Title

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Authors

Ng, Melvin M.R.
Goh, Winston D
Yap, Melvin J
et al.

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The Past and Future are in Your Hands: How Gestures Affect Our Understanding of Temporal Concepts

Melvin M. R. Ng (a0052092@nus.edu.sg)
Winston D. Goh (psygohw@nus.edu.sg)
Melvin J. Yap (melvin@nus.edu.sg)
Department of Psychology, National University of Singapore, 9 Arts Link,
Singapore 117570, Singapore

Chi-Shing Tse (cstse@cuhk.edu.hk)
Wing Chee So (wingchee@cuhk.edu.hk)
Department of Educational Psychology, The Chinese University of Hong Kong,
Shatin, N.T., Hong Kong

Abstract

Metaphors are commonly used by individuals to represent and reason about time in daily conversations. These metaphors are often paired with gestures that reveal the possible axes along which our internal conceptualisation of time may be aligned against. The present study attempts to use such gestures as temporal primes to investigate how individuals conceptualize time. Results revealed effects of congruency along the sagittal axis, but not the lateral. This suggests that individuals primarily represent time most strongly along the sagittal axis. Implications for models of how individuals represent time as well as methods of investigating how time is represented in the mind are discussed.

Keywords: Time; gestures; priming

Introduction

According to Lakoff and Johnson's (1999) Conceptual Metaphor Theory, abstract concepts such as time are grounded in more concrete dimensions such as space or motion. For example, in English, as well as the majority of languages of the world, metaphors referring to time are arranged primarily along the sagittal axis (Radden, 2003), e.g., "I am looking *forward* to tonight's dinner" and "It is good that we put our past *behind* us".

Recent research have found evidence for a lateral timeline. Past-related concepts are situated on the left, while future-related concepts are placed on the right for English speakers, mirroring the way they read and write (e.g., Boroditsky, Fuhrman & McCormick, 2011). Previous findings have also provided evidence for a mental timeline running along the sagittal axis (e.g., Walker, Bergen & Nunez, 2013; Ulrich, Eikmeier, de la Vega, Fernández, Alex-Ruf & Maienborn, 2012), whereas others failed to find that (e.g., Fuhrman, McCormick, Chen, Jiang, Shu, Mao & Boroditsky, 2011).

Studies that found evidence of a lateral timeline (but not a sagittal one) often used response congruency as their main means of investigation. This method is based on the spatial-temporal association of response codes (STEARC) effect, and "past-related" or "earlier" responses have been found to be responded to faster from a congruent location than an incongruent one (e.g., in the case of the lateral timeline, "past" responses made with the left hand/button/key should be faster than if the response had to be made on the right). This congruency effect between temporal event and spatial location is taken to suggest the existence of a 'mental time line' (Ishihara, Keller, Rossetti & Prinz, 2008). However, one of the factors that determine how an individual represents time is the immediate presence of spatial representations that may be recruited to help them think about time (e.g., Casasanto & Boroditsky, 2008; Casasanto & Bottini, 2014). In studies that use response congruency as their main means of investigation, the required mode of response naturally becomes the spatial frame that is most cognitively available for participants to co-opt for thinking about time. Hence, it is entirely possible that any results found may arise from task demands; requiring participants to make specific motor responses would naturally evoke transient directional spatial frames that they then recruit on the spot to represent time. As such, findings of a lateral plane (and the absence of a sagittal plane) may be a product of the response congruency methodology, rather than how people naturally represent time in their minds.

In the present study, we propose a new means of investigation that circumvents the potential problem of the response congruency method. Instead of varying the response keys for past and future responses, we kept the method of response consistent throughout, focusing instead on accessing temporal representations directly through priming. An advantage of this is that by having each target serve as its own control, while holding other aspects of the experiment constant, it is possible to determine if the conditions evoked by the prime are responsible for any differences observed. In essence, rather than relying on specific responses as a proxy to mental timelines (which may be heavily influenced by such responses), the usage of priming allows for a direct investigation of temporal representations in the mind while circumventing any inclination towards a particular axis as a result of the imposition of specific response frames. To that end, our study makes use of stimuli that is commonly encountered in everyday conversations about time: Gestures. Gestures are

spontaneous hand movements produced by speakers when they speak and convey substantive information (McNeill, 1992). Speakers have commonly been found to produce gestures along both sagittal and lateral planes when talking about time (Casasanto & Jasmin, 2012). As such, the prevalence of gestures accompanying temporal speech may imply a possible role of bodily motion in temporal cognition and communication of such temporal concepts. Previous studies have reported that iconic gestures are capable of priming semantically related words and concepts (Wu & Coulson, 2011; Yap, So, Yap, Tan & Teoh, 2011). In essence, the usage of gestures as primes may present a means to access the very same objects or concepts they represent. Furthermore, the usage of gestures yokes the axis of interest to the gesturer, allowing participants the freedom to interpret time without the constraint of specific response methods.

As such, by using temporal gestures as primes, in conjunction with binaural auditory tokens which have been found to be as effective as visual stimuli in probing temporal concepts (Ouellet, Santiago, Israeli & Gabay, 2010), the present research hopes to probe temporal concepts directly without using any specific method of response as a proxy.

Experiment 1

In Experiment 1, we investigated the sagittal axis. Previous studies found mixed evidence for a mental timeline spanning the sagittal axis. However, given the abundance of sagittal metaphors in text corpus in languages around the world (e.g., "I am looking forward to seeing you"; Radden, 2004), researchers have been reluctant to discount its existence. Since past-related concepts are commonly situated behind the individual in English, a temporal gesture indicating an area of space behind the gesturer should prime past-related concepts and aid in the temporal judgement of past-related words, and forward gestures for future-related words.

Method

Participants. A group of 44 undergraduates from the National University of Singapore participated in the study for course credit or payment. All participants were English-Mandarin bilinguals who have studied in Singapore for at least 10 years. Participants reported their level of proficiency in English and Mandarin using a language background questionnaire and indicated that their first language was English and they had better proficiency in it than Mandarin.

Design. A 2 (Temporality: past- vs. future-related word) x 2 (Congruency: congruent vs. incongruent) within-subject design was used. Congruency was determined with respect to the gesturer, so a point towards the back is considered to be congruent if it was paired with a past-related word, and incongruent if paired with a future-related one.

Materials. Time-related words were chosen from the online Oxford Dictionary (2015). Ten students from the same population sample, but who did not take part in the main experiments, rated how past- or future-related the words were. A 5-point Likert scale was used, with 1 representing a strongly past-related word, 5 a strongly future-related word, and 3 being a temporally neutral word. A final set of 80, with an equal number of past- and future-related words, was chosen from words that were rated as either past- (<3) or future-related (>3). Interrater reliability was high and there was high agreement between raters on whether a word was past- or future-related, Cronbach's $\alpha = .967$. Characteristics of the chosen words are summarised in Table 1 and the words themselves can be found in the Appendix.

Within each temporal category, the words were further divided into two equal sub-lists, with each group being either paired with a congruent gesture (e.g., the model pointing to her left + "yesterday") or an incongruent gesture (e.g., the model pointing to her right + "olden"). Thus, each word was paired with either a related or unrelated gestural prime for each participant in a Latin-squared fashion, and across all participants, all targets were preceded equally often by related and unrelated gestural primes.

As past and future words could not be made identical, separate one-way analyses of variance (ANOVAs) were conducted between each sub-list to ascertain that the words were properly distributed between sub-lists.

Results showed the temporal words were matched across sub-lists on word duration, log-transformed hyperspace to analog (HAL) frequency, phonological neighbourhood density, number of phonemes, number of syllables and phonological Levenshtein distance (all Fs < 1).

All stimuli were spoken by a linguistically trained female speaker and recorded digitally in 16-bit mono, 44.4Tim kHz, .wav format.

Two gesture video clips were paired with either related or unrelated temporal words. These gesture clips were constructed by recording silent videos of a female actor facing and looking at the camera and pointing either backwards or forwards along the sagittal axis. The video included the actor's face. One video was made for each gesture of interest, with an emphasis on its stroke. (Figure 1 shows a snapshot of the gestural stimuli used.)

Figure 1. Snapshot of the gestural stimuli with the gesturer pointing forwards.

Procedure. The experiment was conducted using E-Prime 2.0 and the data was collected using the PST Serial Response Box (Schneider, Eschman, & Zuccolotto, 2002). Participants were seated in front of a 17-inch screen and instructed to make a temporal judgement, as quickly and accurately as possible, of the word using the response box

Table 1: Average Word Properties of the Word Sets in the Experimental Conditions

	Past-related words		Future-related words	
	M	*SD*	*M*	*SD*
Word Duration (ms)	853.38	166.27	821.68	165.16
Log HAL Word Frequency	8.08	2.17	9.08	1.96
Phonological neighbourhood size	1.4	3.74	4	7.52
No. of Phonemes	6.7	1.86	6.58	2.21
Phonological Levenshtein distance	3.02	1.06	2.55	1.01
Temporality rating	1.58	0.39	3.99	0.24

with the left- and right-most buttons assigned to *Past-related* and *Future-related*, respectively. To minimize the imposition of a spatial frame, the response box was situated at a central location relative to the participant, and the response keys were situated in close proximity to one another. Each trial began with a gesture video clip lasting 1000 ms, immediately followed by an auditorily presented temporal word to be judged as either past- or future-related. Prior to the actual experiment, 10 practice trials were administered to familiarize the participants with the experiment. There were a total of 80 experimental trials and participants were allowed a break after every 20 trials

Results and Discussion

For the reaction time (RT) data, only correct judgements with RTs more than 200 ms and less than 3000 ms were included in the analyses. Following which, the overall mean and *SD* of each participant's RT was calculated and trials with latencies being 2.5 *SD*s above or below each participant's mean RT were removed. These trimming criteria resulted in a removal of 5.00% of accurate trials. Overall accuracies were all very high (M = .91, SD = .06).

The mean RTs across the 4 conditions in Experiment 1 are summarised in Figure 4. A two-way repeated-measure ANOVA was conducted on participants' mean RTs by congruency (congruent vs. incongruent) and temporality (past vs. future).

Participants were found to judge past-related and future-related words equally quickly (1348ms vs 1346ms), $F(1,43) = 0.01$, $p > .05$. More crucially, participants were found to respond faster to congruent gesture-word pairs (1335ms) than to incongruent pairs (1360ms), $F(1,43) = 4.372$, $MSe = 6238$, $p < .05$. The interaction between the two variables was not significant ($p > .05$). In other words, an effect of congruency was found along the sagittal plane indicating that gestures were able to prime temporal concepts that were either congruent or incongruent with the auditory target. Furthermore, the effect of congruency was found to mirror the spatio-temporal metaphors commonly recruited to talk about time, with the past situated behind the individual and the future, ahead. Having established that our paradigm was capable of priming temporal concepts, we proceeded to investigate the lateral axis using the same method.

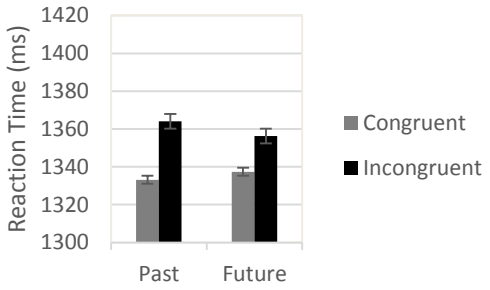

Figure 2. Average RTs for responses in Experiment 1 (error bars indicate 1 standard error above and below the mean)

Experiment 2

In Experiment 2, we addressed the following question: Would individuals be found to represent time along the lateral axis, as shown in previous studies, when a non-response congruency method was employed? If so, we expected that when a primed temporal gesture was congruent with the word to be judged (e.g., a temporal gesture indicating "left" + "yesterday"), responses would be faster than when the primed temporal gesture was incongruent (e.g., a temporal gesture indicating "right" + "yesterday"). Since past-related concepts have previously been found to be situated on the left, a temporal gesture that indicates the left should prime past-related concepts and aid in the temporal judgement of past-related words, and vice versa for future-related words.

Method

Participants. Forty-four undergraduates from the National University of Singapore participated in the study for course credit or payment. All participants were English-Mandarin bilinguals who have studied in Singapore for at least 10 years. Participants also reported their level of proficiency in English & Mandarin using the same language background questionnaire as in Experiment 1 and indicated that their first language was English and they had better proficiency in it than Mandarin.

Design. The same design as Experiment 1 was used.

Materials. The same words in the previous experiment were used. Two gesture video clips were constructed by recording silent videos of the same female actor pointing either left or right the lateral axis. One video was made for each gesture of interest, with an emphasis on its stroke. Figure 3 shows a snapshot of the gestural stimuli used.

Figure 3. Snapshot of the gestural stimuli with the gesturer pointing to her left.

Procedure. The experiment employed the same procedure as in Experiment 1.

Results and Discussion

The same trimming criteria were used as in Experiment 1, and resulted in the loss of 5.97% of accurate trials. Once again, overall accuracies were very high (M = .90, SD = .06).

The mean RTs across the 4 conditions in Experiment 1 are summarised in Figure 2. A two-way repeated-measures ANOVA was conducted on participants' mean RTs, by congruency and temporality.

Overall, neither variable was found to exert an effect on the obtained RTs (ps > .05). There was no difference in response latencies between congruent and incongruent pairs (1359ms vs 1374ms), F < 1, as well as past- and future-related words (1355ms vs 1378ms), $F(1,43) = 1.68$, MSe = 607152, p > .05. In addition, the interaction was also not statistically significant (p > .05). Our results appear to run contrary to previous findings of individuals favouring the lateral axis for representing time, reflecting both reading and writing directions (see Fuhrman et al., 2011). This discrepancy is discussed further in General Discussion.

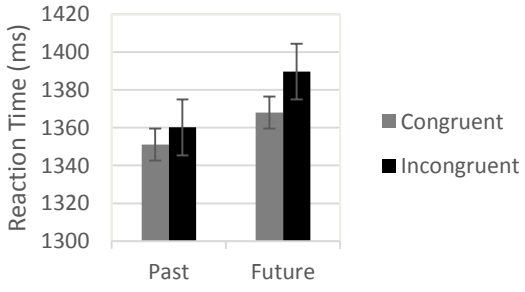

Figure 4. Average RTs for responses in Experiment 1 (error bars indicate 1 standard error above and below the mean)

General Discussion

The results of the present study did not replicate the congruency effect found along the lateral axis in previous studies that have used the response congruency method in their investigations. A significant effect of congruency was found along the sagittal plane, however, providing further support for a mental timeline that is aligned along the sagittal axis.

Our results support the notion that spatiotemporal metaphors found in language reflect temporal concepts in the mind (Lai & Boroditsky, 2013; Lakoff & Johnson, 1999). The overwhelming abundance of metaphors aligned along the sagittal plane in both English (Radden, 2004) and Mandarin (as compared to vertical ones; Chen, 2007), coupled with the almost complete absence of lateral spatiotemporal metaphors would conceivably predispose individuals in representing time along the sagittal axis, rather than the lateral or vertical axes. More recent studies have also found evidence that the left-right mapping of time along the lateral axis may not be as strong as the sagittal one (Eikmeier & Ulrich, 2014).

Participants in our study did not show evidence of a mapping of time along the lateral axis. This suggests that it might be possible that the previously found conceptualization of time along the lateral axis is a result of the methodologies employed by response congruency methods. However, it is unlikely that this possibility can account fully for previous findings as there have been studies that do not employ response congruency methods have also found evidence for time representations arrayed along the lateral axis (e.g., Fuhrman et al., 2011). Hence, rather than the lateral timeline being a product of the paradigm, it could be that the response congruency methodology serves to make prominent this lateral representation, thereby predisposing participants to preferentially adopt that frame for thinking about time at the point of the experiment.

Why then did our lateral temporal gestures not predispose our participants into adopting a conceptualization of time along the lateral axis? After all, it has been proposed by Casasanto and Jasmin (2012) that the lateral axis is of greater informational value and changes along this axis are often easier for interlocutors to perceive than the sagittal axis. A possible reason behind this unexpected finding could be due to the nature of the stimuli chosen for our experiments. Words such as "primordial" or "impending" are more akin to general deictic expressions of time that point in the direction to either the "past" or "future" with respect to the "present". This is in contrast with sequential expressions of time that array events in a sequential manner (E.g., Monday comes *before* Wednesday or lunch comes *after* breakfast). Further to this, isolated words are more likely to be perceived of as deictic rather than sequential, given that the latter requires a point of reference that needs to be set with respect to the word. As noted by Casasanto & Jasmin (2012), people are more likely to produce lateral gestures than sagittal gestures when using sequential expressions of time. The reverse is true when deictic expressions are used.

Hence, it might be possible that sagittal gestures are more meaningful when paired with deictic expressions of time than lateral gestures. As such, our lateral temporal gestures would not be as useful as the sagittal temporal ones considering our largely deictic stimuli. Further studies could potentially determine if sagittal gestures aid the comprehension of deictic expressions of time and if lateral gestures aid the comprehension of sequential expressions, given their greater co-occurrences.

While our new paradigm provides a useful method of investigating how individuals represent time, it is not without its limitations. For one, our method of response (using the left and right keys of a response box oriented laterally for both experiments) may have been subject to a shortcoming of the response congruency method by providing a spatial frame that participants might have then used to represent time. However, we found no evidence of it predisposing participants in adopting a representation of time along the lateral axis. Furthermore, the effect of congruency along the sagittal plane that was found is unlikely to be a result of our response method, given that the layout is different from the plane being investigated (lateral response vs. sagittal plane). Nonetheless, future studies could adopt the use of non-spatial responses such as vocal responses (e.g., Walker et al., 2014).

The present study also has implications for future investigations into the structure of our mental timeline. When a response congruency method is not adopted, individuals are withheld from any readily available spatial frames that they might potentially adopt to transiently represent time. As a result, effects of congruency along the lateral axis are diminished, and individuals are less constrained in conceiving about time. Such findings are partially replicated in Lai and Boroditsky (2014, Study 2) where, when allowed to point to regions in space instead of being constrained along certain modes of response, participants are found to represent time along the sagittal axis as well when asked to arrange events in temporal order. In short, as noted by Walker et al. (2013), the majority of space-time associations observed thus far in response congruency experiments (e.g., Boroditsky et al., 2011; Fuhrman & Boroditsky, 2010) could have arisen from the particulars of the experimental paradigm being used.

Future studies may explore if these findings are particular to gesture or if other spatial stimuli (e.g., arrows) may similarly prime temporal concepts in individuals. The sagittal spatialization of time has been proposed to be oriented with respect to an individual's sagittal axis, and is grounded in the experience of front-back locomotion that our bodies are accustomed to (Clark, 1973, Lakoff & Johnson, 1999; Radden, 2004). As such, while other spatial stimuli may prime temporal representations, gestural stimuli involving seeing another person may be most effective in priming the sagittal timeline. Furthermore, given that an individual's representation of time appears to be heavily influenced by sensorimotor systems that coincide with human movement, having participants perform these gestures may result in a stronger priming of the sagittal timeline. This may then be reflected in greater effects of congruency in a similar paradigm wherein participants are tasked with producing the gestures themselves instead of watching a video of an actor. Studies that investigated Mandarin speakers have also found evidence of a top-to-bottom pattern of aligning time along the vertical axis (e.g., Fuhrman et al., 2011) as well as corresponding gestures along this axis (Chui, 2011), mirroring Chinese spatiotemporal metaphors that place past concepts higher than future ones. Future investigations may also look into Mandarin speakers using vertical gestures and Mandarin words or phrases as stimuli to see if the vertical metaphors in their language would predispose them in adopting a vertical plane for the representation of time.

In conclusion, we present a novel paradigm in which gestures may act as a means by which we may access an individual's implicit spatial conceptualization of time. This paradigm may provide future researchers with a way to investigate how individuals construe time without constraining them through necessitating particular modes of response, and may reveal patterns that would otherwise be obscured as a result of task demands.

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Appendix

List of words used as stimuli for the experiments.

Past-Related Words		Future-Related Words	
aged	memoir	advanced	future
ancestor	nostalgia	after	hence
ancient	obsolete	ahead	impending
antique	old	anticipated	later
archaic	outdated	approaching	looming
before	passe	brewing	modern
beforehand	preceding	coming	nearing
bygone	precursor	conclusion	next
classic	predecessor	consequently	pending
dated	prehistoric	destiny	prophesy
defunct	previous	emerging	prospective
departed	primitive	ensuing	resulting
earlier	prior	eventually	someday
extinct	recollection	expect	soon
flashback	reminiscence	fate	subsequent
forefather	retrospect	final	succeeding
former	stale	following	thereafter
fossilized	timeworn	forecast	tomorrow
history	vintage	foretell	ultimately
initial	yesterday	forthcoming	upcoming