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Does Mandarin Spatial Metaphor for Time Influence Chinese Deaf Signers' Spatio-Temporal Reasoning?

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Abstract

In Mandarin Chinese, the space-time word “前/qian” is used to express both the spatial concept of *front/forward* and the temporal concept of *early/before* (e.g., “前天/qiantian”, literally *front day*, meaning the day before yesterday). This is consistent with the fact that Mandarin speakers can gesture to the front of the body to refer to a past event, and more generally can have *past-in-front* space-time mappings. In Chinese Sign Languages, however, the spatial *front/forward* and the temporal *early/before* are signed differently as the sign for spatial *front* is only used for the spatial concept of *forward*, and the sign for *before/past* is directed to the *back*. In this study we investigate whether the Mandarin sagittal spatial metaphors for time influence Chinese deaf signers' spatio-temporal reasoning. In two experiments, we found that Chinese deaf signers with higher Mandarin proficiency were more likely to interpret the Mandarin word “前/qian” as the temporal conception of past (Study 1), and to perform past-in-front space-time mappings (Study 2) as opposed to signers with lower Mandarin proficiency. The findings of the study not only provide within-culture evidence for the influence of language on thought, but also demonstrate that even cross-modal space-time metaphors can have an impact on deaf-signers' spatio-temporal reasoning.

Keywords: space and time; Chinese deaf signers; language and thought; conceptual metaphor

Introduction

Across cultures people use spatial representations to think about time (Bottini, Crepaldi, Casasanto, Crollen, & Collignon, 2015; Boroditsky, 2000; Casasanto & Boroditsky, 2008; see reviews Bender & Beller, 2014; Núñez, & Cooperrider, 2013). Most Europeans feel that the future is in front of them and the past is at their back (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. Interestingly, the future-in-front and past-at-back mappings are also expressed as such in many languages. For instance, in English, one can say “We look *forward* to the New Year *ahead*, and look *back* to the hard times *behind* (e.g., Clark, 1973; Lakoff & Johnson, 1980).

However, the way of conceptualizing 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 mappings, 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 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, even though in Arabic the front/back time metaphors are similar to most future-in-front languages such as English. It has been argued that the reason for Moroccans' past-in-front space-time mapping is that, in their culture, tradition and old generations are more valued. Thus space-time mappings in people's minds are conditioned by their cultural attitudes towards time (e.g., with a strong focus on past times and old generations). It is claimed that the mental space-time mappings are dependent on attentional focus and can be independent from the space-time mappings expressed in language (de la Fuente, Santiago, Román, Dumitrache, & Casasanto, 2014). Moreover, a recent study on Mandarin speakers shows that there are both long-term effects of cultural attitudes on the spatialization of time, and immediate effects of lexical cues to space-time metaphors which can probe people's mental representations (Gu, Zheng, & Swerts, 2016).

Despite the fact that a growing number of studies have shown that linguistic, cultural and bodily experiences have separate influences on people's spatial representation of time (e.g., Boroditsky, 2001; Casasanto, & Bottini, 2014; Fuhrman & Boroditsky, 2010; Núñez & Sweetser, 2006; Núñez, Cooperrider, Doan, & Wassmann, 2012; Saj, Fuhrman, Vuilleumier, & Boroditsky, 2014; Torralbo, Santiago, & Lupáñez, 2006), our knowledge on why some communities adopt a future-in-front mapping whereas others a past-in-front mapping for time is still incomplete. For instance, very few studies have researched deaf signers' spatio-temporal reasoning.

Sign language speakers also tend to use spatio-temporal metaphors to express time. For instance, signers' bodies are often referred to as a deictic reference of *now*, and the future is signed to the front (e.g., the American Sign Language, Emmorey, 2001) relative to the signer's body, and the past to the back (e.g., the French Sign Language, Maeder & Loncke, 1996; the Spanish Sign Language, Pereiro & Soneira, 2004). At first sight, it would seem reasonable to assume that the metaphorical timelines in those sign languages would agree with the way these are used in the corresponding spoken languages.

Interestingly, there are dramatic differences in the deictic sagittal timelines between the Chinese Signed Language (CSL) and Mandarin Chinese. In Mandarin

Chinese, the sagittal space-time word “前/qian” indicates both the spatial concept of *forward/front* and the temporal concept of *early/before* (Yu, 2012) (e.g., “前天/qian tian”, literally: *front day*, meaning: *the day before yesterday*). A case study on gestural behaviour has shown that Mandarin speakers can point to the back or front of their body to refer to the conception of *before*, depending on whether the language suggests an ego-moving perspective (e.g., We are running to the future ahead.) or a time-moving perspective (e.g., The future is coming.) (Chui, 2011). Recent quantitative research, on the other hand, finds that Mandarin speakers are more likely to gesture the past to the front when referring to temporal expressions with the sagittal space-time word (前/qian) (Gu, Mol, Hoetjes, & Swerts, in prep). Partially due to this lexical effect, some Mandarin speakers even explicitly report to believe the past to be positioned behind and the future in front of them (Gu, Zheng, & Swerts, 2016).

In CSLs, however, the spatial *forward* and the temporal *early/before* are signed differently, i.e., the sign of *front* is only used for the spatial concept of *forward*, whereas the concept of *before/past* is signed towards the back (e.g., Zheng, 2009; Wu & Li, 2012). In other words, in their lexicon, deaf signers only have the past-at-back space-time mappings, which is different from Mandarin speakers who additionally have past-in-front mappings (Table 1). As deaf signers learn the spatial concepts earlier than the abstract concepts of time, it is plausible that if a signer has not acquired the Mandarin space-time word (前/qian) as a temporal past conception, s/he is likely to interpret the word as a spatial concept of *forward*, which is consistent with that in CSL (*front* in the space). By contrast, if a signer has acquired the space-time word as a temporal past conception, s/he is likely to map the past to the back as suggested by the CLS past-at-back mappings, or s/he may also establish new space-time mappings with the past in the front, similar to Mandarin speakers.

Table 1: Differences between Mandarin Chinese and Standard CSL in sagittal spatio-temporal metaphors.

	Front (space)	The day before yesterday (time)
Mandarin	前面 (<i>front surface</i>)	前天 (<i>front day</i>)
		
CSL	One hand with the index finger extended, <i>point to the very front.</i>	The index and middle fingers <i>point to the back</i> once.

Note: The spatial concept of *front* in Mandarin is consistent with that in CSL. Figures of signs are reproduced from the CSL, 2003.

Given the cross-linguistic differences in space-time metaphors between Mandarin Chinese and CSL, and given that learning a new category of spatial metaphors for time may influence one’s mental representation of time (Boroditsky, 2001), this paper aims to study (1) whether the differences in space-time metaphors between Mandarin Chinese and CSL influence Chinese deaf signers’ understanding of time; (2) in the context of

Chinese culture, whether the acquisition of Mandarin sagittal spatial metaphors leads Chinese deaf signers to a change in space-time mappings. To this end, we have conducted two studies: study 1 used a clock question to test how Chinese deaf signers interpret the sagittal space-time word 前/qian (spatial *front* or temporal *before*); study 2 used a temporal diagram task to explicitly examine Chinese deaf signers’ space-time mapping.

Study 1: The Clock Question

Method

Participants

15 deaf signers ($F = 8$) from Rizhao Special Education School participated in the experiment. They were fluent users of Standard CSL. They studied in different grades at school, ranging from the 4th grade to 9th grade ($M = 7.5$). Their mean age was 17.6 years ($SD = 2.9$). The average hearing loss was moderate-severe, as reported by the signers themselves and their teacher ($M = 3.8$, 1-Slight, 2-Mild, 3-Moderate, 4-Moderately Severe, 5-Severe, 6-Profound). Permission was granted to the investigators to have access to the participants’ Mandarin Chinese exam scores from the record of their last end-term exam.

Materials and Procedure

Signers were given a questionnaire to fill in personal information and family background. The instructions were not in sign language but in written Mandarin. In the middle of the questionnaire, there was a clock question (Table 2). The sagittal space-time word 前/qian (literally *front/forward* or *temporally before*) in this question is somewhat ambiguous in meaning though mainly used as a temporal expression. Most Mandarin speakers will interpret the question as moving the clock one hour *before/earlier*, thus answering the question as 12 AM (Lai & Boroditsky, 2013). However, if deaf signers think of the space-time word (前/qian) as a spatial *front*, then they are likely to move the clock one hour *forward*, thus giving 2 PM as an answer. It is also assumed that deaf signers of higher Mandarin proficiency levels are more likely to interpret the space-time word as a *temporal past*, as opposed to signers of lower Mandarin proficiency levels.

Table 2: 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	<i>forward front</i>	one hour	is which hour
what time is it if I would ask you to move the clock one hour	<i>forward/before (early)</i>		

Data Analysis

Data of two participants were excluded from the analysis, as they did not fully complete the questionnaire. As a dependent variable, we counted participants’ responses to the clock question (answer: 12 AM or 2 PM).

We would discuss below how those responses were moderated by possible factors. The first and most important factor was 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. Second, signers' Mandarin exam score (*exam score*) was used to supplement the proficiency measurement, albeit that the exam 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. Participants' *hearing loss* and their parents' deafness (*deaf parents*) were also considered to be factors that may influence participants' space-time mappings.

Results and Discussion

About 70% of participants (9 out of the 13 deaf signers) responded according to the *spatial* understanding of the word “前/qian” (forward), giving 2 PM as an answer. In comparison to the 13% (3 out of 24) of Mandarin monolinguals in Lai & Boroditsky (2013)'s study, Chinese deaf signers were significantly more likely to give an answer of 2 PM than Mandarin monolinguals (Fisher exact test, $p = .001$, Odds Ratio = 15.75, 95% CI = [2.91, 85.22]). Given that these deaf signers have already learned Mandarin temporal conceptions in low grades, this indicated that participants may still be influenced by the spatial sign of *front* from their CSL.

Furthermore, we tested whether Mandarin proficiency influenced signers' understanding of the space-time word (前/qian). The results showed that the factor *grade* was significant ($\beta = .387$, $t = 3.01$, $p = .020$, 95% CI = [.083, .691]), while controlling for the other factors *exam score*, *age*, *deaf parents* and *hearing loss* (Table 3). This indicated that those higher graders were more inclined to interpret the space-time word (前/qian) as temporal *before* (12 AM). Assuming that higher graders are likely to have higher Mandarin proficiency levels than lower graders, the effect of *grade* suggests that signers' Mandarin proficiency levels play a role in shaping their understanding of the conceptions of the space-time word (前/qian). A seemingly contradictory finding is that *exam score* was not significant ($\beta = -.0002$, $t = -.020$, $p = .985$, 95% CI = [-.019, .019]), keeping all other variables constant. This might be due to the fact that there was only limited variation in Mandarin proficiency within a grade.

Table 3: Results of the clock question.

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
_cons	-1.20	-1.76	.122	-2.83 .413

Note: * $p < .1$, ** $p < .05$

The fact that signers with lower Mandarin proficiency levels were more likely to give an answer of 2 PM may be caused by their use of spatial reference of *front* (primarily be triggered by lexical cues), though this does not necessarily imply that they also explicitly conceptualise the future as in front of them. Study 2 investigated the Chinese deaf signers' sagittal space-time mappings using a more explicit temporal diagram task.

Study 2: A Temporal Diagram Task

Method

Participants

All participants in study 1 took part in study 2.¹

Materials and Procedure

Participants performed a temporal diagram task (de la Fuente *et al.*, 2014, Experiment 1), which has been adapted and used in Gu, Zheng, and Swerts (2016)'s study. They sat at a table and saw 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 (Fig. 1). Participants were provided with a written instruction in which they could read that *the day before yesterday* (前天/qian-tian, tr. front day) Xiaoming went to visit a friend who liked eating apples, and *the day after tomorrow* (后天/hou-tian, tr. back day) he would be going to visit a friend who likes eating pears. 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/yi-qian, tr. to front) and the *pear* to the box that corresponded to the *future* (今后/jin-hou, tr. now back). The mentioning order of the *apple* and *pear* and the way they were paired with the *day before yesterday* or *the day after tomorrow* were counterbalanced. Note that there was no ambiguity in the interpretation of the space-time words in this instruction (cf. study 1), e.g., the concept of the space-time expression “前天/qian-tian”, tr. *front day* can only be interpreted as *the day before yesterday*.

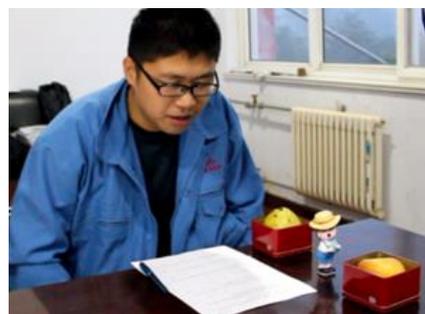


Figure 1: Schematic setting up of the Experiment reproduced from Gu, Zheng, & Swerts (2016).

Following Gu, Zheng, & Swerts (2016)'s procedure, we asked participants to perform the task with real entities rather than doing it on paper (cf. de la Fuente *et al.*, 2014).

¹ Participants did Study 2 first, followed by the clock question (Study 1) that was inserted in the middle of a questionnaire. As participants were not given any feedback, no significant influence was expected from the first task on the second one.

This can minimise the potential projection of vertical timelines into the sagittal axis (as Chinese can conceptualise time vertically, mapping the *up* and *down* to the time conceptions of *early* and *late*, e.g., Boroditsky 2001; Gu, Mol, Hoetjes, & Swerts, 2017). Participants were tested individually in Rizhao, China, and all instructions were not in sign language but in written Mandarin Chinese. After all tasks, they were given a small token of appreciation and signed a consent form.

Data Analysis

In total, data of fourteen participants were used in the analysis (Data from a 4th grader was excluded as she was helped during the task). The dependent variable was participants' responses towards space-time mappings (past-in-front or past-at-back).

As was the case with the previous experiment, we again controlled for possible factors such as participants' *exam score*, *grade*, *age*, *hearing loss* and *deaf parents*.

Results and Discussion

42.9% of participants responded according to the past-in-front mapping, placing the past event in the box in front of the character and the future event in the box behind it. Although this rate was not significantly different from 50%, $p = .79$, Odds Ratio = .75, 95% CI = [.18, .71] ($N = 14$), we expect it to be significant with a larger sample size. It is unlikely that deaf signers randomly performed the space-time mappings by chance, as shown below.

As we further examined the relationship between signers' Mandarin proficiency and their responses towards space-time mappings, controlling for *deaf parents*, *age* and *hearing loss*, the results showed that *grade* and *exam score* were significantly positive (Table 4). Specifically, first, higher graders had a stronger tendency to perform past-in-front mappings ($\beta = .34$, $t = 2.61$, $p = .031$, 95% CI = [.039, .641]), keeping all other variables constant. Second, those who had higher Mandarin exam scores were more inclined to respond towards past-in-front mappings ($\beta = .008$, $t = 2.04$, $p = .075$ (two-tailed), 95% CI = [-.001, .017]), *ceteris paribus*. The results indicated that Mandarin proficiency has an effect on 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 gradually establish the Mandarin past-in-front space-time mappings during their learning process of Mandarin.

Table 4: Results of the temporal diagram task.

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
_cons	-1.52	-4.38	.002	-2.32	-.722

Note: * $p < .1$, ** $p < .05$

Additionally, those signers whose parents were deaf

were less likely to perform past-in-front mappings ($\beta = -.48$, $t = -2.04$, $p = .075$ (two-tailed), 95% CI = [-1.015, .062]), *ceteris paribus*. The results suggested that deaf parents may influence deaf children's space-time mappings. This is plausible, as deaf children may often be exposed to the past-at-back temporal signs performed by their deaf parents. Consequently, they may be more likely to have past-at-back space-time mappings than their counterparts with non-deaf parents.

General Discussion

In study 1, we used a clock experiment to examine how Chinese deaf signers interpreted Mandarin spatial metaphor of time. We observed effects of both CSL and learning Mandarin Chinese on their understanding of time. There is a co-activation of signs even in the non-signing linguistic contexts, whereas within the signers' group, those with higher Mandarin proficiency levels were more likely to interpret the space-time word 前/qian as temporal *before* (like Mandarin speakers). Our results suggest that language transfer occurs across modalities (i.e., a spoken language and a sign language, cf. bimodal bilinguals, Emmorey, Borinstein, Thompson, & Gollan, 2008).

Alternatively, the results can also be explained in terms of differences in time perspective-taking (e.g., Gentner, Imai, & Boroditsky, 2002; Moore, 2011; Núñez, Motz, & Teuscher, 2006; Walker, Bergen, & Núñez, 2017), which would be consistent with claims of a previous study on Mandarin-English sequential bilinguals (Lai & Boroditsky, 2013). Similar as in CSL, in English the spatial *front* usually does not have a meaning of temporal *before*. That study found that Mandarin-English speakers were influenced by English when answering the clock question in Mandarin, such that Mandarin-English speakers were less likely to answer the clock question as 12 AM, in comparison with what Mandarin monolinguals did. According to Lai and Boroditsky (2013), Mandarin speakers mostly take the time-moving perspective (12 AM), whereas English speakers mostly take the ego-moving perspective (2 PM). If monolingual signers of CSL mainly take the ego-moving time perspective in deictic time, it is possible that they gradually gain the time-moving perspective after learning Mandarin Chinese.

In study 2, we used a temporal diagram task to explicitly test deaf signers' sagittal space-time mappings. We found that some signers performed past-in-front space-time mappings. Given that Mandarin speakers also have past-in-front mappings (Gu, Zheng, & Swerts, 2016), the pattern of signers' space-time mappings may be due to a characteristic of the Chinese culture, in which people give more importance to tradition and focus more on the past (Guo, Ji., Spina, & Zhang, 2012), analogous to what appears to be true for Moroccans. However, within the Chinese culture, we found that the extent to which signers performed past-in-front mappings was positively related to their Mandarin proficiency. Similar to the results of the clock question, we found effects of Mandarin proficiency on Chinese signers' spatio-temporal reasoning, which suggests that learning a novel linguistic spatial metaphor for time may foster a new way of thinking about time (Boroditsky, 2001; Hendricks & Boroditsky, 2015).

Future studies can further examine this using a non-linguistic task (e.g., Fuhrman & Boroditsky, 2010).

Alternatively, according to the temporal-focus hypothesis (de la Fuente *et al.*, 2014), cultural attitudes towards time exert an important influence on people's space-time mappings. One may argue that the typical Chinese culture is more past-focused than that of the Chinese deaf culture, although this needs a further survey. Given such an assumption, signers may gradually adjust themselves into the mainstream Chinese culture and hence become more similar to the Mandarin speakers. Future study can additionally control for signers' temporal-focus of attention to corroborate the present findings.

Note that in Standard CSL, there are no sign metaphors that reflect past-in-front space-time mappings but only signs for past-at-back mappings. It would therefore be ideal if we could supplement the current set of results with those obtained from a control group of monolingual deaf signers of CSL to provide stronger evidence that deaf signers indeed think of the past as being situated at the back, though, practically, we can hardly find a group of deaf signers who do not know Mandarin Chinese. Future research may also study illiterate hearing Mandarin speakers to at least examine the effects of written Mandarin proficiency on people's spatial-temporal conceptualisations. By contrast, in our study, we found that a certain proportion of Chinese deaf signers put the entity corresponding to the past in the front. Additionally, the effects of *exam score* and *study grade* clearly suggest that Chinese deaf signers can gradually "learn" to have past-in-front mappings as a function of an improved Mandarin proficiency. This is an intriguing finding as it shows that within the Chinese culture, learning a spatial metaphor in a different modality can still influence people's mental representations of time.

Furthermore, the past-in-front mappings performed by the deaf signers in the temporal diagram task can be argued to be a consequence of a direct translation of the spatial conception of *front* in the Standard 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 interpret the sagittal space-time word (前/qian) as *front* in space rather than understanding the concept of space-time expression (前天/qian-tian, front day) as the past conception of *the day before yesterday*, though the conception of *front day* is not ambiguous at all. This is, however, quite unlikely. First, the instructions were checked beforehand by their teacher to ensure that those participants have previously learned all the vocabulary and would be able to understand the sentences and the concept of *front 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 word (前/qian) as *front*, thus would produce a larger proportion of past-in-front 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 past-at-back mappings, which was consistent with the CSL where the past is signed towards the back. This indicates that

participants even with a low Mandarin proficiency can already understand that *front day* is a temporal concept. Therefore, needless to say for the higher proficient group, the tendency of having past-in-front space-time mappings likely reflects their spatio-temporal reasoning.

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

Additionally, we conducted both studies in Mandarin Chinese rather than in CSL. It would be interesting to ask the deaf signers to fulfil the temporal diagram task with a sign language instruction, the results of which probably can also reveal the effect of Mandarin Chinese on deaf signers' spatio-temporal reasoning, even when signers think in CSL. Possibly, participants may be visually primed by the spatial movements of the signs in the instruction, for example, for the clock question the CSL will give a strong hint where the clock hand is moving in the signs (either a clockwise or an anti-clockwise movement). This will not allow us to examine signers' authentic interpretation of the 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, hinting a past-at-back space-time mapping.

Conclusions

In the current study we investigate whether the Mandarin sagittal space-time metaphors influence Chinese deaf signers' spatio-temporal reasoning. In two experiments, we found that signers with higher Mandarin proficiency were more likely to interpret the Mandarin space-time word (前/qian) as *temporal before* (Study 1), and to perform past-in-front space-time mappings (Study 2), in comparisons to signers with lower Mandarin proficiency. These findings not only provide within-culture evidence for the influence of language on thought (cf. Boroditsky, 2001; Hendricks & Boroditsky, 2015), but also demonstrate that even cross-modal space-time metaphors can have an impact on signers' spatio-temporal reasoning.

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