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Brief article

Do English and Mandarin speakers think about time differently?

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ABSTRACT

Time is a fundamental domain of experience. In this paper we ask whether aspects of language and culture affect how people think about this domain. Specifically, we consider whether English and Mandarin speakers think about time differently. We review all of the available evidence both for and against this hypothesis, and report new data that further support and refine it. The results demonstrate that English and Mandarin speakers do think about time differently. As predicted by patterns in language, Mandarin speakers are more likely than English speakers to think about time vertically (with earlier time-points above and later time-points below).

1. Introduction

To represent time, people around the world rely on space. However, the way they spatialize time differs across languages and cultures, depending on the available spatial representations, spatio-temporal metaphors, cultural artifacts, and on individual disposition, age and experience (e.g., Boroditsky & Gaby, in press; Carstensen, 2006; Casasanto et al., 2004; Chan & Bergen, 2005; Fuhrman & Boroditsky, 2010; Gonzalez & Zimbardo, 1985; Ji, Guo, Zhang, & Messervey, 2009; Núñez & Sweetser, 2006; Ouellet, Santiago, Israeli, & Gabay, 2010; Tversky, Kugelmass, & Winter, 1991). Across these studies, people in different cultures or groups have been shown to differ in whether they think of time as stationary or moving, as limited or open-ended, as horizontal or vertical, as oriented from left-to-right, right-to-left, front-to-back, back-to-front, east-to-west, and so on.

In this paper we will focus on the representations of time in English and Mandarin speakers, and examine whether they differ.

2. Mandarin speakers talk about time vertically more than English speakers do

Both English and Mandarin use horizontal front/back spatial terms to talk about time. In English, we can look *forward* to the good times *ahead*, or think *back* to travails past and be glad they are *behind* us. In Mandarin, front/back spatial metaphors for time are also common. For example, Mandarin speakers use the spatial morphemes *qián* ("front") and *hòu* ("back") to talk about time.

Unlike English speakers, Mandarin speakers also systematically and frequently use vertical metaphors (Chun, 1997a, 1997b; Liu & Zhang, 2009; Scott, 1989; Zhang & Ding, 2003; Zhu, 2006). The spatial morphemes *shàng* ("up") and *xià* ("down") are used to talk about the order of events, weeks, months, semesters, and more. Earlier events are said to be *shàng* or "up", and later events are said to be *xià* or "down". For example, "shàng ge yuè" is last (or previous) month, and "xià ge yuè" is next (or following) month. In one corpus of written Mandarin (Chen, 2007) fully 36% of the spatial metaphors for time were vertical.

Although in English vertical spatial terms can also be used to talk about time (e.g., "hand down knowledge from generation to generation"), these uses are rare. The difference between Mandarin and English in the productivity

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and frequency of vertical time metaphors has been noted by a large number of scholars, including many in China, Taiwan, and Hong Kong (e.g., Chun, 1997a, 1997b; Liu & Zhang, 2009; Scott, 1989; Zhang & Ding, 2003; Zhu, 2006).

The key linguistic observation then is that vertical metaphors for time are more frequent in Mandarin than they are in English. This difference between the two languages offers the prediction that Mandarin speakers would be more likely to conceive of time vertically than would English speakers.[1]

3. Do Mandarin speakers think about time vertically more than English speakers do?

The literature to date can be distilled as follows. Across many paradigms, English speakers (and speakers of French, German, Dutch, and Spanish) have been shown to construct representations of time that are horizontal (Boroditsky, 2000, 2008; Boroditsky & Ramscar, 2002; Calbris, 1990; Casasanto, 2008, 2009; Chan & Bergen, 2005; Cienki, 1998; Cooperrider & Núñez, 2009; Fuhrman & Boroditsky, 2010; Gentner, Imai, & Boroditsky, 2002; Gevers, Reynvoet, & Fias, 2003; Ishihara, Keller, Rossetti, & Prinz, 2008; Miles, Nind, & Macrae, 2010; Núñez, Motz, & Teuscher, 2006; Núñez & Sweetser, 2006; Ouellet et al., 2010; Santiago, Lupiáñez, Pérez, & Funes, 2007; Torralbo, Santiago, & Lupianez, 2006; Tversky et al., 1991; Weger & Pratt, 2008). Importantly, many of these studies demonstrate that people spatialize time naturally and automatically, even when not required to look at spatial stimuli or make spatial responses.

A number of these studies were also equipped to find vertical representations of time in English speakers, but they found these to be either non-existent or extremely rare (e.g., Casasanto, 2008, 2009; Chan & Bergen, 2005; Cooperrider & Núñez, 2009; Fuhrman & Boroditsky, 2010; Ishihara et al., 2008; Tversky et al., 1991).[2]

Finally, studies comparing English and Mandarin speakers have found that Mandarin speakers do construct vertical representations for time, and do so more often than English speakers (e.g., Boroditsky, 2008; Chan & Bergen, 2005). For example, when asked to spatially arrange temporal sequences shown in pictures, Mandarin speakers arranged the pictures in vertical arrays 30% of the time (18–39% depending on group), whereas English speakers never did so (Chan & Bergen, 2005). Likewise, when the task was to locate events in 3-dimensional space by pointing to locations around the body, Mandarin speakers were more likely to arrange time vertically (42%) than were native English speakers (5%) (Boroditsky, 2008).

One experimental paradigm used to test English and Mandarin speakers' representations of time has produced inconsistent results (Boroditsky, 2001; Chen, 2007; January & Kako, 2007; Tse & Altarriba, 2008; Liu & Zhang, 2009). Initial findings using this paradigm were in accord with the linguistic observation: Mandarin speakers appeared more likely to think about time vertically than did English speakers (Boroditsky, 2001). But follow-up studies, including ones in our own laboratory, have yielded inconsistent outcomes: some support and some fail to support the original findings. Further work in our lab suggests several reasons for the inconsistent patterns of results from this paradigm.

In this experimental paradigm, participants made temporal judgments following horizontal or vertical spatial primes. On each trial, participants first answered several questions about the spatial relationship between two objects (arranged either horizontally or vertically on a computer screen), and then answered a question about time (e.g., March comes earlier than April; TRUE or FALSE). Participants' response times to the target question about time following either the horizontal or vertical primes were the measure of interest.

Early investigations of English speakers' conceptions of time focused on time as laid out on a front/back axis as suggested by the set of English spatio-temporal metaphors. However, new work has shown evidence for an additional horizontal representation that runs left-to-right (see references earlier in this section). Unfortunately, in Boroditsky (2001) paradigm these two horizontal axes were conflated in the horizontal spatial primes: the images were presented on the left/right axis of a computer screen, while the questions that accompanied them used front/back metaphors. Participants might see a blue worm on the left and a white worm on the right (with leftward or rightward arrows indicating their direction of motion) and be asked to verify whether "The blue worm is ahead of the white worm". The "ahead" and "behind" questions were randomly paired with leftward and rightward oriented images, putting the two competing horizontal axes in conflict and collapsing over the preferred and non-preferred directions on the left/right axis.

Further, the original paradigm tested only for effects of axis (e.g., vertical), not direction within that axis (e.g., moving upward vs downward). If representations of time are spatial in a specific way, then they should have not only an orientation but also a direction (time is not just vertical, but specifically has an upward or downward trajectory). Primes and targets were paired randomly regardless of direction in Boroditsky (2001), likely creating further interference and instability.

In this paper we present a new paradigm that improves on and extends the early studies in a number of ways. First, the task separates the directions within the axes. Second, the task is non-linguistic (the stimuli are photographs and the responses are button-presses). Third, the task relies on reaction-time (an implicit measure of processing that participants are unlikely to manipulate to please the experimenter). And finally, the task tests temporal reasoning across a wide range of temporal progressions and durations.

[1] A different question was tested in Chen (2007), who asked whether vertical metaphors in Mandarin are more frequent than are horizontal metaphors in Mandarin. The results showed that vertical metaphors in Mandarin, though very frequent, are not as frequent as horizontal metaphors in Mandarin. For the purposes of cross-linguistic comparison, however, the key observation is that vertical metaphors are more frequent in Mandarin than they are in English.

[2] It isn't the case that English speakers never think about time vertically or that they are incapable of doing so, but simply that such representations are rare, and perhaps restricted to specific domains (e.g., kinship relations).

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4. Methods

4.1. Participants

A total of 181 members of the Stanford University community or students at the Foothill Community College participated in this study. Of the participants, 118 were native English speakers with no exposure to Mandarin (Mage = 19.18, SDage = 1.61), and 63 were Mandarin-English bilinguals for whom Mandarin was the native language (Mage = 24.98, SDage = 5.74).

To achieve a clean comparison between language groups, we included only Mandarin-speaking participants who were highly proficient in Mandarin (4 or 5 on a 5-point scale), and who reported only reading text arranged in horizontal rows left-to-right (as in English) (see SI online for a discussion of writing direction in Mandarin, the language experience questionnaire, and further information about the participants).

4.2. Procedure

On each trial, participants saw two pictures, presented one after the other in the same location in the center of the screen. Participants would see, for example, a 500 ms fixation cross, followed by a photo of Woody Allen for 2 s, and then a second photo of Woody Allen that remained until they made their response. The participants' task was to say whether the second photo shows Woody Allen at an earlier or later time in his life than the first photo. Participants made their responses with the right hand, by pressing one of two adjacent keys that were covered with black and white stickers, where black represented 'earlier' and white – 'later'. The keys had no other labels.

For some of the participants (51 native English speakers and 26 native Mandarin speakers), the response buttons were arranged horizontally on the left/right axis. In this condition, responses were made on a keyboard that lay flat on the table-top in the normal keyboard orientation. For one block, the left key was covered with the black ('earlier') sticker and the right key with the white ('later') sticker, and for the other block this mapping was reversed.

For the other participants (67 native English speakers and 37 native Mandarin speakers) the response buttons were arranged vertically. For this condition, a keyboard was mounted vertically (perpendicular to the table-top) such that one response key was physically above the other. For one block, the top key was covered with the black ('earlier') sticker and the bottom key with the white ('later') sticker, and for the other block this mapping was reversed.

All testing took place at Stanford University or Foothill College, with all participants receiving the same instructions in English. Each participant completed both blocks within their assigned condition (either all horizontal or all vertical). Each block consisted of 76 trials. The order of the blocks was counterbalanced across participants. Materials comprised 114 images. The pictures represented a range of object types and temporal intervals: from events that last only a few seconds (e.g., filling a cup of coffee), to intervals that spanned decades (e.g., a person at different stages in life). Further details about the materials and design are available in the SI online.

We reasoned that if people automatically access left-to-right or top-to-bottom representations for time, then asking them to make a space–time mapping that is incongruent with this representation should cause interference. For example, if participants automatically activate a left-to-right representation for time, then they should respond faster when the earlier key is on the left than when it is on the right.

5. Results

Results are plotted in Figs. 1 and 2, with descriptive statistics in Table 1. Responses of ten participants (5 native English speakers and five native Mandarin speakers) were excluded from analysis because of their exceptionally high error rates (more than 25% errors in at least one of the two blocks). The accuracy rate for these ten participants was 54.5%. Accuracy for the remaining 171 participants was 95.5%. Error responses were not included in the analyses.

We submitted all correct responses to a by-participants $2 \times 2 \times 2 \times 2$ mixed ANOVA, with native Language (English/Mandarin), spatial Axis (Horizontal vs. Vertical) and Block order (whether the left-is-earlier/top-is-earlier block came before or after the right-is-earlier/bottom-is-earlier block for that participant) as between participants factors, and canonicality of key-mapping (whether the left/top key or the right/bottom key was designated as earlier or later) as a within-participants factor. We also conducted a by items (2 language $\times$ 2 spatial axis $\times$ 2 block order $\times$ 2 canonicality) ANOVA.

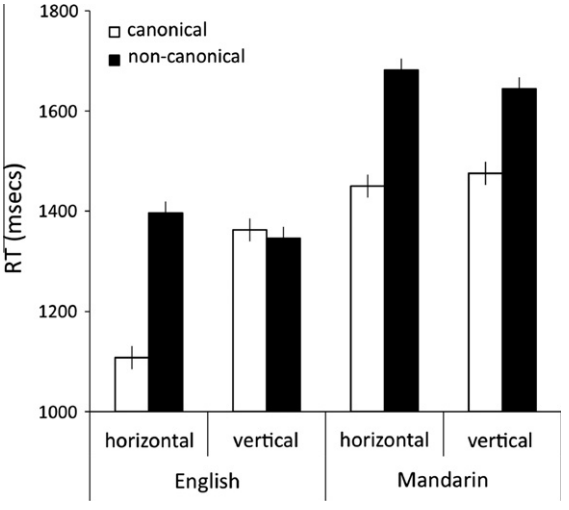

Fig. 1. Native English and native Mandarin speakers' response times. The figure plots by-participants mean response times (in msecs). The error bars represent within-participants standard error (sqrt(MSsc/N)). For the horizontal conditions, the canonical bars show response times in the left-is-earlier key-mapping and the non-canonical bars show response times in the right-is-earlier key-mapping. For the vertical conditions, the canonical bars show response times in the top-is-earlier key-mapping and the non-canonical bars show response times in the bottom-is-earlier key-mapping.

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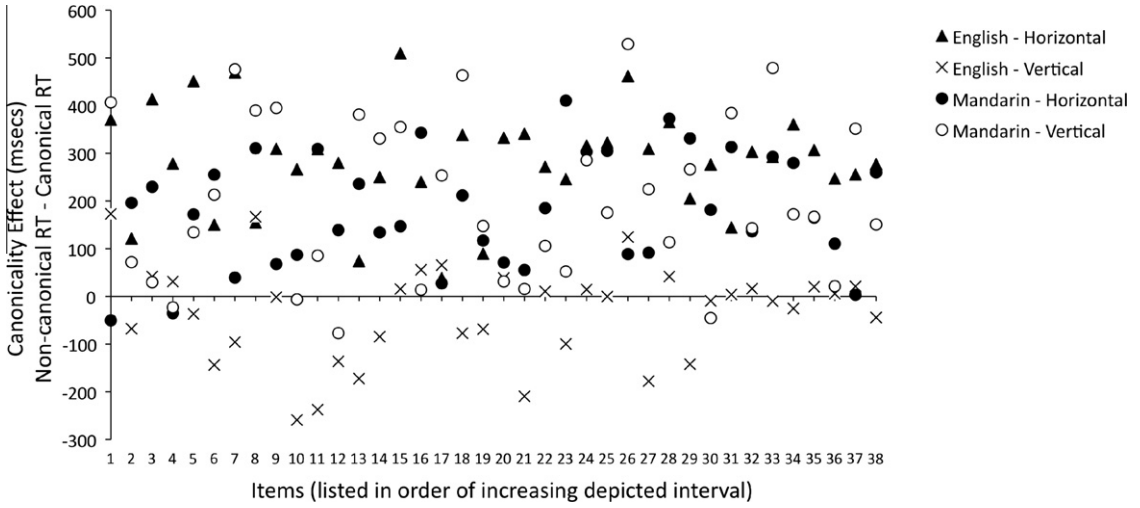

Fig. 2. Canonicality effect (in msecs) plotted by items. Items are shown in order of increasing depicted interval duration. The results show that the canonicality effect was present in all groups, except as predicted for English speakers tested in the vertical response condition (marked as Xs). For the other three groups, the canonicality effect is present across the range of durations represented in the study.

Table 1
Mean response times (in msecs) obtained from native English and native Mandarin speakers in each of the four response conditions. The table shows by-participants means.

	English	Mandarin
Horizontal		
Left is earlier	1108	1450
Right is earlier	1396	1682
Vertical		
Up is earlier	1362	1475
Down is earlier	1345	1645

5.1. Results overview

As predicted, English and Mandarin speakers showed different patterns: both showed a canonicality effect on the horizontal axis, but only Mandarin speakers showed a canonicality effect on the vertical axis. That is, in the horizontal response condition, both English and Mandarin speakers responded faster when the "earlier" response key was on the left than when it was on the right. The left-is-earlier mapping is consistent with the direction of writing in both English and Mandarin. In the vertical condition, only Mandarin speakers responded faster when the "earlier" response key was on top (congruent for Mandarin) than when it was on the bottom (incongruent for Mandarin). There was no difference for the English speakers. The top-is-earlier mapping is consistent with the Mandarin use of vertical metaphors which places earlier events as "up".

The difference in these response patterns was confirmed as a 3-way (language × axis × canonicality) interaction, $F1(1, 163) = 5.79$, $p = .017$, $F2(1, 37) = 71.9$, $p < .001$. The by items analysis also revealed an interaction between Language and Axis, with Mandarin speakers responding equally quickly in the vertical as in the horizontal axis, while English speakers were faster in the horizontal than in the vertical, $F(1, 37) = 16.6$, $p < .001$. Analyses of accuracy confirmed these results were not due to speed-accuracy trade-offs (see SI online).

Overall, the native English speakers responded faster than the native Mandarin speakers, $F1(1, 163) = 10.7$, $p < .01$, $F2(1, 37) = 175.7$, $p < .001$. Very likely, the native English speakers were more accustomed to taking part in timed psychological experiments than the Mandarin speakers. Further results for the two language groups separately are reported below.

5.2. Results: native English speakers

ANOVAs (2 Axis × 2 Canonicality × 2 Block Order) conducted on the data from native English speakers revealed a significant main effect of canonicality, ($F1(1, 109) = 10.3$, $p < .01$, $F2(1, 37) = 94.0$, $p < .001$), and importantly a significant canonicality by axis interaction ($F1(1, 109) = 15.6$, $p < .001$, $F2(1, 37) = 202.4$, $p < .001$). As can be seen in Fig. 1, English speakers showed a horizontal but not a vertical canonicality effect. The by items analysis also revealed a main effect of axis, with English speakers overall faster in the horizontal than in the vertical condition, $F(1, 37) = 47.0$, $p < .001$.

5.3. Results: native Mandarin speakers

ANOVAs (2 Axis × 2 Canonicality × 2 Block Order) conducted on the data from native Mandarin speakers revealed a significant main effect of canonicality, ($F1(1, 54) = 10.6$, $p < .01$, $F2(1, 37) = 137.9$, $p < .001$), and unlike the native English speakers' data no canonicality by axis interaction (both $F < 1$). As can be seen in Fig. 1, Mandarin speakers showed both a horizontal and a vertical canonicality effect. Unlike in the English speakers' data, the by items analysis revealed no main effect of axis, with Mandarin speakers responding equally quickly on the

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vertical as on the horizontal axis, $F < 1$. An analysis of just the data from Mandarin speakers in the vertical condition (2 canonicality × 2 block order) confirmed an independent significant main effect of canonicality on the vertical axis ($F1(1, 33) = 5.94$, $p = .02$, $F2(1, 37) = 22.1$, $p < .001$).

5.4. Results: Effects of depicted time interval

The events depicted in our pictures represented time spans from seconds to decades (e.g., from filling a coffee cup to a person aging from a young boy to an old man). We split the items into two groups at the median duration of the depicted interval (based on independent duration estimates collected in Fuhrman and Boroditsky (2010)). We'll refer to the items above and below the median as "long intervals" and "short intervals." We then conducted a (2 Language × 2 Axis × 2 Canonicality × 2 Block Order) by items ANOVA with depicted interval duration (long or short) added as a between-items variable.

People were overall faster to make order judgments for long intervals than for short intervals (Mean = 1338 and 1456 ms; SD = 167 and 171 ms respectively), $F(1, 36) = 4.58$, $p < .05$. This finding replicates classic mental distance effects (e.g., Cattell, 1902) in which people are faster to distinguish things that are more different (in perceptual or conceptual space). In our case, people are faster to make temporal judgments about events that are conceptually further apart in time.

As shown in Fig. 2, the canonicality effect was present (data points above the abscissa) across the wide range of durations used in this study (except, as predicted, for native English speakers in the vertical response condition – designated by Xs). There was no interaction between canonicality and depicted duration, $F < 1$. It appears that constructing culturally-specific spatial representations for time (e.g., left-to-right or top-to-bottom) is not restricted to a particular range of durations (e.g., not just those depicted on calendars), but is rather a strategy people use across a wide range of durations.

6. Discussion

Previous work has demonstrated that Mandarin speakers are more likely than English speakers to make explicit use of the vertical axis when mapping out time (Boroditsky, 2008; Chan & Bergen, 2005). The current study extends and supports this previous work. We find that both groups organize time on the left-to-right axis with earlier events on the left, a pattern consistent with writing direction. But, Mandarin speakers also show evidence of vertical representations of time, with earlier events represented further up. English speakers showed no evidence of such a representation. This difference between the two groups was predicted by patterns in spatio-temporal metaphor in English and Mandarin. The results provide evidence of a cross-cultural difference in temporal reasoning in an implicit, non-linguistic task. It appears that speakers of different languages automatically activate different culturally-specific spatial representations when reasoning about time.

To be sure, our representations of time are constrained and informed by evolutionary adaptations and physical experience. But many aspects of our mental representations of time go beyond the basic physical reality and differ across cultures. Does time move horizontally or vertically? Does it move forward or back, left or right, up or down? Does it move past us, or do we move through it? These properties of mental time are specified in spatio-temporal metaphors in language and in other aspects of culture. Evidence demonstrating cross-linguistic differences in how people mentally represent time requires that we include patterns in language and culture as a central ingredient in the human conception of time.

6.1. Testing for cross-linguistic differences in thought

While the spatial priming paradigm used in a set of previous studies has produced inconsistent results (Boroditsky, 2001; Chen, 2007; January & Kako, 2007; Tse & Altarriba, 2008; Liu & Zhang, 2009), these studies highlight an important issue in testing hypotheses of linguistic relativity.

To study effects of language on thought one must test whether manipulating some aspect of language (be it current linguistic context or past language experience) results in differences in behavior. To find out if there are differences in thinking as a function of linguistic experience, one must test groups that differ in linguistic experience on the same cognitive task.

In Boroditsky (2001) there were three such comparisons: (1) comparing English and Mandarin speakers on the same task; (2) comparing Mandarin speakers who learned English at different stages of life on the same task; and (3) comparing English speakers tested with and without training to talk about time vertically. The experimental design used requires cross-group comparisons to be interpretable. The horizontal and vertical primes differ from each other in many ways, and these differences are not controlled. As a result, this type of design can only be used to test for interactions between groups tested on the same stimuli. Without a meaningful comparison group, evidence from this type of design cannot be used to assess people's representations of time or make inferences about the relationships between language and thought.

Some of the follow-up studies followed this logic and included meaningful cross-linguistic comparisons (Tse & Altarriba, 2008), but others relied exclusively or almost exclusively on data from only one language group—English speakers (January & Kako, 2007), Mandarin speakers (Liu & Zhang, 2009), and 73 Mandarin speakers but only 14 English speakers (Chen, 2007).[3] Further, each study used different stimuli and experimental procedures, in all cases

[3] Studies in Chen (2007) included 73 Mandarin speakers but only a small group ($N = 14$) of English speakers, and in only one of the four studies (studies in Boroditsky (2001) included 26–70 English speakers each). The 14 English speakers tested in Chen (2007) were residing in Taiwan, and so had an importantly different linguistic background from native English speakers tested in earlier studies.

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different from the original study.[4] Data from such studies cannot in principle test hypotheses about cross-linguistic differences in thought. To do that, one must compare people with different linguistic backgrounds on the same task.

7. Conclusions

Previous work has established that mental representations of time differ across cultures and groups. The way one conceives of time has been shown to have important affective and behavioral consequences (e.g., Boyd & Zimbardo, 2005; Brock & Del Giudice, 1963; Carstensen, 2006; Lewin, 1942). In this paper we reviewed evidence for one cross-cultural difference in temporal thinking predicted by patterns in spatio-temporal metaphors. Mandarin speakers use vertical terms to talk about time more than English speakers do. Converging evidence from several paradigms supports the idea that Mandarin speakers also think about time vertically more often than English speakers do.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.cognition.2010.09.010.

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[4] The studies in January and Kako (2007) aimed to replicate Boroditsky (2001) precisely, using the same stimuli in 5 of the studies. Unfortunately, after the paper was accepted for publication in *Cognition* (though before it was published) two crucial bugs in the programs used to run the studies were discovered. The experiments were not counterbalanced. First, a different set of time questions was tested after the vertical primes than after the horizontal primes (and this was not counterbalanced across participants). This confound makes it impossible to evaluate the independent effect of the primes. Second, in 3 of the studies all the spatio-temporal (before/after) time questions were tested in the first half of the experiment, while all the purely temporal (earlier/later) time questions were tested in the second half of the experiment. This made it impossible to compare the two types of questions. These procedural errors compromise the interpretation of these studies. We thank David January for sharing the program used to run the studies in January and Kako (2007) with us. In Footnote 2 of January and Kako (2007) it is noted that after discovering these bugs, a new study was created and 8 participants were tested before the study was halted as the preliminary results were unpromising.

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