lexical metaphors to express time, and whether acquiring Mandarin sagittal space-time metaphors influences signers' spatio-temporal reasoning.

In Experiment 1, we used a temporal performance task to test Chinese deaf signers' sagittal space-time mappings. Participants were asked to map the entities representing the deictic time "the day before yesterday" and "the day after tomorrow" to the corresponding boxes representing conceptions of the "past" and the "future". We found that some Chinese deaf signers performed past-in-front space-time mappings. Interestingly, the extent to which deaf signers performed past-in-front mappings was positively related to their Mandarin proficiency levels.

In Experiment 2, we used a clock experiment to examine how Chinese deaf signers interpreted Mandarin sagittal spatial metaphor of time. Again we obtained an effect of learning Mandarin Chinese. Note that in Mandarin the spatial "front" and temporal "before" share the same lexicon whereas the signs for "front" and "before" are different in CSL. Within the signers' group, those signers with higher Mandarin proficiency levels were more likely to interpret the sagittal space-time metaphor ("前/qián") as a temporal concept "before" (like Mandarin speakers) than signers with lower Mandarin proficiency.

Interestingly, in Experiment 2 we also observed an effect of Chinese Sign Language on their understanding of time, as deaf signers' answers reflected a strong influence of their signing metaphors about time. Additionally, Chinese deaf signers were found to have a different understanding of the sagittal space-time word from Mandarin speakers. This may be due to the co-activation of signs even in the non-signing linguistic contexts (Emmorey *et al.*, 2005; Morford *et al.*, 2010). If we consider the phenomenon of language transfer (either from an L1 to an L2 or an L2 to an L1) (Brown & Gullberg, 2008, 2011; Casey & Emmorey, 2009), our results suggest that language transfer also occurs *across different modalities* (i.e., a spoken language and a sign language, cf. bimodal bilinguals, Emmorey, Borinstein, Thompson, & Gollan, 2008).

These results point out that there may be cross-modal influences of CSL space-time metaphors on the spatio-temporal reasoning of deaf CSL learners of Mandarin. Admittedly, one may argue that the future-in-front metaphor used in CSL is the most common one found across cultures, and may also be mostly cognitively available one. Thus CSL signers' future-in-front mappings are not necessarily due to

their modality experience with CSL. However, this is quite unlikely when we look at our results together with the findings of another study which investigated the effect of cross-modal CSL space-time metaphors on the co-speech gestures about time by Mandarin speakers who have learned CSL. That study found that Mandarin-CSL late bimodal bilinguals exhibited a different temporal orientation of sagittal gestures than Mandarin-speaking non-signers, in that they were significantly more likely to spontaneously gesture past events to their back (future-in-front/past-at-back mappings) when speaking their *native Mandarin*. Thus, the experience of cross-modal CSL space-time metaphors can indeed influence bimodal bilinguals' spatio-temporal reasoning (Chapter 4). Consistent with that study, this study may provide a first insight into a cross-modal influence of space-time metaphors on deaf signer's mental representations of time.

Alternatively, the results of both experiments can also be explained in terms of differences in two kinds of time perspective-taking, related to a moving-ego and moving-time metaphors (e.g., Moore, 2011; Núñez, Motz, & Teuscher, 2006; Walker, Bergen, & Núñez, 2017). English speakers usually take an ego-moving perspective whereas Mandarin speakers mostly take a time-moving perspective (e.g., Gentner, Imai, & Boroditsky, 2002; Xiao, Zhao, & Chen, 2017; Yu, 2012). According to Lai and Boroditsky (2013)'s study, Mandarin-English speakers were influenced by English ego-moving time perspective when answering the clock question in *Mandarin*, such that Mandarin-English speakers were less likely to answer the clock question as 12 AM (a time-moving perspective) than Mandarin monolinguals. Similar as in English, in CSL the spatial "front" usually does not have a meaning of temporal "before", and the deictic of time in CSL is also an ego-moving time perspective (Wu & Li, 2012). Therefore, deaf CSL signers are likely to be influenced by the CSL ego-moving time perspective when answering the clock question in Mandarin. Our results of the clock experiment are consistent with the results of Lai and Boroditsky (2013)'s study on Mandarin-English sequential bilinguals.

Similarly, in the temporal performance task, the past-in-front/future-at-back mappings may be argued to represent a time-moving perspective, whereas the future-in-front/past-at-back mappings can be regarded as an ego-moving time perspective. In both Experiments 1 and 2, we found an effect of Mandarin proficiency on Chinese deaf signers' spatio-temporal reasoning, which may be due to the fact that they gradually gain the Mandarin time-moving perspective after learning Mandarin Chinese. This is also in line with the proposal that the acquisition of a novel spatial metaphor for time in a language may foster a new way of thinking

about time (Boroditsky, 2001; Hendricks & Boroditsky, 2017). Future studies can further examine this in signers using a non-linguistic task (e.g., Fuhrman & Boroditsky, 2010; Fuhrman *et al.*, 2011).

Even when the results of both experiments provided convergent evidence that Mandarin sagittal space-time metaphors had an influence on deaf signers' spatio-temporal reasoning, the differences between the deaf and hearing participants in the temporal performance task (Experiment 1) was not as large as the one in the clock question task (Experiment 2). This could be caused by the fact that the two tasks were not identical and the paradigm of clock question is more explicit than the temporal performance task. Alternatively, it could also be due to the instruction used in the temporal performance task involving overt spatial metaphors (e.g., "front day"). Such spatial language may have an online lexical effect on space-time mappings (Chapter 3), and provides a cue about how to do the task, which may have minimised differences between the two groups. Another possible reason could be that the temporal diagram task was originally used to examine the effect of cultural attitudes towards time on space-time mappings, thus the paradigm might not be as sensitive as the clock question in the testing of the effect of linguistic space-time metaphors. A previous study using the temporal diagram paradigm showed that cultural attitudes towards time exert a dominant influence on people's sagittal space-time mappings (temporal-focus hypothesis, de la Fuente *et al.*, 2014). On the assumption that the deaf and hearing participants share the same Chinese culture, Chinese deaf signers may have similar cultural values towards time to the Mandarin speakers (or deaf signers may have gradually adjusted themselves into the mainstream Chinese culture and hence become more similar to the Mandarin speakers). The subtle influences of the linguistic space-time metaphors on the sagittal space-time mappings might not be fully captured by the temporal performance task. Future study can use space-free instructions and additionally control for deaf signers' temporal-focus of attention and other individual differences (see Duffy, Feist, & McCarthy, 2014; Duffy & Feist, 2014) to corroborate the present findings with a larger sample size.

Additionally, the past-in-front mappings performed by the deaf signers in the temporal performance task can be argued to be a consequence of a direct translation of the spatial conceptions of "front" and "back" in CSL, thus characterising the results as merely an effect of language interferences without reference to the differences in spatio-temporal reasoning. For example, participants may simply have interpreted the sagittal space-time word ("前/qián") as spatial "front" rather than

understanding the space-time expression (“前天/qián-tiān”, front day) as a past conception of “the day before yesterday”, even though the conception of “front day” is unambiguous. Similarly, they may interpret the space-time word “后/hou” as spatial “back” rather than understanding the temporal expression (“后天/hòu-tiān”, back day) as a future conception of “the day after tomorrow”.

This alternative explanation is, however, quite unlikely for the following reasons. First, the instructions were checked beforehand by their teacher to ensure that the participants had previously learned all the vocabulary and would be able to understand the sentences and the temporal concepts of “front day/back day”. Second, if deaf signers would have done a direct translation, those signers of lower Mandarin proficiency levels should be more likely to translate the space-time words “前/qián” as “front” and “后/hòu” as “back”, thus would produce a larger proportion of past-in-front/future-at-back mappings. However, quite on the contrary, we found that deaf signers of lower Mandarin proficiency levels or studying in lower grades were actually more inclined to perform future-in-front/past-at-back mappings, which is consistent with CSL where the past is signed towards the back. This implies that participants even with a low Mandarin proficiency can already understand that “front day” and “back day” are temporal concepts. Therefore, needless to say for the higher proficiency group, the tendency of having past-in-front/future-at-back space-time mappings likely reflects their spatio-temporal reasoning. Third, when relating signers’ performance in the temporal diagram task to that in the clock question, we found that those who had past-in-front mappings/future-at-back were more likely to give 12 AM as an answer (one hour *before*), $r = 0.53$, $p = .0642$ (two tailed). This indicates that signers who put the past (e.g., “front day”) in front of them also tended to understand the Mandarin space-time word “前/qián” as the conception of “temporal past” (12 AM), rather than as “spatial front” in space leading to an answer of 2 PM.

Moreover, it is possible that deaf signers have to rely on their vision heavily as a result of the hearing loss. Consequently, this may cause them to consider things that they have seen in front of them as the past whereas the events that they have not seen as the future behind them (cf. Aymara speakers, Núñez & Sweetser, 2006). However, this explanation does not hold for deaf people universally, as deaf users of many other sign languages (e.g., ASL, NGT) do not exhibit a tendency towards past-in-front space-time mappings (e.g., Schermer & Koolhof, 1990).

We conducted both studies in Mandarin Chinese rather than in CSL. It would be interesting to ask the deaf signers to fulfill the experiments with a sign language

instruction, the results of which might also reveal the effect of Mandarin Chinese on deaf signers' spatio-temporal reasoning, even when they think in CSL. However, there is a danger of a possible confound as participants may then be visually primed by the spatial movements in the signed instruction. For example, for the clock question, CSL will give a strong hint as the clock hand is moving in the signs (either a clockwise or an anti-clockwise movement), which makes them unambiguous. Thus deaf signers will simply give a definite answer according to the signs they have seen. This will not allow us to examine deaf signers' authentic interpretation of the Mandarin sagittal space-time word. Furthermore, the sign for "front day" (the day before yesterday) is signed as two fingers pointing to the back of the body, in that way hinting a past-at-back space-time mapping.

Finally, this study has some limitations. Although the paradigms we used to study spatial-temporal reasoning have been shown to be quite reliable in eliciting participants' performances in several studies (e.g., de la Fuente *et al.*, 2014; Lai & Boroditsky, 2013; Li & Cao, 2018), it is undeniable that the sample size of the deaf participants was rather small. Future studies should also have a more standard measurement of signers' language proficiency, language dominance, and nativeness²⁷, as they may have an impact on cross-language activation (Morford, Kroll, Piñar, & Wilkinson, 2014; van Beijsterveldt & van Hell, 2012).

Additionally, the results of the current study can provide a first insight into the spatial-temporal reasoning of deaf signers, which has been somewhat neglected in the literature, but we only investigated the most extreme case (the reversed mappings) of sagittal space-time metaphors. Mandarin speakers are not exclusively using past-in-front/future-at-back metaphors, but also have the option to make use of other temporal expressions suggesting future-in-front mappings or expressions that contain no hint of time orientation. Future studies can further examine the effect of such linguistic mapping differences on both deaf signers' and Mandarin-CSL bimodal bilinguals' spatio-temporal reasoning. Moreover, as CSL and Mandarin can make use of the vertical spatial metaphors for time differently (e.g., lexicons, frequency), it is interesting to explore whether there are subtle differences in the mental vertical mappings, as well.

²⁷ In our study, one participant became deaf at around 60-month old, which was a bit older than that of other deaf participants. One may wonder whether she performed differently. However, due to her relatively lower Mandarin proficiency, her results were still more influenced by the CSL (2 PM and future-in-front mappings).

5.6 Conclusions

In the current study we investigated whether the Mandarin sagittal spatial metaphors for time influenced Chinese deaf signers' spatio-temporal reasoning. With the experiments of the temporal performance task and the clock question, the study revealed a previously unexplored difference in spatial conceptions of time between a typical and an atypical Chinese population. We observed effects of both CSL and Mandarin Chinese on signers' understanding of time. Chinese deaf signers with higher Mandarin proficiency were more inclined to interpret the Mandarin sagittal space-time metaphor in the way Mandarin speakers did, and we found evidence that deaf participants used more past-in-front mappings as a function of an improved Mandarin proficiency. These findings not only show a *cross-modal* influence of space-time metaphors on people's mental representations of time *within a culture*, but also have practical implications for signers' education: Teachers of deaf schools should give importance to the cross-linguistic differences between Mandarin Chinese and CSL, such as the conceptions of space and time, which play a vital role in spatio-temporal reasoning.

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6

General Discussion and Conclusions

This thesis reported on four studies in which Chinese people's conceptualisation of time was investigated, with a focus on the production and perception of gestures, mental space-time mappings, and cultural temporal attitudes. The studies have examined whether the linguistic spatial metaphors and cultural attitudes towards time influenced Chinese people's temporal gestures and spatial conceptions of time. These issues have been studied cross-culturally and within the Chinese culture, including analyses of different Chinese populations (monolinguals, bilinguals, and bimodal bilinguals). In this concluding chapter, firstly a summary of the four studies is provided and then general theoretical implications of this work are discussed. The chapter ends with suggestions for future studies and a general conclusion.

6.1 Summary of the Empirical Chapters

The studies presented in this thesis suggest that, in addition to potential cultural influences, linguistic space-time metaphors can have an influence on people's production and perception of temporal gestures and mental space-time mappings. The chapters can be summarised as follows.

The study in Chapter 2 investigated whether and why Chinese-English bilinguals produce vertical gestures about time and how the lexical and conceptual factors interact with each other in bilingual language processing. These questions were addressed by investigating Chinese-English bilingual speakers' production and perception of gestures for temporal expressions. It was found that Chinese-English bilinguals produced vertical temporal gestures spontaneously, both in Chinese and in English. The between-language and within-language comparisons showed that Chinese-English bilinguals produced more vertical gestures when talking about Chinese time references with vertical spatial metaphors than (1) when talking about time conceptions in the English translations, and (2) than in the case of Chinese time references without spatial metaphors. It was further shown that Chinese-English bilinguals 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, though to a lesser extent. Nevertheless, there was no such bias towards vertical gestures when they perceived time references without spatial metaphors. Additionally, a control study with English speakers showed that this vertical tendency was not due to the fact that vertical gestures were generally less ambiguous than lateral gestures for addressees (lateral gestures may be mirrored in addressees' perspective). In short, the vertical gestures about time by Chinese-English bilinguals were shaped by both the stable conceptualisations of time, and the online changes in linguistic choices.

The study in Chapter 3 reported on how exactly Chinese people conceptualise time on the sagittal axis. The goal was to determine the influence of language and cultural values towards time on people's mental space-time mappings. Firstly, by studying spontaneous temporal gestures of Mandarin monolinguals, it was found that, in addition to future-in-front/past-at-back gestures that were also commonly observed in the temporal gestures of native speakers of English, some Chinese people produced gestures associated with the past in the front and the future at the back, especially in cases where they also used space-time metaphors that implied the past in the front and the future at the back. Secondly, a temporal diagram/action performance task was adopted to more explicitly test Chinese people's mental space-time mappings. The results confirmed that some Chinese people conceptualise the future as behind them and the past as in front of them, and such mappings were affected by the different wordings of Mandarin space-time metaphors. Thirdly, a survey on Chinese people's cultural attitudes towards time (temporal-focus of attention) was conducted, the results of which showed that Chinese people generally focus a little bit more on the future than on the past. Furthermore, the results that the extent to which Chinese people conceptualise the future as behind them and the past as in front of them was influenced by the linguistic spatial metaphors for time were replicated, even after controlling for participants' temporal-focus of attention. Finally, a cross-cultural comparison in space-time mappings between Chinese, Moroccans, and Spaniards showed that people's space-time mappings appear to be influenced by both the lexical cues to space-time mappings and the culture-specific temporal-focus of attention.

In Chapter 4, the study of gesture and space-time mappings was extended to bimodal bilinguals. Mandarin speakers often use gestures to represent time laterally, vertically, and sagittally, whereas Chinese Sign Language (CSL) users can also exploit signs for that purpose. Mandarin Chinese-CSL bimodal bilinguals share a similar culture with non-signers, but have acquired CSL which exploits different time-space mappings than Mandarin Chinese. The study investigated whether the experience of CSL influenced the production of co-speech gestures about time in bimodal bilinguals. The results showed that both Mandarin-speaking non-signers and Mandarin-CSL late bimodal bilinguals performed spontaneous temporal gestures on the lateral, vertical, and sagittal axes. However, compared to non-signers, late bimodal bilinguals (1) produced more sagittal but fewer lateral temporal gestures, and (2) exhibited a different temporal orientation of sagittal gestures, in that they were more likely to gesture past events to their back. Based on the mechanism of a shared production system between gestures and signs (Emmorey *et*

al., 2008), and the *Gesture-for-Conceptualisation Hypothesis* (Kita, Alibali, & Chu, 2017), the study suggests that the learning of a signed language can not only have an impact on the nature of co-speech gestures but may also exert an influence on users' spatio-motoric thinking and their abstract reasoning such as space-time mappings.

In the final empirical study, Chapter 5, the cross-modal influence of spatial metaphors for time on temporal thinking in deaf users of CSL was studied. Given that Chinese signers use future-in-front/past-at-back space-time metaphors in CSL, whereas Mandarin speakers additionally exploit past-in-front/future-at-back metaphors in Mandarin (Wu & Li, 2012; Zheng, 2009), the chapter has studied whether deaf users of CSL conceptualise time differently from Mandarin speakers, due to the differences in the use of lexical metaphors to express time. A temporal action performance and a clock question task were used. Results showed that there were effects of both CSL and Mandarin Chinese on the understanding of time by deaf users of CSL who have learned some written Mandarin. Deaf users of CSL with higher written Mandarin proficiency levels were more inclined to interpret the Mandarin sagittal space-time metaphor in the way Mandarin speakers did. Evidence was also found that those deaf participants gradually used more past-in-front mappings as a function of an improved written Mandarin proficiency.

6.2 Theoretical Implications

The work presented in this thesis has some theoretical implications which are discussed below.

6.2.1 Implications for the Mechanism of Gesture Production and Abstract Reasoning

This thesis provides the first quantitative analysis of Chinese people's (including Mandarin-English bilinguals', Mandarin monolinguals', and Mandarin-CSL bimodal bilinguals') spontaneous temporal gestures (Chapters 2, 3, and 4), the results of which can provide a better understanding of the mechanism of the production of temporal gestures and abstract reasoning. Previous studies have shown that temporal gestures can be shaped by reading and writing direction (Casasanto & Jasmin, 2012), culture-specific beliefs (Floyd, 2016; Le Guen & Balam, 2012; Núñez & Sweetser, 2006), spatial schemas (Kita, Danziger, & Stolz, 2001), geographical environment (Núñez *et al.*, 2012), or cardinal frames of references (Boroditsky & Gaby, 2010). All these studies provide evidence that the way one thinks of time in space affects the temporal gestural representation. However, the work in this thesis shows that temporal gestures are not only shaped by the stable

conceptualisations of time, but are also affected by the online linguistic spatial metaphors for time. Thus, the words people use at a specific moment can also influence how they move our hands.

More generally, the results of the gesture studies presented in Chapters 2, 3, and 4 offer support for the *Interface Hypothesis* (Kita & Özyürek, 2003) that the contents of concurrent gesture and speech tend to converge because the iconic gesture production system and speech production system exchange information and align their contents. So far, positive evidence for the *Interface Hypothesis* has predominantly come from studies of motion events. However, this thesis provides support based on the results of studies related to the spatial conception of time (c.f., Kita *et al.*, 2007; Özyürek *et al.*, 2005; Özçalışkan, Lucero, & Goldin-Meadow, 2016). In general terms, our results suggest that gesture production is dynamic and sensitive to linguistic encoding possibilities, even for abstract concepts (Argyriou, Mohr, & Kita, 2017).

Likewise, the studies that focus on the perception of gestures (Chapter 2) show that the interpretation of metaphoric gestures can also be affected by linguistic choices and conceptualisations. The analogous pattern of results from both the production and perception studies of gestures are very much in line with more general claims about the interconnection between language production and perception (Pickering & Garrod, 2013).

Furthermore, the results from the study of the effect of signs on gestures (Chapter 4) show that the way people gesture is affected by characteristics of the signed language production system (Emmorey *et al.*, 2008). Previous studies on the effect of signs on gestures mainly focused on changes in gesture rate, character viewpoint, and handshape in bimodal bilinguals after speakers learned American Sign Language (ASL), and sometimes these changes “were not large enough to create significant group differences” (e.g., after learning one-year of ASL) in comparison to non-signers (Casey, Emmorey, & Larrabee, 2012). The study in this thesis, however, focusing on temporal gestures, provides clear evidence that the knowledge and experience of an L2 sign language can indeed impact the content and form of L1 co-speech gestures. Moreover, the results of the study also appear to show an effect of a signed language on a person’s thinking about time.

According to the *Gesture-for-Conceptualisation Hypothesis*, performing actions or gestures can activate and change one’s spatial thinking (Kita, Alibali & Chu, 2017). Similarly, signing, a special kind of action in space, may also activate and change one’s spatial thinking. The results of Chapter 4 suggest that the bodily experience of a signed language not only impacts the nature of co-speech gestures,

but may also influence users' spatio-motoric thinking and abstract reasoning (in our case: space-time mappings).

6.2.2 Implications for Theoretical Accounts of Space-Time Mappings

First of all, the study on Chinese people's space-time mappings (Chapter 3) extends previous knowledge on cross-cultural differences in space-time mappings. It was found that Chinese more often have past-in-front/future-at-back mappings than Spaniards and less often than Moroccans. These cross-cultural differences in space-time mappings can largely be explained by the differences in culture-specific temporal-focus of attention. That is, in comparison to the Chinese culture, Moroccans are more past-focused whereas Spaniards are more future-focused (and people who are past-focused have a tendency to literally place the past in front of them). This provides new evidence in support of the *temporal-focus hypothesis*, which proposes that space-time mappings in people's minds are conditioned by their cultural attitudes towards time (i.e., attentional focus) (de la Fuente *et al.*, 2014).

Furthermore, the results on the study on spatial conceptions of time (Chapters 3 and 5) also show that people's mental space-time mappings are not only the result of general cultural attitudes towards time, but may additionally be affected by other factors. According to de la Fuente *et al.* (2014)'s *temporal-focus hypothesis*, whether people conceptualise the past as behind and the future as ahead of them depends on the extent to which their (sub)culture is future-oriented or past-oriented. Importantly, the authors claim that such conceptualisations vary independently from the way time is linguistically expressed in terms of spatial metaphors. However, within the Chinese culture, the propensity of past-in-front/future-at-back mappings is sensitive to the wording of Mandarin space-time metaphors, irrespective of people's temporal-focus of attention. Such linguistic differences even contribute to the explanation of cross-cultural differences in space-time mappings. Therefore, a modification of the *temporal-focus hypothesis* was proposed: Whether people conceptualise the past as behind and the future as ahead of them is not only influenced by cultural attitudes towards time, but also, directly, by the space-time metaphors used in language. Thus, there are not only long-term effects of cultural attitudes on the spatialisation of time, but also immediate effects of the linguistic space-time metaphors that probe people's mental representations.

The results of the thesis provide a better understanding of the Chinese metaphorical orientation of time (laterally, vertically, and sagittally), especially of the temporal orientation on the sagittal axis. Most studies on sagittal space-time mappings state that there are two kinds of time perspective-taking, related to a

moving-ego and moving-time metaphor (e.g., Gentner, Imai, & Boroditsky, 2002; Moore, 2011; Núñez, Motz, & Teuscher, 2006; Walker, Bergen, & Núñez, 2017). According to Xiao, Zhao and Chen (2017), time can be perceived as moving from the future to the past, where the ego *always* faces the future (Figure 3.1, Chapter 3): From the time-reference-point perspective, earlier events are in front of later events, thus the past is in the front of the timeline; from the ego-reference-point perspective (*stationary* or *moving*), earlier events are behind the ego, and the past is at the back of the ego.

However, these proposed temporal reference frames cannot account for some of the empirical results in the present thesis (e.g., some Chinese participants believe that the past is in front of the ego). This thesis has provided evidence for the possibility that an observer might see the time (from the future to the past) as passing from the back to the front (Figure 3.9, Chapter 3). Such an explanation may rely heavily on the observer's vision and experience, because the events that an observer has seen or experienced will be visualised in front of him/her, whereas future events are still not seen and unknown and, therefore, may be at the back of the observer (in line with what some participants said in the interview, Chapter 3). Furthermore, to account for those who believe that both "earlier" and "future" can be in front of the ego, and both "late" and "past" can be behind the ego, human's queuing experience (Figure 3.10, Chapter 3) was used to explain that there is both an internal sequential timeline and an external ego-moving timeline, as initially proposed by Yu (1998, 2012) (see also Ng *et al.*, 2017).

6.2.3 Implications for Theories on the Relation between Language, Culture, and Thought

The findings of this thesis provide new insights into the relation between language, culture, and thought (e.g., Bylund & Athanasopoulos, 2017; Lai & Boroditsky, 2013; Slobin, 1996). First, as mentioned above in the section on space-time mappings, there is a direct effect of linguistic metaphors on people's reasoning about time, as revealed by spontaneous gestures and by the temporal diagram/action performance task (Chapters 2 and 3). Furthermore, learning of *cross-modal* spatio-temporal metaphors can also impact learners' time conceptualisations. The study on Chinese deaf signers (Chapter 5) shows that deaf users of CSL displayed a different spatio-temporal reasoning than Mandarin speakers. However, deaf signers gradually establish the Mandarin-style past-in-front/future-at-back mappings as a function of an improved proficiency in written Mandarin. It appears that Mandarin sagittal

space-time metaphors may have a long-term influence on people’s mental representations of time (cf. Lai & Boroditsky, 2013).

Finally, an important finding of this thesis is that Chinese people can spontaneously gesture about time vertically with the past positioned “above” and the future “below”. The vertical gestures are driven both by the effects of vertical spatial metaphors and culture-specific vertical time conceptualisation. Given such a finding, anthropologists or archaeologists may ask what the historical origin of Chinese people’s culture-specific vertical temporal thinking is (e.g., the relationship between vertical language, vertical writing culture, and vertical thinking about time). This thesis cannot provide an answer to this question but some speculations are given below.



Figure 6.1. Row 1 shows the ideographic representations of “up”, “middle”, and “down” in Chinese oracle bone inscriptions²⁸. Row 2 shows the modern writing of “up”, “middle”, and “down”. Note that the symbol of ☀ is only used to represent the location of the sun.

It is likely that Chinese people were able to think about space and time before language as we know it today was used (also the vertical writing system). For instance, the spatial words “上/shàng” (up) and “下/xià (down)” are ideographic in origin. As Figure 6.1 (the first row) shows, from the ancient “oracle bone inscriptions” (about 1200-1050 B.C., Boltz, 1986), the spatial words of “上/shàng”(up), “中/zhōng”(middle), and “下/xià” (down) indicate that an object is “above”, “between”, and “below” a reference level. Such vertical spatial metaphors

²⁸ The ideographic representations of these Chinese oracle bone inscriptions and their evolution to modern Chinese words can be found at: http://chinese-linguipedia.org/search_source.html.

for time may have originated from the concept of the sun rising and setting (Causarano, 2014; Scott, 1989). That is, the representations of “上午/shàng-wǔ (up noon, morning)”, “中午/zhōng-wǔ” (middle noon, noon)”, and “下午/xià-wǔ (down noon, afternoon)” are consistent with the different locations of the sun during the day.

However, conceptualising the periods of a day in terms of the sun location alone may not necessarily lead to a vertical conceptualisation of time, as the sun is similar in many countries across the world, but the vertical temporal conceptualisation mapping the “past” to “up” is not common in Western culture. There are also other natural events suggesting different vertical space-time mappings. For instance, the earth gravity makes a fruit fall from a tree, or waterfalls go downwards, whereas trees grow upwards as time progresses.



Figure 6.2. A picture from the news “Bamboo forests at Hunan Yuelu Academy suffered from inscriptions by tourists (湖南岳麓书院竹林遭游客刻字)”.²⁹

Chinese vertical temporal thinking may also have been influenced by the traditional vertical writing (e.g., Chen, 2007; Chen, & O’Seaghdha, 2013; Fuhrman

²⁹ The link of the news is http://hk.on.cc/cn/bkn/cnt/news/20171011/bkncn-20171011111204840-1011_05011_001_cn.html.

et al., 2011), but again it is unknown what might shape such a culture-specific writing system. It is speculated that the ancient vertical writing habit may have been influenced by the convenience of inscribing and reading the Chinese characters. For instance, as Figure 6.2 shows, Chinese, Korean, and Japanese tourists inscribed their names or wishes on the bamboos³⁰ vertically. Given the fact that a bamboo is rather thin, it must be more difficult to write or read words on the bamboo laterally than vertically, as the limited visible surface at the front side largely restricts one to write or read the texts laterally, whereas vertical writing/reading seems more convenient.



Figure 6.3. 毛公鼎/Máo gōng dǐng³¹ (Duke Mao Tripod) (827-782 B.C., National Art Museum of China).

³⁰ Most bamboos originate from Asian-Pacific area. China has the largest area of bamboos around the world, and it was a custom that ancient Chinese often wrote on bamboos. However, Europe and Western America originally did not have bamboos (Kang & Hu, 2011).

³¹ Picture sources: <https://baike.baidu.com/item/%E6%AF%9B%E5%85%AC%E9%BC%8E/1161082>.

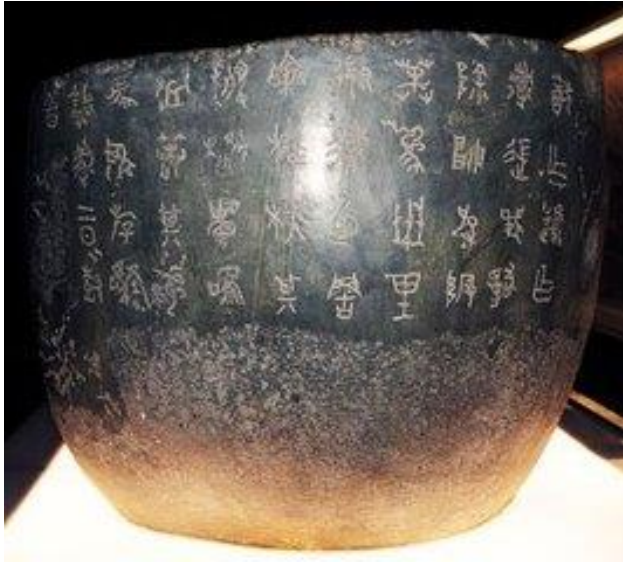


Figure 6.4. Inscriptions on drum-shaped stone blocks of the warring states period (475-221 B.C.)³².

Interestingly, the vertical writing has also been found in the bronze inscription on ancient antiques in China. Bronze inscription was one of the most historical writings found in Chinese history (in Shāng Dynasty, about 1200 B.C., Boltz, 2000). As Figure 6.3 and Figure 6.4 show, the texts were inscribed vertically inside or outside a bronze tripod. 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 vertically whereby 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 (Figure 6.5 and Figure 6.6).

³² Picture source: <http://www.guoxue.com/?p=43822>.



Figure 6.5. A sample of bamboo slips (300 B.C.) at the Shanghai Museum, recording part of a commentary on the *Classic of Poetry*³³.



Figure 6.6. A bamboo book at Yinqeshan bamboo slips museum, Linyi (临沂银雀山汉墓竹简博物馆)³⁴.

Plausibly, the vertical writing system has had an influence on Chinese people’s *vertical* conceptualisation of time (e.g., Bergen & Chan Lau, 2012; Chen, 2007; Chen, Friedrich, & Shu, 2015; Fuhrman *et al.*, 2011), but the vertical writing actually may also partially explain why Chinese people are likely to conceptualise sequential time on the *sagittal* axis, unlike English people who mostly conceptualise sequential time on the lateral axis (e.g., Casasanto & Jasmin, 2012, Cienki, 1998; Walker & Cooperrider, 2016). Apart from the effects of Mandarin linguistic spatial metaphors for time (that is, 前/qián (*front*, “early”) and 后/hòu (*back*, “late”)) which have been discussed in Chapter 3, one can also argue that *the vertical writing on paper lying on a table in fact also forms a sagittal writing system with the words written earlier as in front of the words written later* (a projection of vertical axis to the sagittal axis), though all words can still be in front of the writer.

Given that writing directions can have an impact on people’s mental space-time mappings (e.g., Bergen & Chan Lau, 2012), given that people can project the vertical timeline onto sagittal timeline, and given that “forward” and “up” can be psychologically equivalent (Levine, 1982), one can imagine that the traditional Chinese vertical writing may not only influence Chinese people’s vertical space-

³³ Picture source: https://en.wikipedia.org/wiki/Bamboo_and_wooden_slips#/media/File:Manuscript_from_Shanghai_Museum_1.jpg.

³⁴ Picture source: <http://www.yqszy.com/back/upload/2007623942500.jpg>.

time mappings but also affect their thinking about sequential time that is rotated to the sagittal axis, and thus even influence their sagittal space-time mappings (resulting in past-in-front/future-at-back mappings). In future studies, researchers may conduct empirical experiments to examine this assumption while controlling for linguistic influences. Additionally, it might be worth to study the (disappearing) population of illiterate Chinese people, as they have minimal vertical reading and writing experience. If the vertical writing system has an influence on sagittal space-time mappings, illiterate Chinese people are expected to have different space-time mappings than their literate counterparts.

6.3 Conclusion

In this thesis, Chinese people's temporal gestures and conceptualisations of time have been studied. The findings contribute to our understanding of cross-cultural differences in temporal gesture production and space-time mappings. Specifically, Chinese may have different mental space-time mappings than Spaniards and Moroccans. In addition, within the Chinese culture, we have shown that Mandarin-English bilingual speakers gesture differently about time when speaking Mandarin Chinese 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 horizontal axis when explaining in English). We have also shown that 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, we have shown that Mandarin-Chinese Sign Language (CSL) bimodal bilinguals perform different temporal gestures than Mandarin-speaking non-signers, even when they speak in their L1 Mandarin Chinese. Finally, we find evidence showing that deaf users of CSL display a different spatio-temporal reasoning than Mandarin speakers and that there is an effect of written Mandarin proficiency on signers' spatio-temporal reasoning. All the studies in this thesis suggest that there are not only long-term effects of cultural attitudes on the spatialisation of time, but also immediate effects of the linguistic space-time metaphors that probe people's mental representations. In conclusion, culture and language may not simply influence how we *think*, but may also shape how we *move* our hands.

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Curriculum Vitae

Yan Gu was born in Suzhou (China) in 1986. He attended Nantong University (2005-2009) and obtained a bachelor's degree in English-language teaching and pedagogy. In 2009 he was awarded the Huygens Scholarship Programme from the Dutch Ministry of Education, Culture and Science to study for a Master in Linguistics at Radboud University, from which he obtained his MA degree. During the Master's programme he also took an internship in the Language Comprehension Group at the Max Planck Institute for Psycholinguistics in Nijmegen. In 2010 he was awarded the Huygens Scholarship for a second time to study in a joint Research Master programme (MPhil) "Language and Communication" at Radboud University & Tilburg University, from which he earned his Research Master's degree in 2012. In the same year he was awarded with a full scholarship by Chinese Scholarship Council (declined), and a grant from The Netherlands Organization for Scientific Research (NWO Promoties in de Geesteswetenschappen) to do his PhD research in the Netherlands. In September 2012, he started his PhD project at Tilburg University. This thesis is the main product of that research. Since February, 2018, he has joined the Language and Cognition Lab at University College London.

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56. Sylvia Huwaë *Different Cultures, Different Selves? Suppression of Emotions and Reactions to Transgressions across Cultures*. Promotores: E.J. Kraemer and J. Schaafsma. Tilburg, 11 October, 2017.

57. Mariana Serras Pereira, *A Multimodal Approach to Children's Deceptive Behavior*. Promotor: M. Swerts. Co-promotor: S. Shahid Tilburg, 10 January, 2018.
58. Emmelyn Croes, *Meeting Face-to-Face Online: The Effects of Video-Mediated Communication on Relationship Formation*. Promotores: E.J. Krahmer and M. Antheunis. Co-promotor A.P. Schouten. Tilburg, 28 March 2018.
59. Lieke van Maastricht, *Second Language Prosody: Intonation and Rhythm in Production and Perception*. Promotores: E.J. Krahmer and M. Swerts. Tilburg, 9 May 2018.
60. Nanne van Noord, *Learning Visual Representations of Style*. Promotores: E.O. Postma and M. Louwerse. Tilburg, 16 May 2018.
61. Ingrid Masson Carro, *Handmade: On the Cognitive Origins of Gestural Representations*. Promotores: E.J. Krahmer and M. Goudbeek. Tilburg, 25 June 2018.
62. Bart Joosten, *Detecting Social Signals with Spatiotemporal Gabor Filters*. Promotores: E.J. Krahmer and E.O. Postma. Tilburg, 29 June 2018.
63. Yan Gu, *Chinese Hands of Time: The Effects of Language and Culture on Temporal Gestures and Spatio-Temporal Reasoning*. Promotor: M. Swerts. Co-promotores: M. Hoetjes and R. Cozijn. Tilburg, 5 June 2018.