THE EFFECT OF LANGUAGE AND SPATIAL INFORMATION ON THE PERCEPTION OF TIME IN MANDARIN AND ENGLISH SPEAKERS

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Abstract

Existing studies suggest that English speakers conceptualize time on both the sagittal and transverse axes (Casasanto & Jasmin, 2012), whereas Mandarin speakers conceptualize time on both the sagittal and vertical axes (Boroditsky 2001; Scott, 1989). It has been suggested that the different temporal directions on the sagittal dimension between the two languages are likely to be caused by the different emphases of temporal sequences: deictic time vs. sequential time. While a large amount of literature has focused on differences across the two languages in terms of using different axes, very little has looked at differences that exist within axes. I report findings from English monolinguals, Mandarin monolinguals and Mandarin-English (ME) bilinguals on an explicit task that involves pointing directions for temporal words. It showed that English monolinguals associated the future with front and up; the overt encoding of metaphor has a significant effect in Mandarin but not in English. More importantly, ME bilinguals showed intermediate patterns. The current study tested cross-linguistic influences on the perception of temporal information. It found that when two languages encode time with different spatial words, both language and spatial cues can affect bilingual speakers' associations between time and directions. Future studies could test other languages, such as Māori, which see the past as ahead and the future as behind based on visual accessibility.

1. Background

1.1 Introduction

How do we perceive time? What are our mental representations of time? Time is an abstract concept, and it cannot be directly felt. We can see objects through our eyes and we can hear sound through our ears. However, we do not have an organ evolved to feel time. One possibility is that we sense time through motion (Lakoff, 1993). We sense time by perceiving objects moving and changing status. In other words, we sense time through sensory-motor experiences. Based on Conceptual Metaphor Theory (Lakoff & Johnson, 1980/2003), we store time in our mental representation in forms of space. The spatial mental representations of time can be revealed in several different phenomena. On the one hand, people talk about time by using spatial information (Casasanto & Boroditsky, 2008). We talk about an upcoming event as it is ahead of us, and we put our past behind us. At the same time, we provide temporal gestures accompanying speech, and these temporal gestures can reflect how time is structured in one's mind (Casasanto & Jasmin, 2012). On the other hand, spatial information can influence how people make temporal judgements (Boroditsky & Gaby, 2010; Casasanto, 2008; Matlock, Ramscar, & Boroditsky, 2005). Casasanto (2008) described an experiment which found that it was difficult for the English speakers to ignore a growing line on the screen when they tried to estimate temporal durations whereas it was difficult for the Greek speakers to ignore a glass that was being filled with water during the same temporal judgement task. These results are consistent with the fact that English uses length to describe duration but Greek uses volume such as *much time* instead of using *long time*.

Results from Casasanto (2008) also suggest that people's mental representation of duration can occupy a three-dimensional space. In fact, people's mental representation of time can be on any dimension in a three-dimensional space. The use of three-dimensional space is relevant to the current study and therefore will be elaborated in the next section.

1.2 Space-Time Relationships in Three-dimensional Space

Three-dimensional space consists of the sagittal, vertical and transverse dimensions. Many studies have demonstrated that human languages encode time on both the sagittal and vertical dimensions. However, people also think about time on the transverse dimension despite the fact that languages do not encode time by using terms such as left and right.

On the sagittal dimension, time is linear and therefore time has directions. Western cultures see time as a road extending forward into the future and backward to the past (Hall, 1976: 16). Such a view is different from some non-Western cultures such as Aymara (Núñez & Sweetser, 2006) and Māori (Thornton, 1987), which see the past as ahead and the future as behind because the past can be seen whereas the future is unknown. Apart from Aymara and Māori languages, some other languages also see the past as ahead and the future as behind, including languages spoken in Western cultures, for a different reason. In many languages, including languages spoken in Western cultures such as English and German, there are two types of temporal sequences/metaphors: deictic time and sequential time (Clark, 1973; Traugott, 1978).

Deictic time describes moments as their relationships to the current moment. In deictic time, the future is ahead and the past is behind, which has been discussed previously. For example, we can say *Christmas is ahead of us*. On the contrary, in sequential time, events are put on a sequential ordering and events are described in terms of their relationships between each other. In sequential time, the past/earlier events are ahead of the future/later events. For example, *Monday is before Wednesday*. Languages that have sequential time as the dominant temporal sequence, such as Mandarin (Yu, 2012), also see the past as ahead and future as behind. However, as discussed, although Mandarin seem to be similar to Aymara and Māori, fundamentally their temporal directions are caused by different frameworks.

On the vertical dimension, Mandarin heavily relies on vertical spatial words. In Mandarin, up is associated with the past and down is associated with the future (Scott, 1989). A corpus study (Chen, 2007) showed that Mandarin uses the vertical dimension to talk about time 40% of the time, which is probably higher than any other languages. English also uses the vertical dimension to describe time, such as in *passing down to generation,* down is associated with the future (Boroditsky, 2001). However, such an expression does not appear in pairs. Nevertheless, some expressions in English indeed appear in pairs and show that time has a direction on the vertical dimension in English. For example, the future is associated with the unknown and the past is associated with the known as in *It's up in air* and *settle down*. In this pair of expressions, up is associated with the unknown, in other words, the future, and down is associated with the known, which means the past (Radden, 2004).

On the transverse dimension, the direction of time is associated with cultural artifacts such as writing directions. A large amount of research

has found a close link between transverse temporal direction and writing directions across different languages (Dobel, Diesendruck, & Bölte, 2007; Fuhrman & Boroditsky, 2010) or for the same language that is written in different directions in different geographical regions (Bergen & Lau, 2012). Research also found that in English the transverse dimension is often used for sequential time whereas the sagittal dimension is often used for deictic time.

1.3 Perception of Time and Bilingualism

One importance of studying conceptual metaphor is that it can be an approach to studying bilingualism (Jarvis, 2011). As a type of conceptual metaphor, temporal metaphor can reveal how and whether bilinguals learn new conceptualizations of time through using and learning another language when time is described differently in the two languages. Despite this, learning of new concepts such as new ways of conceiving time may not be reflected in language production. For example, it has been argued that deictic time is more easily activated than sequential time in English (Sell & Kaschak, 2011), whereas sequential time is the dominant temporal sequence in Mandarin (Yu, 2012). Several existing studies have tested how bilinguals of Mandarin and English perceive time, and it has been found that bilinguals with higher Mandarin proficiencies are more likely to use sequential time than bilinguals with lower Mandarin proficiencies (Fuhrman et al., 2011; Lai & Boroditsky, 2013). Their studies show that ME bilinguals with higher Mandarin proficiencies are more likely to associate the past with front, and the bilinguals in the English context were more likely to associate the future with front.

This type of potential effect of language is not reflected in language production, but exists in cognition and can be revealed by experimental tasks. The current study conducted an experiment on ME bilinguals and compared their behaviours with those from monolinguals of the two languages. By doing so, I reveal the effect of learning a second language on the perception of time.

1.4 Aims of the Current Research

Previous research (e.g., Fuhrman et al., 2011) has looked at the within-dimensional difference between English and Mandarin. However, they only used the frontal space when testing temporal sequences (e.g., Fuhrman et al., 2011; Walker, Bergen, & Núñez, 2014), their study failed to test and find temporal directions on the sagittal dimension for both English and Mandarin. The current study was going to test the within-dimensional differences between Mandarin and English by using a different methodology.

The other aim was related to the fact that Mandarin heavily relies on spatial words when describing conventional temporal expressions. When observing a conversation in Mandarin, Chui (2011) found that the Mandarin speaker associated *zuotian* (yesterday) with back, but he also associated *zhiqian* (before now) with front. The latter result clearly revealed a possibility of an immediate effect of spatial information in temporal perception.

Previous studies also have found that Mandarin speakers are more likely to give vertical gestures when talking about temporal words with vertical spatial information (Gu, Mol, Hoetjes, & Swerts, 2014), and they are also likely to give sagittal responses when being prompted with sagittal spatial information (Lai & Boroditsky, 2013). The current study was going to explore the immediate effect of spatial information in Mandarin and look at whether Mandarin speakers behaved according to the spatial information. Therefore, the aims of the current study were:

1. to test Mandarin and English speakers' mental time lines on the three dimensions, and
2. to test whether overtly embedded Mandarin spatial cues can have immediate effects on Mandarin speakers, and
3. to compare results between bilinguals and monolinguals and find possible effect of language on temporal perception

2. Experiment

2.1 Methodology

2.1.1 Experimental Task

The current study used a 3D pointing task that had been previously adopted by others (Boroditsky, 2001; Fuhrman & Boroditsky, 2010). The advantage of the 3D pointing task is that it uses a three-dimensional space rather than only using the space in front of people (e.g., Fuhrman et al., 2011). In such a task, a participant needed to point to a direction for each stimulus (a word). In the current study, a list of stimuli was created so quantitative data could be collected. The list consisted of 80 items, including fillers, which will be described in the following sections. The participants first needed to point directions for the 80 items in one condition, and then repeat the experiment in other three different conditions. The four conditions made a whole session of

the experiment. Whether doing one or two sessions was dependent on whether a participant was monolingual or bilingual (see below).

2.1.2 Participants

10 native English speakers and 10 Mandarin-English (ME) late bilinguals were recruited by using public sign around the campus of the University of Canterbury, whose age were between 18 to 34. 10 Mandarin monolinguals were recruited in a vehicle research academy in ChangChun city in Mainland China. Their participation was for an exchange of shopping vouchers. As for the Mandarin monolinguals, their ages were between 30 and 40, and their jobs were to do vehicle testing. The Mandarin monolinguals' educational level was unknown, but based on the nature of their job, their education level was presumably high school and technological college graduates, and they reported that they had little knowledge about English. During the recruiting process, the native English speakers and the bilinguals were asked how many languages they can speak. The bilinguals also needed to answer when they learned English. These were to make sure that the native English speakers had no knowledge about Mandarin and the bilingual speakers did not learn English from childhood and did not speak Cantonese, and therefore, late bilinguals can be recruited. The reason is that it has been found that Mandarin proficiency has an effect of the likelihood of using sequential time in ME bilinguals (Fuhrman et al., 2011; Lai & Boroditsky, 2013). Late bilinguals are more likely to show the opposite temporal direction to that in English. We also asked them to answer a questionnaire that had six questions regarding the use of English. Their answers indicated that they were late ME bilinguals and used Mandarin every day.

2.1.3 Materials

As noted above, the material was a list of eighty short words in both languages. In each language, there were twelve pairs of time-related words and some of them had overt spatial cues. The rest of the list was fillers. The fillers contained five pairs related to time of day, five pairs related to health, five paired related to emotion, five pairs of random words with positive and negative values, and sixteen non-paired random words. In each pair related to time of day, one was related to daytime and one was related to night. In each pair related to health and emotion, one had a positive meaning and the other one a negative meaning. The reason for including negative and positive

meanings in each pair was to include stimuli that were likely to elicit confident answers. There were two types of overtly embedded spatial cues.

1. The first type consisted of spatial cues in Mandarin Chinese on the sagittal dimension. In this type of cue, *qian* and *hou* are used for describing temporal sequences or deictic direction (there are disagreements among studies, but based on recent studies they are highly likely to be sequential). The Mandarin word *qian* means 'before' or 'front' in English, and it can be used in both spatial and temporal situations. The Mandarin word *hou* means 'after' or 'back' in English, and it also can be used as a spatial and a temporal reference. For example, a word *qian tian* (literal meaning would be front day) means the day before yesterday, and *liang-ge-yue hou* (literally means two months back) means two months later or in two months' time depending on the context.

2. The second type consisted of spatial cues in Mandarin Chinese on the vertical dimension. In this type of cues, *shang* and *xia* were used for describing temporal information. The Mandarin word *shang* and *xia* means up or upper and low or lower in English respectively. For example, *shang ge yue* (literally means upper month) means last month and *xia ge yue* (literally means lower month) means next month.

Table 1 is a summary of spatial cues in the two languages. Note that there were four words in English containing before and after, however, because their existence was only a side-effect of translational equivalence, they were not the testing target in the current study. Preliminary analyses also suggested that the four English spatial cues had no effect on the English monolinguals and the bilinguals.

Table 1: The numbers of each type of spatial cues for each time type in the two languages

LANGUAGE	MANDARIN		ENGLISH	
TIME TYPE	PAST	FUTURE	PAST	FUTURE
type 1: Mandarin sagittal cue	5	5	0	0
type 2: Mandarin vertical cue	3	3	0	0
no cues	4	4	10	10

In order to make it easier for future references, the Mandarin cues *qian, hou, shang, and xia* (literally meaning front, back, up and down respectively) will be addressed as Mandarin-past-front cue, Mandarin-future-back cue, Mandarin-past-up cue and Mandarin-future-down cue respectively.

2.1.4 Procedure

Monolingual English and Mandarin speakers did one session in their native languages, and bilingual speakers did two sessions in two different languages. Half of the bilinguals did the English part first in order to counterbalance. The two sessions for each bilingual were at least one week apart. Each of the eighty phrases appeared once in each condition. Words were also randomized in each condition and there were four conditions. The first condition was always an 'any-direction' condition, in which participants can point any direction they wanted when they saw the words. At the beginning of the first condition there were ten trials and the participants needed to point a direction for each of them. The ten words covered six directions: up, down, front, back, left and right, so after completing the ten words the participants knew that they can point freely in 3D space. The first condition served as a practice, and also suggested how people intuitively associate time with directions.

In the other three conditions, the participants' pointing directions were restricted. The other three conditions were 'front-back only', 'left-right only' and 'up-down' only. The three restricted conditions were in random orders. At the beginning of each of the three follow-up conditions, instructions appeared on the screen which told them that they can only point in two opposing directions on one dimension, and in each of the three conditions the participants only pointed two directions. The whole experiment was designed and run in E-prime 2.0. The experiment started by showing three pages of instruction, which told the participants to press the SPACE key to see the next word, and that they must always use the same hand to press as they have used to point. This was to avoid the tendency that people might repeat their previous action. There were three minutes between conditions so they could rest their hands for a while. The experiment for each participant was video-recorded. All of the responses were coded manually and double- checked by an external RA before any further analyses.

2.1.5 Hypotheses

Referring to the aims of the experiment, I hypothesize the following potential results based on the past research. The hypotheses are based on existing

studies on English and Mandarin speakers' mental representation of time. The hypotheses are listed in Table 2.

Table 2: Hypotheses on the association between time and direction on the three dimensions for the two languages. The hypotheses are for both the any-direction condition and the restricted conditions. Grey cells indicate the participants' primary dimension in the any-direction condition, n/a: not applicable.

GROUP	DIMENSION	RESULT	
English condition (monolinguals and bilinguals)	sagittal	Front for the future more often than for the past	
	vertical	Up for the future more often than for the past	
	transverse	Right for the future more often than for the past	
Mandarin condition (monolinguals and bilinguals)		HAVING CUES	NO CUES
	sagittal	Back for the future more often than for the future	Front for the future more often than for the past
	vertical	Up for the past more often than for the future	Up for the past more often than for the future
	transverse	n/a	Right for the future more often than for the past

3. Results

Data from each of the four conditions was analyzed separately. Data was analyzed in mixed effect logistic regression models in R (R Development Core Team, 2015) with packages Lme4 (Bates, Mächler, Bolker, & Walker, 2015) and LanguageR (Baayen, 2013). In each condition, the first model contained word and participants as random intercepts and the interaction between time type (past vs. future) and language group/context as a fixed effect. After that, for each language group/context, a second model was tested. Preliminary analyses showed that English spatial cues such as before and after had no effects on the English monolinguals and the bilinguals in the English condition. Therefore, only time type was tested for the English monolinguals

and the bilinguals in the English condition. As for the bilinguals in the Mandarin condition and the Mandarin monolinguals, the interaction between time type and spatial cues was tested.

The order of the results will be as follows. I will first present results on the sagittal dimension, followed by those on the vertical and transverse dimensions. On each dimension, I will first present the overall results from the any-direction condition; and then I will present results on the sagittal, vertical and transverse dimensions.

3.1 Overall Tendencies

When analyzing responses of temporal words in the any-direction condition, I first ran Wilcoxon tests by word and by subject within each of the three axes between language groups or contexts. Results from tests by subject show that the Mandarin monolinguals used the vertical axis significantly more often than the English monolinguals ($p < .01$). Results from tests by word also reveal a similar result on the vertical axis ($p < .0001$), and the Mandarin monolinguals used the sagittal and the transverse axes significantly less often than the English monolinguals ($p < .0001$ and $p < .0001$). The bilinguals in the English condition used the sagittal and the vertical axes more often ($p < .05$ and $p < .05$), and used the transverse axis less often than the English monolinguals ($p < .0001$). The Mandarin monolinguals used the vertical and the transverse dimensions more often ($p < .01$ and $p < .001$), and used the sagittal dimension less often than the bilinguals in the Mandarin condition ($p < .0001$).

3.2 Sagittal Responses from the Any-direction Condition

When testing sagittal responses in the mixed effect logistic regression model, it was found that the interaction between language group/context and time type was significant ($p < .001$). The different patterns across groups can be seen in Figure 1, and the result of the model can be found in Appendix in Table 8.

Figure 1 shows that the English monolinguals strongly associated front with the future, and back with the past. The results of the regression model showed that the effect of time type was significant ($p < .001$). The bilinguals in the English context also reveal a similar pattern ($p < .001$), but not as strong as the English monolinguals. The bilinguals in the Mandarin condition seemed to have no preference to associate the future with either front or back and they associated back with the past. The Mandarin monolinguals mostly associated back with the future and they seemed to have no preference to associate the past with either front or back.

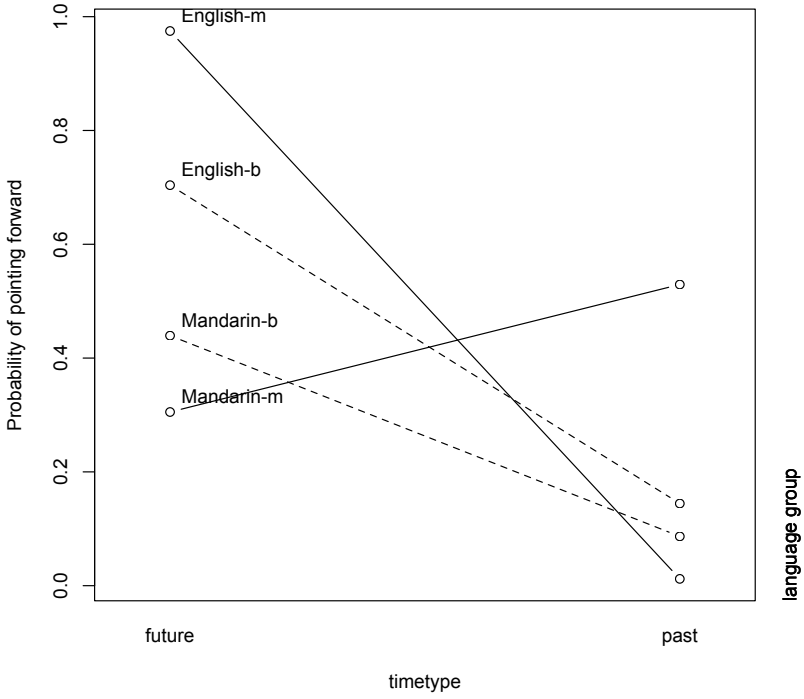

Figure 1: Plot for the results of the model testing the interaction between language group and time type for the participants' responses on the sagittal dimension in the any-direction condition, b/dashed line: bilinguals, m/solid line: monolinguals.

When running tests for the effect of sagittal cues, we found that Mandarin sagittal cues significantly interacted with time type for the bilinguals in the Mandarin context ($p < .05$) and the Mandarin monolinguals ($p < .05$), both groups pointed back more often for the future when there were Mandarin-future-back cues, and they pointed front more often for the past when there were Mandarin-past-front cues. These results suggest that Mandarin sagittal cues have immediate effects in Mandarin and they can be revealed in Figure 2.

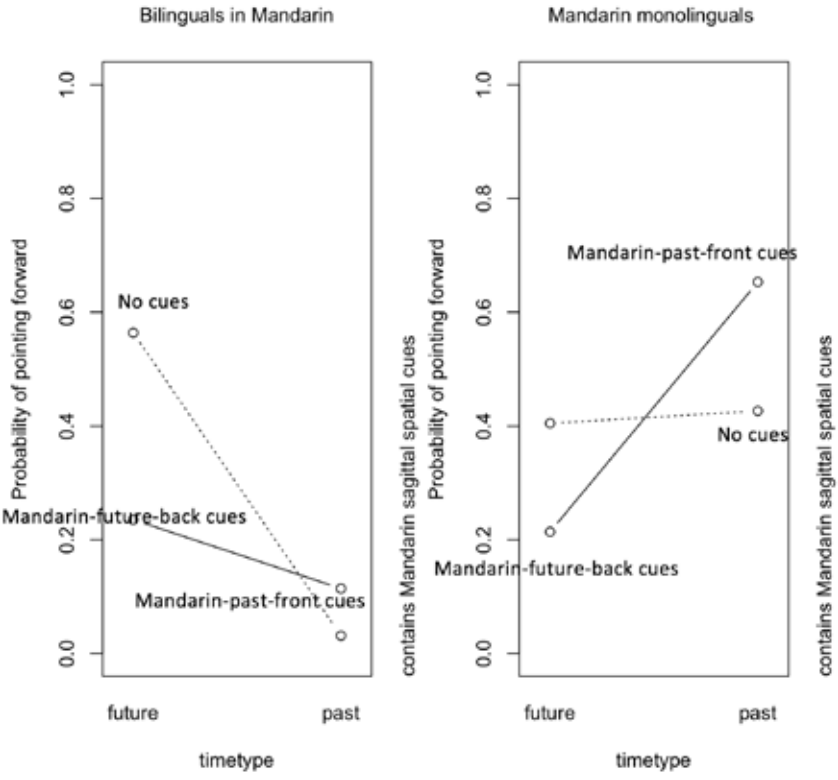

Figure 2: Plots for the results of the models testing the interaction between time type and Mandarin sagittal cues for the bilinguals in the Mandarin condition (left) and the Mandarin monolinguals (right) in the any-direction condition, dashed line: words without cues, solid line: words with sagittal cues.

3.4 Responses from the Sagittal-only Condition

When being forced to provide responses on the sagittal axis, language group significantly interacted with time type ($p < .001$). Both the English monolinguals and the bilinguals in the English condition showed significant preferences toward front for the future, and back for the past, however, the preference was stronger for the former group ($p < .001$) than for the latter ($p < .001$). The bilinguals in the Mandarin context pointed forward for the future and backward for the past both less often than when they were in the English context. The Mandarin monolinguals showed the weakest front-future and

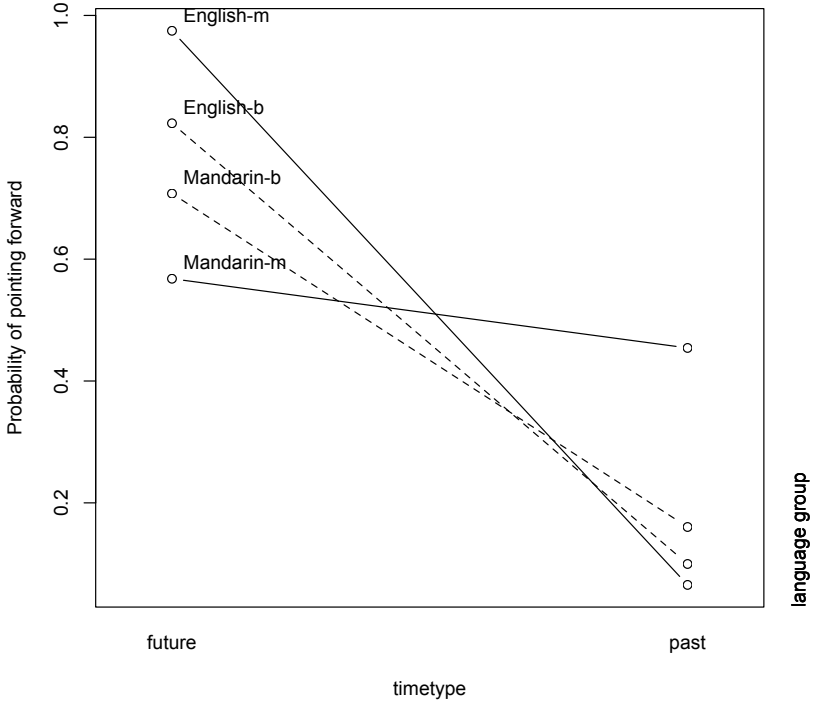

Figure 3: Plot for the results of the model testing responses in the sagittal-only condition across three groups, b/dashed line: bilinguals, m/solid line: monolinguals

back-past associations. The results of the model are plotted in Figure 3, and given in Appendix in Table 9.

When conducting analyses for the bilinguals in the Mandarin condition and the Mandarin monolinguals, it was found that the interactions between time type and Mandarin spatial cues for both groups were near-significant ($p = 0.085$ and 0.083 respectively). Both groups pointed front for the future less often when there were Mandarin-future-back cues, and pointed back for the past less often when there were Mandarin-past-front cues, but the effect of Mandarin cues was stronger for the Mandarin monolinguals than for the bilinguals. The interactions for both groups are plotted in Figure 4.

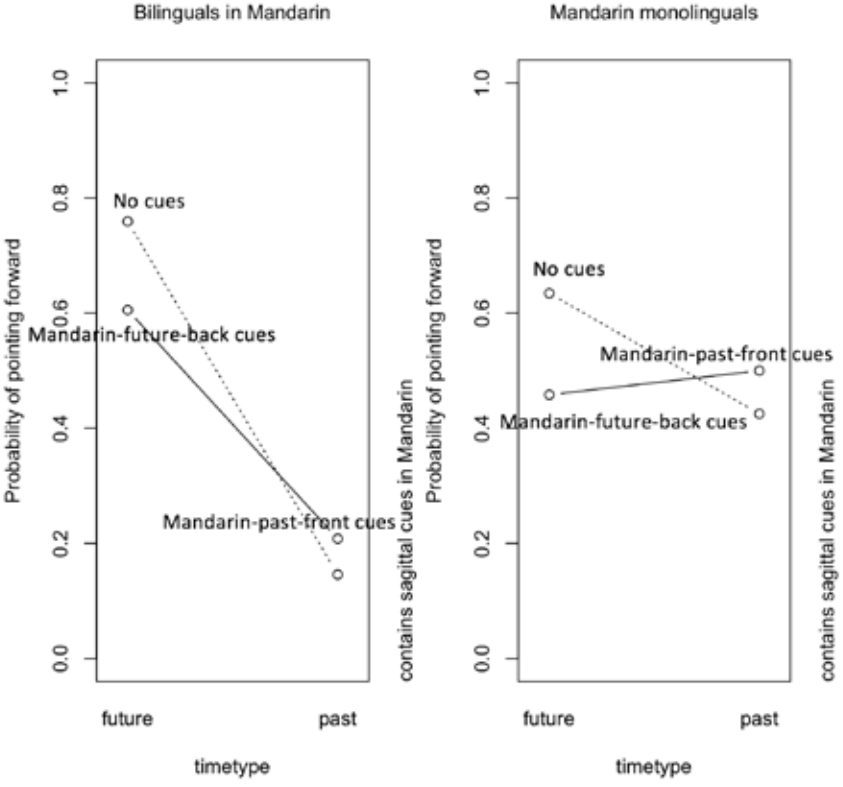

Figure 4: Plots for the results of the models testing the interaction between time type and sagittal cues for the Mandarin monolinguals (right), and the bilinguals in the Mandarin context (left). Solid line: temporal words that contained sagittal directional cues in Mandarin, dashed line: temporal words that did not contain sagittal directional cues in Mandarin

3.5 Vertical Responses from the Any-direction Condition

When testing vertical responses in the any-direction condition, language also significantly interacted with time type ($p < .05$). The English monolinguals strongly associated up with the future and down with the past ($p < .001$). The bilinguals also showed the similar pattern but not as strong as the English monolinguals ($p < .05$). The bilinguals in the Mandarin context also strongly associated up with the future; however, their association between down and the past was weak. The Mandarin monolinguals' association between up and

the past was strong; however, they mostly associated up with the future. The different patterns across groups can be seen in Figure 5. The results of the model are given in Table 10 in Appendix.

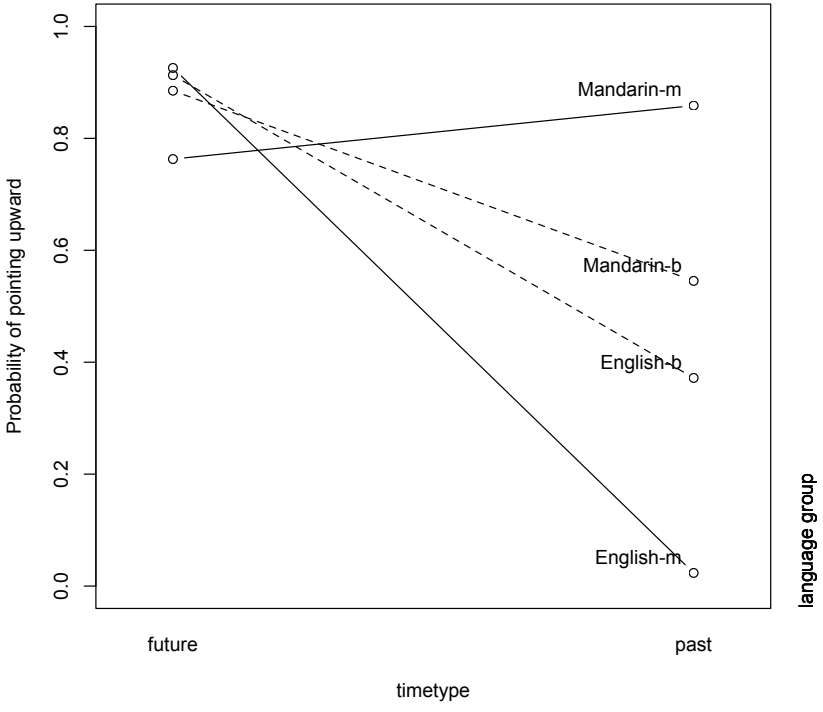

Figure 5: Plot for the results of the model testing the interaction between language group and time type for the participants' responses on the vertical dimension in the any-direction condition, b/dashed line: bilinguals, m/solid line: monolinguals

Vertical spatial cues were tested in Mandarin. Vertical cues significantly interacted with time type for the bilinguals in the Mandarin condition and the Mandarin monolinguals. The bilinguals in the Mandarin condition ($p < .001$) pointed down more often for the future when there were Mandarin-future-down cues, and they pointed up more often for the past when there were Mandarin-past-up cues. The Mandarin monolinguals almost categorically pointed down for the future and up for the past when there were vertical cues and they did not show

any preferences when there were no vertical cues. The results for the bilinguals in the Mandarin condition are plotted in Figure 6. The Mandarin monolinguals' responses for words with vertical cues were too sparse to explore reliably in regression models, and therefore, their responses for words with vertical cues are summarized in Table 3.

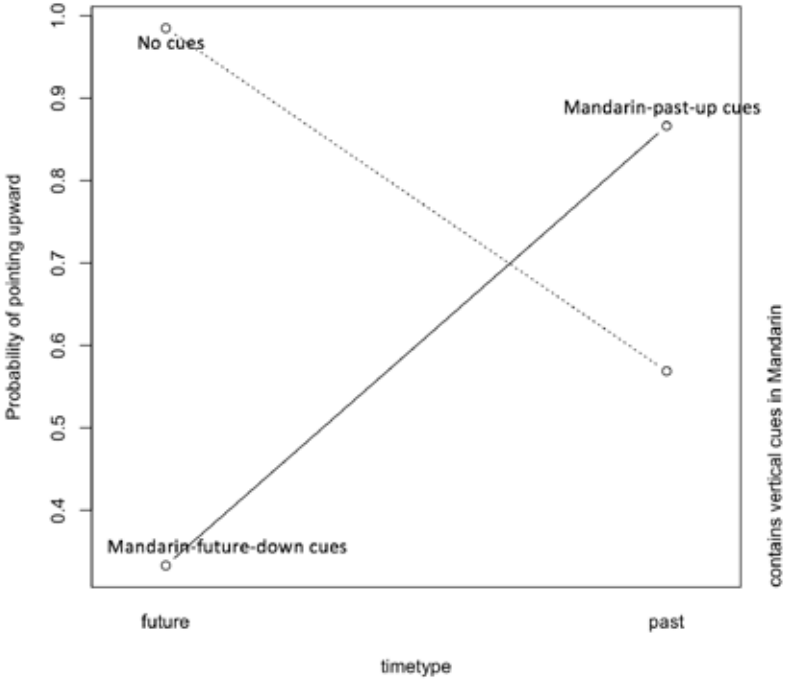

Figure 6: Plot for the results of the models testing the interaction between time type and Mandarin vertical cues for the bilinguals in the Mandarin condition, dashed line: words without cues, solid line: words with sagittal cues.

Table 3: Mandarin monolinguals' vertical responses for temporal words with vertical cues in the any-direction condition

	DOWN	UP
Future	9	3
Past	0	16

3.6 Responses from the Vertical-only Condition

When testing responses on the vertical axis, it was found that language group/context significantly interacted with time type ($p < .001$). Both the English monolinguals and the bilinguals in the English context showed significant preferences toward up for the future, and down for the past and the preference was stronger for the English monolinguals ($p < .001$) than for the bilinguals ($p < .001$). Both the bilinguals in the Mandarin context and the Mandarin monolinguals showed weak preferences, and the preference for the Mandarin monolinguals was weaker than the bilinguals. The differences across groups/conditions can be seen in Figure 7. The results of the model are in Table 11 in Appendix.

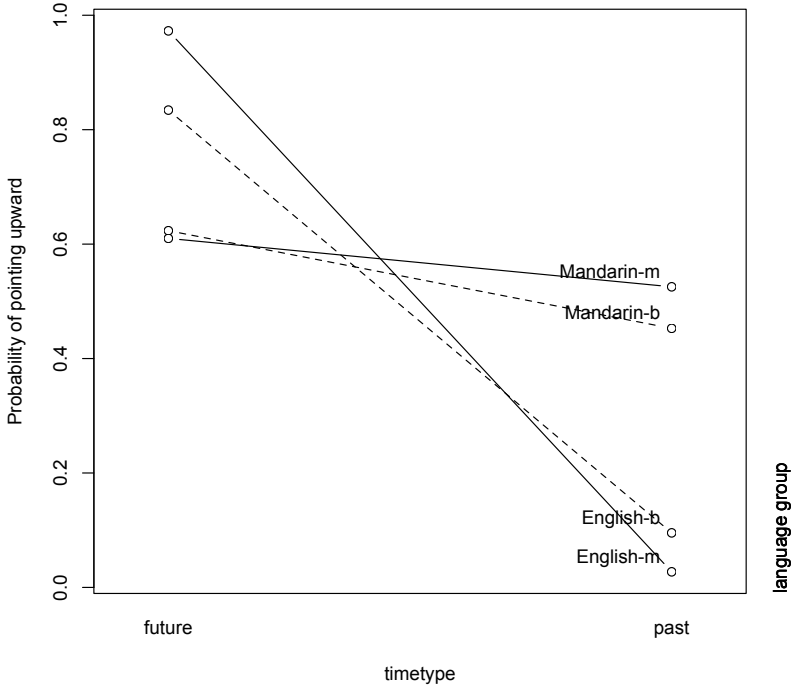

Figure 7: Plot for the results of the model testing responses in the vertical-only condition across three groups, b/dashed line: bilinguals, m/solid line: monolinguals

When testing the effect of Mandarin vertical cues, it was found that vertical cues significantly interacted with time type for the bilinguals in the Mandarin context ($p < .001$) and the Mandarin monolinguals ($p < .001$). Both groups pointed up more often for the future than for the past when there were no cues, and they pointed down for the future more often than for the past when there were Mandarin-future-down cues. The significant interactions for both groups can be revealed in Figure 8.

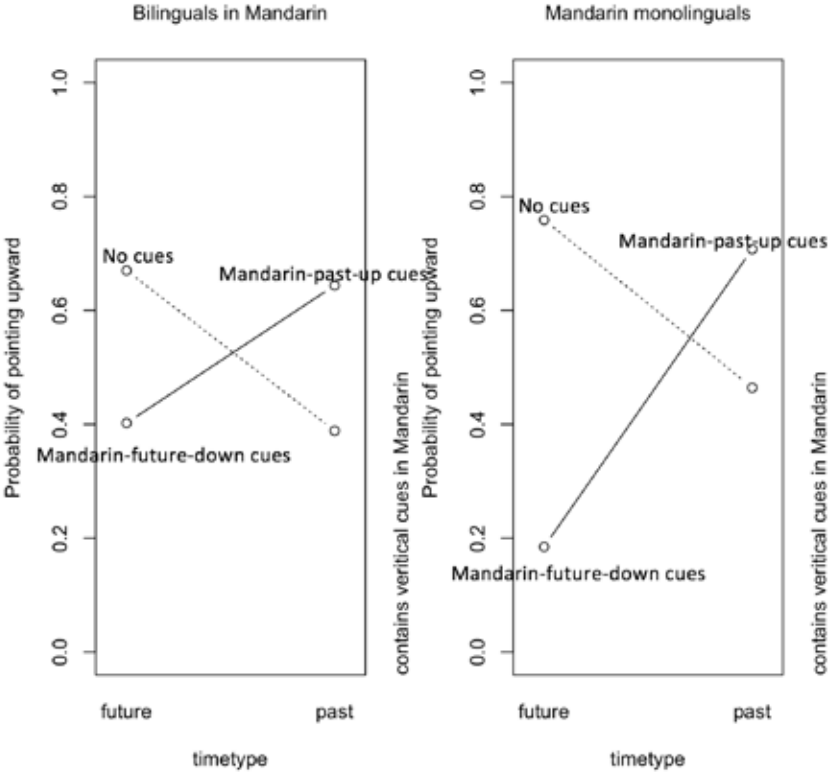

Figure 8: Plots for the results of the models testing the interaction between time type and vertical cues for the Mandarin monolinguals (right), and the bilinguals in the Mandarin context (left). Solid line: temporal words that contained sagittal directional cues in Mandarin, dashed line: temporal words that did not contain vertical directional cues in Mandarin

3.7 Transverse Responses from the Any-direction Condition

For responses on the transverse dimension from the any-direction condition, it was found that the data was too sparse to explore reliably in regression models except for the Mandarin monolinguals; however, they did not show any significant results. Therefore, each language group/condition was analyzed separately. The numbers of responses for each group except for the Mandarin monolinguals are listed in Table 4, 5 and 6.

Table 4: The English monolinguals' transverse responses for temporal in the any-direction condition

	LEFT	RIGHT
Future	0	34
Past	32	0

Table 5: The bilinguals' transverse responses in the English condition for temporal in the any-direction condition

	LEFT	RIGHT
Future	0	13
Past	11	0

Table 6: The bilinguals' transverse responses in the Mandarin condition for temporal in the any-direction condition

	LEFT	RIGHT
Future	1	9
Past	8	0

3.8 Responses from the Transverse-only Condition

When testing responses from the transverse-only condition, it was found that language significantly interacted with time type ($p < .001$). English monolinguals strongly associated the future with right and the past with left ($p < .001$). The bilinguals in the English condition ($p < .001$), the bilinguals in the Mandarin condition ($p < .01$) and the Mandarin monolingual ($p < .01$)

also showed the similar patterns, which were not as strong as English monolinguals. The differences across groups can be revealed in Figure 9. The results of the model are in Table 12 in Appendix.

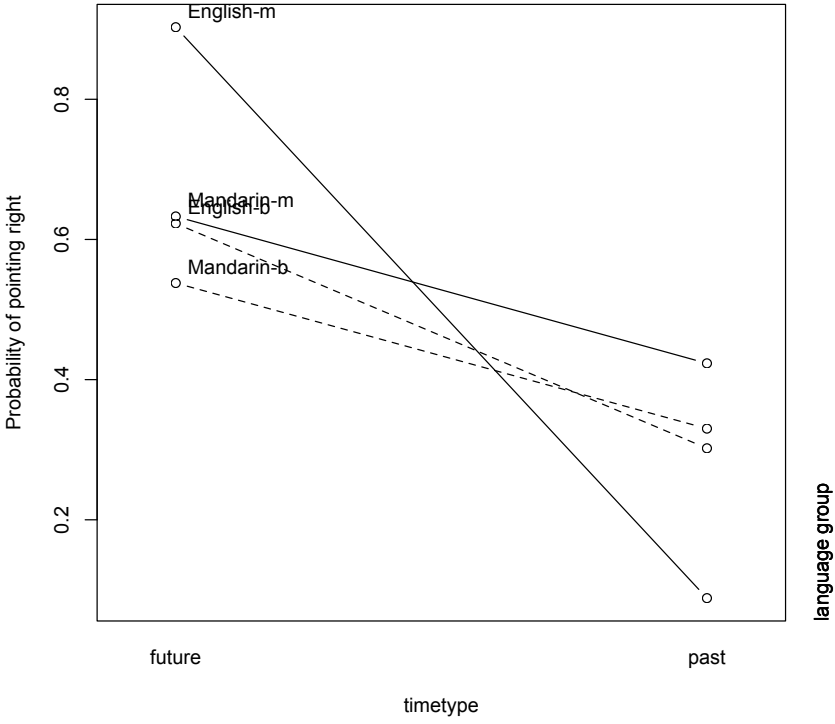

Figure 9: Plot for the results of the model testing responses in the transverse-only condition across three groups, b/dashed line: bilinguals, m/solid line: monolinguals

3.9 Correlation between the sagittal and the vertical dimensions

The participants associated up with the future and down with the past when there were no vertical cues. Such a preference exists in theory but existing studies did not find it when testing English speakers. It was suspected that this might be a projection from the sagittal axis. Therefore, after removing responses for the temporal words, Spearman's correlations between the sagittal and the vertical axes on the fillers for the English monolinguals, the bilinguals in the English context and in the Mandarin context, and the

Mandarin monolinguals were tested and the results were 0.931, 0.881, 0.764 and 0.760 respectively. When testing the differences between correlations, we used the Fisher r-to-z transformation and found significant differences between them: $z = 1.68$ and $p = 0.0465$ between the first two, $z = 2.1$ and $p = 0.0179$ between the second and the third one, and $z = 0.06$ and $p = 0.4761$ between the last two, which shows no significant differences.

A regression model was also conducted on responses for the fillers. The model use responses from the vertical-only condition as the dependent variable, the interaction between language group and responses from the sagittal-only condition as a fixed effect, and participants and words as random intercepts. The results revealed a significant interaction between sagittal responses and language ($p < .001$). When a word was pointed as front, the English condition would significantly increase the likelihood of pointing it as up for both the English monolinguals and the bilinguals in the English condition, and the likelihood was stronger for the group than for the latter.

4. Discussion

The results of the current experiment are summarized in Table 7. Speaking overall, all the groups of the participants chose the sagittal dimension as the primary dimension to point for temporal words when they could point freely. Such a result is consistent with the fact that English speakers use the sagittal dimension to gesture time when producing elicited gestures (Casasanto & Jasmin, 2012), and Mandarin speakers use the sagittal dimension to talk about time more often than the vertical one (Chen, 2007).

On the sagittal dimension, the English monolinguals showed consistent patterns between the any-direction condition and the restricted condition. They pointed front for the future more often than for the past, which is consistent with deictic time in English (Boroditsky, 2000). The bilinguals in the English context behaved like the English monolinguals, and they showed consistent patterns between the two conditions.

The bilinguals in the Mandarin context pointed front for the future more often than for the past when there were no overt sagittal cues; however, they pointed front less often for the future and pointed back less often for the past when there were cues. Although sagittal cues had an effect on them, it was not strong enough to change their associations between time and directions. The Mandarin monolinguals showed no preferences when there were no overt

Table 7: A summary of the results collected from all the conditions across language groups. Grey colour: the results that are inconsistent with the hypotheses, n/p: no preferences, n/a: not applicable.

GROUP	DIMENSION	RESULT-ANY DIRECTION CONDITION		RESULT-RESTRICTED CONDITIONS	
English monolinguals	sagittal	Front for the future more often than for the past		Front for the future more often than for the past	
	vertical	Up for the future more often than for the past		Up for the future more often than for the past	
	transverse	right for the future more often than for the past		right for the future more often than for the past	
Bilinguals in English	sagittal	Front for the future more often than for the past		Front for the future more often than for the past	
	vertical	Up for the future more often than for the past		Up for the future more often than for the past	
	transverse	Right for the future more often than for the past		Right for the future more often than for the past	
		HAVING CUES	NO CUES	HAVING CUES	NO CUES
Bilinguals in Mandarin	sagittal	Front for the future more often than for the past	Front for the future more often than for the past	Front for the future more often than for the past	Front for the future more often than for the past
	vertical	Up for the past more often than for the future	Up for the future more often than for the past	Up for the past more often than for the future	Up for the future more often than for the past
	transverse	n/a	Right for the future more often than for the past	n/a	Right for the future more often than for the past
Mandarin monolinguals	sagittal	Back for the future more often than for the past	n/p	Back for the future more often than for the past	Front for the future more often than for the past
	vertical	Up for the past more often than for the future	n/p	Up for the past more often than for the future	Up for the future more often than for the past
	transverse	n/a	n/p	n/a	Right for the future more often than for the past

sagittal cues in the any-direction condition, and they pointed front less often for the future and pointed back less often for the past when there were sagittal cues.

The Mandarin monolinguals behaved like the bilinguals in the Mandarin condition in the sagittal-only condition when there were cues; however, the effect of the cues was stronger for them than for the bilinguals. The Mandarin monolinguals showed no preference on the sagittal dimension in the any-direction condition when there were no cues. It seemed temporal direction on the sagittal dimension was salient for them only when sagittal cues existed. However, the effect of sagittal cues was consistent across the two conditions for them. The immediate effect of sagittal cues in Mandarin is consistent with Chui's (2011) observation, in which it was found that the Mandarin speakers pointed a past word with a sagittal cue and a past word without it in different directions. The two different temporal directions from the Mandarin speakers show that both deictic time and sequential time exist in Mandarin. Yu (2012) suggests that the temporal direction of sequential time in Mandarin is consistent with the direction that is described by Mandarin overt sagittal cues, which are front-past and back-future.

On the vertical dimension, the English monolinguals and the bilinguals in the English condition behaved in similar ways. Both groups also showed similar patterns between conditions. They all pointed up for the future more often than for the past. This result is consistent with the vertical temporal direction in English according to CMT (Lakoff & Johnson, 1980/2003). The bilinguals in the Mandarin condition also showed a similar pattern when there were no overt vertical cues. However, they pointed up for the past more often than for the future when there were cues. As for the Mandarin monolinguals, the effect of vertical cues is consistent in both conditions. However, when there were no vertical cues, they had no preference in the any-direction condition and they pointed up for the future more often than for the past in the vertical-only condition.

The up-future/down-past mapping is not supported by Mandarin linguistic data; however, it theoretically exists in English despite the fact that it has never been observed. It was found that when looking at the fillers, the participants' sagittal responses can predict their vertical responses. Correlation tests also reveal that there might be a close connection between the two dimensions. It seems the Mandarin speakers' up-future/down-past associations might be a projection from their front-future/back-past associations on the sagittal dimension. However, they had the weakest correlations. Future studies can test such a possibility.

On the transverse dimension, almost all the participants associated left with the past and right with the future, which is consistent with the writing direction in both Mandarin and English, given the fact that most of the Mandarin speakers in the current study are from mainland China. Only Mandarin monolinguals showed no preference in the any-direction condition.

As we can see, the current study found potential within-dimensional differences. The differences are caused by both languages of the stimuli and spatial information in the stimuli. Sagittal cues in Mandarin reflect temporal direction of sequential time (Yu, 2012), which is future-back and past-front. Sagittal cues had effects on the Mandarin-speaking groups/condition, but had no effects on the English-speaking groups/condition. This is consistent with the idea that sequential time is dominant and less restricted in Mandarin (Yu, 2012), whereas deictic time is more easily activated than sequential time in English (Sell & Kaschak, 2011). The immediate effects of spatial cues are also consistent with the immediate effects found from existing studies (e.g., Lai & Boroditsky, 2013). Taken together, they suggest that Mandarin speakers are sensitive to spatial information in temporal expressions, which is consistent with the fact that Mandarin heavily relies on spatial words when describing time.

The other important finding is that the bilinguals in the English condition behaved in similar patterns to the English monolinguals, whereas when the bilinguals were in the Mandarin condition, they behaved in similar patterns to the Mandarin monolinguals. Despite the fact that the bilinguals' associations between time and directions were significantly weaker than those from the monolingual counterparts, the effect of language was clearly revealed. The bilinguals showed intermediate patterns between the English monolinguals and the Mandarin monolinguals most of the time.

5. Conclusion

The experiment found differences and similarities in each dimension between groups of speakers. It used a pointing task, which was to mimic deictic gestures and temporal gestures, to test English and Mandarin speakers' perception of time in a real 3D environment with and without restricted conditions. The pointing experiment established a baseline for each language group on how they explicitly associate time with directions in the current New Zealand context. It provides references for future studies that will further test

the implicit association between time and directions across the two languages. The current study can also serve as a stepping stone for anyone who wishes to test Māori-English bilinguals in New Zealand in the future. Since Māori language has a temporal direction that is opposite to deictic time in English based on visual accessibility instead of focusing on sequential time, studying bilinguals of Māori and English would provide strong evidence for cross-linguistic influence on conceptual structures.

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Appendix

Table 8: The results of the model testing the interaction between time type and language for the participants' sagittal responses in the any-direction condition, time type: future vs. past

	ESTIMATE	STD. ERROR	Z VALUE	PR(>|Z|)	
(Intercept)	0.8657	0.3241	2.671	<0.01	**
languagegroup= English-monolingual	2.7899	0.7951	3.509	<0.001	***
languagegroup= Mandarin-bilingual	-1.1092	0.3661	-3.03	<0.01	**
languagegroup= Mandarin-momolingual	-1.6883	0.4631	-3.646	<0.001	***
timetype=past	-2.645	0.4507	-5.869	<0.001	***
languagegroup= English-monolingual: timetype=past	-5.4239	1.3049	-4.157	<0.001	***
languagegroup= Mandarin-bilingual: timetype=past	0.5325	0.6221	0.856	0.392028	
languagegroup= Mandarin-monolingual: timetype=past	3.5848	0.6145	5.834	<0.001	***

Table 9: The result of the model testing responses in the sagittal-only condition across three groups, time type: future vs. past

	ESTIMATE	STD. ERROR	Z VALUE	PR(>|Z|)	
(Intercept)	1.5367	0.3534	4.349	<0.001	***
language= English-monolingual	2.1201	0.6176	3.433	<0.001	***
language= Mandarin-bilingual	-0.6528	0.3324	-1.964	<0.05	*
language= Mandarin-monolingual	-1.2635	0.3945	-3.203	<0.01	**
time=typepast	-3.7374	0.4775	-7.826	<0.001	***
language= English-monolingual: time=typepast	-2.58	0.7382	-3.495	<0.001	***
language= Mandarin-bilingual: time=typepast	1.198	0.5169	2.318	<0.05	*
language= Mandarin-monolingual: time=typepast	3.2808	0.4882	6.72	<0.001	***

Table 10: The results of the model testing the interaction between time type and language for the participants' vertical responses in the any-direction condition, time type: future vs. past

	ESTIMATE	STD. ERROR	Z VALUE	PR(>|Z|)	
(Intercept)	2.3499	0.9309	2.524	<0.05	*
languagegroup= English-monolingual	0.1752	1.2753	0.137	0.89073	
languagegroup= Mandarin-bilingual	-0.3071	0.7906	-0.388	0.69771	
languagegroup= Mandarin-monolingual	-1.1806	0.9584	-1.232	0.21801	
timetype=past	-2.8738	1.1503	-2.498	<0.05	*
languagegroup= English-monolingual: timetype=past	-3.3789	1.7907	-1.887	<0.1	
languagegroup= Mandarin-bilingual: timetype=past	1.013	1.2	0.844	0.3986	
languagegroup= Mandarin-monolingual: timetype=past	3.5079	1.1825	2.966	<0.01	**

Table 11: The result of the model testing responses in the vertical-only condition across three groups, time type: future vs. past

	ESTIMATE	STD. ERROR	Z VALUE	PR(>|Z|)	
(Intercept)	1.6154	0.4169	3.875	<0.001	***
language= English-monolingual	1.9577	0.6256	3.129	<0.01	**
language= Mandarin-bilingual	-1.1112	0.3351	-3.316	<0.001	***
language= Mandarin-monolingual	-1.1692	0.4612	-2.535	<0.05	*
time=typepast	-3.8654	0.5296	-7.299	<0.001	***
language= English-monolingual: time=typepast	-3.2831	0.796	-4.124	<0.001	***
language= Mandarin-bilingual: time=typepast	3.1716	0.5158	6.149	<0.001	***
language= Mandarin-monolingual: time=typepast	3.5202	0.5105	6.896	<0.001	***

Table 12: The results of the model testing the interaction between time type and language for the participants' transverse responses in the transverse-only condition, time type: future vs. past

	ESTIMATE	STD. ERROR	Z VALUE	PR(>|Z|)	
(Intercept)	0.50143	0.24198	2.072	<0.05	*
language= English-monolingual	1.7276	0.42471	4.068	<0.001	***
language= Mandarin-bilingual	-0.34991	0.27962	-1.251	0.2108	
language= Mandarin-monolingual	0.04285	0.33636	0.127	0.8986	
time=typepast	-1.33917	0.29109	-4.601	<0.001	***
language= English-monolingual: time=typepast	-3.22555	0.55017	-5.863	<0.001	***
language= Mandarin-bilingual:time= typepast	0.48003	0.40623	1.182	0.2373	
language= Mandarin-monolingual: time=typepast	0.48534	0.39944	1.215	0.2244	