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The effect of temporal concept on the automatic activation of spatial representation: From axis to plane

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ABSTRACT

Temporal concepts could be represented horizontally(X-axis) or vertically (Y-axis). However, whether the spatial representation of time exists in the whole plane remains unclear. In this study, we investigated whether processing temporal concepts would automatically activate spatial representations in a whole plane without any guidance or cue. Participants first indicated whether a word was past-related or future-related, then, they identified a target in different visual fields. In Experiment 1, the results demonstrated that past time mapped onto the left and top in a plane or axis, while future time mapped onto the right and bottom, with the horizontal effect being stronger than the vertical effect. In Experiment 2, an index of eye movement showed a similar data pattern. Thinking about temporal concepts activates spatial schema automatically without guidance or cue, and the time-space metaphor is represented not only as an axis but also as a whole plane. The results were discussed in terms of the possible cultural differences that made the Chinese participants tend to be more flexible in spatial representation of time because of their comprehensive thinking.

1. Introduction

How do people represent abstract concepts? Do they need a concrete grounding to sustain the abstraction they refer to? Findings from linguistic studies suggest that processing abstraction needs a concrete grounding (Lakoff & Johnson, 1980, 1999). Temporal concepts provide an example of abstract concepts (Boroditsky, 2000, 2001; Casasanto, 2008; McGlone & Harding, 1998). In almost all languages, everyday expressions related to time and space, such as from 1o'clock to 3o'clock vs. from here to there (Haspelmath, 1997; Radden, 2004). Abstract concepts are associated naturally with the more concrete concepts of space (Bennett, 1975). Some research indicated that when thinking about time, individuals seemed to form an internal spatial representation (Weger & Pratt, 2008; Fuhrman & Boroditsky, 2010; Miles, Tan, Noble, Lumsden, & Macrae, 2011). Temporal concepts could be represented horizontally(X-axis) or vertically(Y-axis), with the left–past and right–future or top(upside)-past and bottom(downside)-future association (Torralbo, Santiago, & Lupiáñez, 2006; Ulrich & Maienborn, 2010; Boroditsky et al., 2011; Boroditsky, 2001; Chen & Huang, 2006). However, whether the spatial representation of time exists in the whole plane remains unclear. In this study, we investigated

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whether processing temporal concepts would automatically activate spatial representations in a whole plane without any guidance or cue.

1.1. A mental time line

Time–space interactions suggest that humans do not process time and space separately. Recently, several researchers have pointed out the possibility that humans represent time flow with a spatial layout, or a "mental time line" (MTL) (Bonato, Priftis, Marenzi, Umiltà, & Zorzi, 2012), which parallels the mental number line (MNL). Small numbers are represented on the left of the MNL, and large numbers on the right (Berch, Foley, Hill, & Ryan, 1999; Dehaene, Bossini, & Giraux, 1993; Moyer & Landauer, 1967; Restle, 1970). The spatial orientation of the MNL is embodied and corresponds with the habit of writing that from left to right or from right to left (Dehaene et al., 1993; Zorzi, Priftis, & Umiltà, 2002). MTL suggests that time is represented as a sequential line in which time flows from one extremity to another (from past to future with left-to-right). Previous studies have found that writing direction affects the spatial representation of time (Fuhrman & Boroditsky, 2007). Moreover, the MTL affects spatial attention (Bonato et al., 2012).

1.2. Time-space connection

Many studies have shown that time processing occurs on a left-to-right mental line. Gevers, Reynvoet, & Fias's (2003) studies showed this association holds for letters of the alphabet, months of the year, and days of the week. Torralbo et al. (2006) examined the conceptual projection of time onto the domain of space. Participants categorized words presented at different spatial locations (back–front, left–right) as referring to the past or to the future. The results showed that left-sided and the back words referring to the past were responded faster than those referring to the future, and a reversed pattern was shown for right-sided and the front words. Categorizing words referring to the past or to the future have also been shown to be facilitated when the response mapping was congruent with the left–past and right–future association (Santiago, Ez, Pérez, & Funes, 2007).

The left-past and right-future association has also been found in sentence processing. When participants responded to a past-related sentence, they pressed a left-sided key faster than a right-sided key, while their responses to a future-related sentence were reversed. This result not only exists in temporal judgments, but also in non-temporal judgments (Ulrich & Maienborn, 2010). Moreover, comparisons between early and late of time are also represented by a left-to-right mental line. In the study of Weger and Pratt (2008), they required participants to decide whether actors were famous earlier or later than their own date of birth after presenting with actors' names. The results showed that for early actors, judgments indicated by the left hand were faster than those indicated by the right hand, and the results for contemporary actors were reversed. This association is also evident when participants are asked whether a story segment was presented earlier or later than a reference segment (Santiago, Román, Ouellet, Rodríguez, & Pérez-Azor, 2010).

Boroditsky, Fuhrman, and McCormick (2011) used a new paradigm to investigate the temporal-spatial representation. Participants were presented with a series of temporal implication pictures, then they were required to judge whether the character in a second picture had been presented earlier than the first one. Both Chinese and English speakers demonstrated the left–past and right–future association.

Some previous studies showed that Chinese speakers also represent temporal concepts in a vertical direction (Boroditsky, 2001; Chen & Huang, 2006; Chun, 1999), with the past relating to the upside, and the future relating to the downside. However, some other studies did not find vertical effect (Glucksberg, Brown, & McGlone, 1993; Keysar & Bly, 1995). By priming the vertical and horizontal spatial schema, Boroditsky (2001) compared the time-space metaphor between Chinese and English speakers. The research demonstrated that a vertical time-space metaphor was found in Chinese speakers, but not in English speakers. Therefore, Boroditsky and her colleagues proposed that different languages might result in different thinking patterns and Chinese speakers tended to think about time in a vertical representation. However, later studies showed different results concerning vertical schema (January & Kako, 2007; Wu, Xu, & Zhang, 2007; Chen, 2007). Also, the study by Tse and Altarriba (2008) contradicted the view that Boroditsky and her colleagues had pointed out. In summary, there is still no consensus about a vertical schema of temporal representation for Chinese speakers.

Furthermore, in terms of ego-moving and time-moving metaphors, researchers discovered a front-back spatial schema (Gentner & Imai, 1992). In the ego-moving metaphor, individual's context progresses along the time-line toward the future. The future is in front of the individual, and the past is in the back of the individual. In the time-moving metaphor, time-line is conceived as a river or a conveyor belt on which events are moving from the future to the past (Boroditsky, 2000; Chen & Huang, 2006; Jin & Huang, 2012). The study by Wu, Mo, and Wang (2005) has shown that Chinese speakers represent time-related language in a "time-moving" view. Leung and Cohen (2007) also found that Chinese speakers and English speakers could have different preferences for time-moving or ego-moving metaphor. In sum, when people understand time concepts, there is a temporal-spatial metaphor representation on the front-back axis.

1.3. Writing direction and time-space metaphor

Several studies of temporal-spatial metaphor confirm that a left-to-right mental line is a consequence of the writing direction (Chatterjee, Southwood, & Basilico, 1999). This conclusion has been demonstrated typically by Hebrew speakers, whose writing direction is from right to left. Fuhrman and Boroditsky (2007) required English and Hebrew speakers to discriminate pictures related to earlier or later time. English participants showed a left effector advantage for earlier pictures, whereas for later pictures, response