

# Whether Chinese Speakers Think about Time More Vertically Depends on their Immediate and Lifetime Experience of Reading Horizontal or Vertical Texts: Evidence from Contextual Priming

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## Abstract

Do Chinese speakers think about time vertically because they use vertical spatial metaphors to express time? Inconsistent findings have been reported even when the same paradigms were used. The present study examined participants' performance on a temporal judgment task while holding language constant but varying their lifetime and immediate reading experience of horizontal and vertical texts. Chinese participants from Taiwan and China were randomly assigned to a reading task involving horizontally or vertically arranged texts (contextual primes). A temporal judgment task (spatial-temporal association of response codes or STARC) followed the reading task, asking the participants to judge if the event depicted in a second picture occurred earlier or later than that in a first picture. Responses were faster when the left keys represented the 'earlier' responses than when the right keys did, representing a STARC effect. Half of the participants responded with horizontally oriented keys while the rest with vertically oriented keys. For the Taiwan participants, the overall STARC effect was greater when the response keys were vertical than horizontal, but no difference was observed for the China participants. A questionnaire indicates that the two groups of participants had similar lifetime experiences of reading horizontal texts, but the Taiwan participants read vertical texts in their life far more frequently than the China participants. Immediate reading experiences interacted with lifetime experiences in modulating the vertical bias. For the Taiwan participants, the vertical bias was strong following the vertical prime, but disappeared following the horizontal prime. For the China participants, the horizontal prime led to no vertical bias whereas the vertical prime brought about a horizontal bias. We conclude that the directionality of orthography and speakers' immediate and lifetime reading experiences, rather than the use of vertical spatial metaphors, can better explain the vertical bias (or the lack of it) in the Chinese speakers.

**Keywords:** linguistic relativity; temporal reasoning; reading direction

## Introduction

Once denounced as scientifically unsound (Devitt and Sterelny, 1987; Pinker, 1994), the linguistic relativity hypothesis has regained much attention in the past two decades. The essence of the hypothesis is that the

particular linguistic form in a language can shape the habitual way of thinking by the speakers of the language (Whorf, 1956; Hunt & Agnoli, 1991). For example, if language A does not distinguish two shades of blue whereas language B does, speakers of language A would not be able to tell apart the two shades of blue as easily as speakers of language B (Davidoff, Davies, & Roberson, 1999; Gilbert, Regier, Kay, & Ivry, 2006; Winawer et al., 2007). Similarly, if language A does not encode the biological gender lexically whereas language B does, the gender information would become less accessible to speakers of language A than speakers of language B (Chen & Su, 2011). In the temporal domain, it has been observed that Chinese speakers seem to conceptualize time continuously and maintain an "extended present" view that encompasses recent past and near future, whereas English speakers tend to maintain a relatively discrete view of time with distinct present, past and future. This cross-linguistic difference has been attributed to the use of explicit tense and aspect markers in English and the lack of them in Chinese (Chen, Su, Lee, & O'Seaghdha, 2012; Chen, Su, & O'Seaghdha, 2013).

While much of recent empirical work has produced evidence consistent with the linguistic relativity hypothesis, there were controversies due to inconsistent findings as well. One particular controversy comes from the study of spatial metaphors of time. An early study employing a spatial priming paradigm found that the frequent use of vertical spatial metaphors to express time in Chinese led to a vertical bias in the Chinese speakers' conception of time whereas the rare use of such metaphors in English led to a horizontal bias in the English speakers (Boroditsky, 2001). However, subsequent studies were unable to confirm such a differential bias (Chen, 2007; January & Kako, 2007; Tse & Altarriba, 2008; Sanvido, de Rose, & Chen, 2011).

More recently, a SNARC-like paradigm (spatial-numerical association of response codes, Dehaene, Bossini, & Giraux, 1993) applied to temporal processing (spatial-temporal association of response codes or STARC) detected a similar vertical bias in the Chinese speakers relative to the English speakers (Boroditsky, Fuhrman, & McCormick, 2011; Fuhrman et al., 2011; Miles, Tan, Noble, Lumsden, & Macrae, 2011). In a STARC task, the participants saw two photographs of an event and had to determine if the second photograph

occurred earlier or later than the first one. In the canonical condition, they pressed a left key to indicate 'earlier' and a right key to indicate 'later' while in the non-canonical condition, the key assignment was reversed. Response times were typically slower in the non-canonical condition relative to the canonical condition, representing a STARC effect. For half of the participants, the keys were placed horizontally while for the other half, the keys were oriented vertically. It was found that Chinese and English speakers displayed similar horizontal STARC effects, but more importantly, the Chinese speakers demonstrated a greater vertical STARC effect than the English speakers. Unfortunately, inconsistent findings were observed with this paradigm as well. Chen and O'Seaghdha (2012 accepted) observed a vertical bias in the Chinese speakers from Taiwan, but no such bias in the Chinese speakers from China. Because horizontal printing of texts is a national policy in China, but not in Taiwan, where vertical texts are fairly common, it was suggested that reading experience of horizontal and vertical texts might have something to do with the participants' performance on the STARC task. The suggestion, however, was inferred from quasi-experimental evidence.

The present study was designed to test the effect of reading experience on Chinese speakers' performance on the STARC task by experimentally manipulating the layout of texts (horizontal or vertical) which participants read before the STARC task. The reading task, serving as a contextual prime, was expected to bias the Chinese participants towards displaying a greater or smaller horizontal or vertical STARC effect depending on the direction of reading. The modulation of immediate reading experience might interact with Chinese speakers' lifetime reading experience, which was assessed by including participants from Taiwan and China. The participants from Taiwan would have more extensive experience of reading vertical texts than the participants from China.

## Method

### Participants

Fifty-six native Mandarin Chinese speakers from Taiwan and the same number from China participated in this study. The participants from Taiwan were graduate or undergraduate students from National Taiwan Normal University and nearby universities in Taipei, while those from China were similar students from Beijing Normal University and nearby universities in Beijing. The age range for the participants was from 18 to 26. All the participants had normal or corrected-to-normal vision and they were paid 200 TWDs or 20 RMBs for participation.

### Design and Materials

**The Reading Task** Seven short essays with 11 comprehension questions were chosen from the Taiwan University Entrance Exams for the reading task. Two versions of the texts (the essays and the questions) were prepared as paper booklets, one arranged horizontally and the other vertically. Participants were randomly assigned to one version. There was no time pressure for taking the

task. On the average, it took approximately 15 to 20 minutes for the participants to complete this task. Upon completion, the participants proceeded immediately to the STARC task.

**The STARC Task** The design and procedure of the STARC task followed those of Chen & O'Seaghdha (2013). The materials were 37 action events, each being photographed at three different phases of time (e.g., Time X: a man holding the handle and about to turn the key to open a door, Time Y: door being open with the man stepping half into the room, and Time Z: door being half closed with the man inside the room facing inward with his left hand holding against the closing door). On each trial, a Time Y picture was randomly chosen from the 37 events and shown to the participants. The Time Y picture was followed by a Time X or a Time Z picture. The participants were asked to determine whether the action depicted in the second picture occurred earlier or later than the action depicted in the first. In one condition (the canonical response), the number-4 key on the numeric keypad of a standard keyboard, marked with a blue sticker, was designated as the 'earlier' response, and the number-5 key, marked with an orange sticker, was designated as the 'later' response. In the other condition (the noncanonical response), the key assignment was reversed, i.e., the '5' key was the blue one designated as the 'earlier' response and the '4' key was the orange one designated as the 'later' response. Canonicity was a within-subjects factor. The same set of 37 action events was used in the two canonicity conditions, with the Time X and the Time Z pictures appearing exactly once in each condition. The order of the two conditions was counterbalanced across the participants. A between-subjects factor was also included. Half of the participants, randomly determined, responded with the keyboard placed on the desk in a normal horizontal orientation, and the other half responded with the keyboard oriented vertically (propped up against a bookend).

The task was programmed in E-Prime and was run on a desktop (ASUS B53S with an Intel® Core™ i5 2520M processor and a 15.6" 16:9 HD 1366x768-resolution LED screen) and a laptop computer (ASUS R500V with an Intel® Core™ i7 3610QM 2.3 GHz processor and a 15.6" 16:9 HD 1366x768-resolution LED screen), both with a separate USB-connected numeric keypad (Kingyo). A trial began with a fixation cross which appeared at the center of the screen for 500 msec. and was followed by a blank screen for 500 ms. Then, the first picture in a pair appeared at the same location for 2000 ms followed by another blank screen for 500 ms. The second picture followed and stayed on until the participants responded. Upon a response, a last blank screen of 500 ms replaced the second picture and the next trial began. Both pictures measured 22.5 cm in width and 17 cm in height. The participants sat at a viewing distance of 70 cm in front of the computer screen. The participants were told to respond with the index finger of their preferred hand as quickly and accurately as soon as the second picture appeared. The index finger was parked at the gulf between the blue and orange keys at the beginning of a

trial. The participants received five practice trials before going on with the experimental trials.

**The Reading Experience Questionnaire** Upon completion of the reading task and the STARC task, the participants also filled out a questionnaire to indicate how frequently they encountered a vertical text, a horizontal text printed from left to right, and a horizontal text printed from right to left on a 8-point scale ranging from never (0) to very frequently (7). They also reported the sources of the texts (e.g., magazines, newspapers, textbooks, street signs, slogans, advertisements, etc.).

## Results

### The Taiwan Sample

For the Taiwan sample, the participants' comprehension scores in the reading task were close to perfect. Their rated experience of vertical texts, horizontal left-to-right texts and horizontal right-to-left texts was 5.7 (SD=1.6), 6.5 (SD=0.5), and 1.4 (SD=1.6), respectively. Their error rate in the STARC task was on the average 3%. The analysis of their log-transformed response times in the STARC task shows the pattern in Figure 1. The STARC effect on the Y-axis represents the averaged difference in log-transformed response time of the noncanonical condition minus the canonical condition. The overall STARC effect was significant by the linear mixed-effect analysis:  $F(1, 7915) = 59.18, p < .0001$ . As the figure shows, the STARC effect was greater when the response keys were oriented vertically than when they were oriented horizontally:  $F(1, 7915) = 11.13, p = .0009$ . This indicates an overall vertical bias in temporal judgment by our Taiwan participants. The figure also shows that whereas the vertical bias was fairly strong following the vertical prime (i.e., having read the vertical texts and questions), it was substantially reduced (in fact disappeared) following the horizontal prime. Statistically, the response orientation by canonicity interaction was highly significant under the vertical prime,  $F(1, 3952) = 18.51, p < .0001$ , but the same interaction was far from being significant under the horizontal prime,  $F(1, 3927) = .35, p = .5564$ .

### The Beijing Sample

For the Beijing sample, the participants' comprehension scores in the reading task were also close to perfect. Their rated experience of vertical texts, horizontal left-to-right texts and horizontal right-to-left texts was 2.7 (SD=1.6), 6.9 (SD=0.7), and 1.3 (SD=1.3), respectively. Their averaged error rate in the STARC task was 3%. The analysis of their log-transformed response times in the STARC task shows the pattern in Figure 2. The overall STARC effect was significant by the linear mixed-effect analysis:  $F(1, 7857) = 50.07, p < .0001$ . As the figure shows, the STARC effect interacted significantly with prime and response orientation:  $F(1, 7857) = 8.01, p = .0047$ . Separate post-hoc analyses show that the response orientation by canonicity interaction was significant under the vertical prime,  $F(1, 3895) = 4.83, p = .0280$ , showing a greater horizontal STARC effect than

the vertical one; under the horizontal prime, the vertical STARC effect was greater than the horizontal one, but the interaction fell short of the conventional level of significance,  $F(1, 3926) = 3.22, p = .0728$ . Worth noting is no significant difference between the horizontal and vertical STARC effects ( $p = .57$ ), indicating no overall vertical bias in the Beijing participants. None of the other effects were significant,  $p$ 's  $> .24$ .

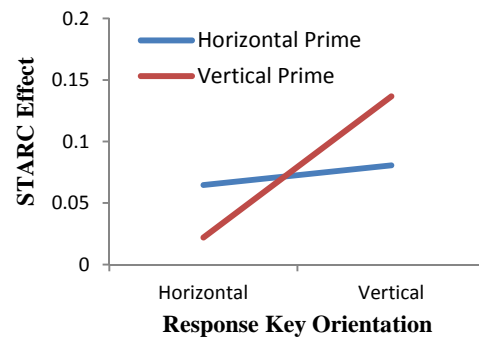


Figure 1: The STARC effect (difference in log RT of the noncanonical condition minus the canonical condition) as a function of response key orientation and type of contextual prime (the Taipei sample).

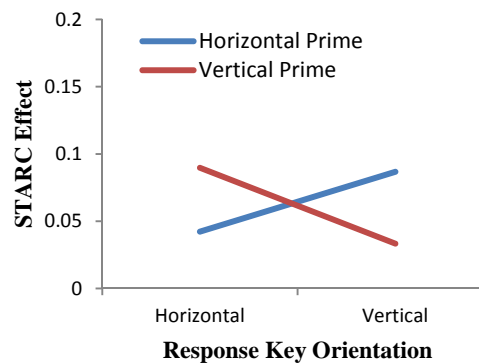


Figure 2: The STARC effect (difference in log RT of the noncanonical condition minus the canonical condition) as a function of response key orientation and type of contextual prime (the Beijing sample).

## Discussion

The Chinese language employs both horizontal and vertical spatial metaphors for expressing time. It has been suggested that the common use of vertical spatial metaphors biases the Chinese speakers to conceptualize time vertically. We hypothesized that reading experience of horizontally and vertically arranged texts might be a potent variable contributing to such a bias. The hypothesis was tested by assigning Chinese participants from Taiwan and China to a reading task involving either horizontally or vertically arranged texts, followed by a STARC task. Although the vertical STARC effect was overall greater than the horizontal one among the Taiwan participants, such a vertical bias was absent among the China participants. These results can be accounted for by the significantly more frequent lifetime experience of encountering vertical texts among the Taiwan participants

than among the China participants: 5.7 vs. 2.7,  $t(110) = 9.9$ ,  $p < .0001$ . The rated experience of encountering horizontal left-to-right texts was similar between the two groups of participants: 6.5 vs. 6.9.

Furthermore, the vertical bias, when present, was modulated by the immediate reading experience such that it disappeared when the Taiwan participants had just read horizontally arranged texts. For the China participants, the immediate reading experience also modulated the vertical bias, but in the opposite direction. The horizontal prime led to no significant vertical bias while the vertical prime brought about a horizontal bias. The different patterns of results between the Taiwan and the Beijing participants indicate that lifetime reading experience interacts with immediate reading experience in its effect on the participants' temporal judgment in the STARC task.

The finding of a causal role of directionality of orthography and reading experience in Chinese speakers' temporal judgment is consistent with the findings of many studies in the literature showing a relationship between the directionality of orthography and the performance on a space-implicated task (Tversky, Kugelmass, and Winter, 1991; Dehaene et al., 1993; Zebian, 2005; Chan & Bergen, 2005; Fuhrman & Boroditsky, 2010; Ouellet, Santiago, Israeli, & Gabay, 2010). In conjunction with these findings as well as the facts that (1) horizontal spatial metaphors are used far more frequently than vertical ones in Mandarin Chinese (Chen, 2007) and (2) our Taiwan and China participants speak the same language, the results of the present study suggest that the directionality of orthography and speakers' (immediate and lifetime) reading experience, rather than the use of spatial metaphors per se, can better explain the vertical bias (or the lack of it) in the Chinese speakers.

Chen and O'Seaghda (2012 accepted) previously observed a vertical bias in the Chinese participants from Taipei (Taiwan), but a horizontal bias in the Chinese participants from Guangdong (China). The discrepancy was attributed to the fact that China has adopted the national policy of printing all texts horizontally whereas both horizontal and vertical directions are allowed and prevalent in Taiwan. The evidence, however, is indirect due to the quasi-experimental nature of the study. By directly manipulating the participants' experience of reading horizontal and vertical texts, the present study offers the needed evidence for establishing the causal role of directionality of orthography and reading experience.

Reading experience can also account for the inconsistent findings across studies. Because the Chinese participants in the previous studies came from different regions, their experience of reading horizontal and vertical texts could vary greatly, which was attested to by the rating data in the present study, and thus could contribute to the inconsistency in findings.

Returning to the use of spatial metaphors for expressing time, Chen (2007) has previously reported that horizontal spatial metaphors were actually used far more frequently than vertical spatial metaphors in Chinese. He argued that the usage pattern did not lend the logical support for the hypothesis that Chinese speakers would think about time

more vertically. Boroditsky et al. (2011) countered Chen's argument by maintaining that it was the cross-language difference in the usage of vertical spatial metaphors that predicted the vertical bias in the Chinese speakers. However, without controlling for potent factors such as directionality of orthography and speakers' reading experience, it is impossible to make certain that Chinese speakers do think about time differently than English speakers and that this is due to the differential usage of vertical spatial metaphors in the two languages.

The hypothesized conceptual link between spatial and temporal reasoning has also been questioned recently with respect to the use of frame of reference. It has been claimed that people reference time onto space, and because different linguistic communities prefer different spatial frames of reference, their temporal references vary as well. Beller, Rothe, Hüther and Bender (2012) examined existing data as well new data, concluding that there is not a close link between referencing preferences across spatial and temporal domains.

Although linguistic relativity has manifested itself in several domains of cognition, whether it extends to the conception of time in relation to the latter's metaphorically projected meaning requires further investigations at best.

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