Later events lie behind her, but not behind you: Compatibility effects for temporal sequences along the sagittal axis depend on perspective

Esther J. Walker (e1walker@cogsci.ucsd.edu)
Benjamin K. Bergen (bkbergen@cogsci.ucsd.edu)
Rafael Núñez (nunez@cogsci.ucsd.edu)
Department of Cognitive Science, 9500 Gilman Dr.
University of California, San Diego
La Jolla, CA 92093-0515 USA

Abstract

Perspective plays a large role in how we think about space. Does perspective also influence how we think about abstract concepts, such as time, which have been shown to be closely associated with how we think about space? Linguistic patterns suggest that speakers talk about temporal sequences from two perspectives: field-based and ego perspective (Moore, 2011). However, the psychological reality of these mappings beyond their use in language is unclear. The present study examines whether sequential reasoning recruits the sagittal (front-back) axis differently, depending on the perspective adopted for the task. We manipulated perspective by using pronouns meant to evoke a field-based or ego perspective ("her" vs "your" high school graduation, respectively). Participants made earlier-than or later-than judgments about event sequences using a mouse in front of or behind their body. We observed an interaction between pronoun, temporal reference, and response location. Participants map space onto time differently depending on the frame of reference from which temporal sequences are interpreted.

Keywords: spatial construals of time; perspective; pronouns; compatibility effects; sequence time

Introductions

Spatial perspective plays an important role in how people think about and comprehend the world around them (e.g., Tversky, 2003, 2005) and humans are quite flexible in the spatial perspectives they are able to adopt. Indeed, individuals are not only able to think about and interpret scenes from their own perspective, but are also able to adapt their perspective to that of another person (Tversky & Hard, 2009). Furthermore, language can also influence the perspective from which one interprets a scene. For example, the use of a single pronoun influences the perspective from which readers simulate actions described in narratives (Brunyé, Ditman, Mahoney, Augustyn, & Taylor, 2009). Brunyé et al. (2009) demonstrated that when participants read sentences such as "You are cutting the tomato" versus "He is cutting the tomato", they were faster to match the sentence to the corresponding picture if the pronoun matched the spatial perspective from which the picture was taken. As such, it appears that one's embodied simulation of actions in the world is sensitive to the perspective from which those actions are described. However, is it also the case that the use of different pronouns influences the perspective from which one thinks about more abstract concepts, which have been suggested to obtain their conceptual structure from our embodied experience of moving through and interacting with the world around us (e.g., Lakoff & Johnson, 1980)? One candidate that may help provide insight into such a question is time—the conceptualization of which appears tightly tied to how we think about space.

Across the world's languages, people use space to talk about time. Nevertheless, there's diversity in precisely how languages spatialize time—what axis they use, and how they map time onto that axis (Clark, 1973; Haspelmath, 1997; Núñez & Sweetser, 2006). Moreover, the use of space to structure time isn't merely a matter of language, it's also a matter of thought—a large literature suggests that conceptualizations of time are also strongly linked to thought about space (e.g., Casasanto & Boroditsky, 2008). Indeed, from linguists to philosophers to psychologists, scholars have discussed at length the ways in which time recruits spatial structure. This research has produced a large body of findings in language (Clark, 1973; Traugott, 1975; Moore, 2006; 2011), gesture (Cooperrider & Núñez, 2009; Casasanto & Jasmin, 2012), and psychological experiments (Santiago et al., 2007; Torralbo et al., 2007; Weger & Pratt, 2008; Ouellet et al., 2010).

Scholars have long noted that there exist at least two distinct spatial construals of time: deictic and sequence (McTaggart, 1908; Núñez & Sweetser, 2006). Deictic time conceptualization reflects past/future relationships and centers around the present moment, or "now," as a reference point. Sequence time, on the other hand, does not use "now" as a reference point. Instead, one event becomes the reference point for another event, capturing "earlier" or "later" relationships in time. Experimental research on this topic has often overlooked this distinction, pooling deictic with sequential judgments, but because the two types of time judgment relate to space differently (Casasanto & Jasmin, 2012; Walker, Bergen, & Núñez, 2013), the present study will focus only on sequence time.

Sequence time has been shown to recruit the transversal (left-right) axis in a systematic manner. In gesture, English speakers often sweep their hand to their left when talking about earlier events and to the right when talking about later events (Cooperrider & Núñez, 2009; Casasanto & Jasmin, 2012). Furthermore, space-time compatibility effects are widely reported for this axis in a variety of languages (e.g., in Spanish: Santiago, Lupiañez, Perez, & Funes, 2007; in

English: Weger & Pratt, 2008; in German: Ulrich & Maienborn, 2010). For example, English-speakers are faster to respond to earlier events on their left and to later events on their right (Weger & Pratt, 2008). Interestingly, this pattern reverses in languages that write right-to-left. Hebrew speakers show the opposite patterns and are faster to respond to earlier events on their right and later events to their left (Fuhrman & Boroditsky, 2010). These consistent patterns are likely the product of our long history of experience with various cultural practices, suggesting a strong role of such practices like graphical notation and writing direction in the recruitment of the transversal axis. By contrast, *linguistic patterns* reveal the spatialization of temporal sequences along a sagittal (front-back) axis, and how such temporal sequences are mapped onto the sagittal axis in language appears to depend on the frame of reference from which it is interpreted.

Moore (2011) observes that, in language, temporal sequences can be interpreted from two different reference frames: ego-perspective and field-based. An ego-perspective depends on the perspective of the ego, as in the sentence "It looks like there are sunny days *ahead"* (of now). In this example, "sunny days" are described as lying *ahead* of the present moment, which is co-located with the speaker's ego. This is clearly a case of deictic time, where the deictic center is the present moment and *ahead* refers to the space in front of the speaker, which is then interpreted as *in the future* or *later-than-now*. On the other hand, while ego-perspective frames depend on the perspective of the ego (as in deictic time), field-based frames are deictically neutral, meaning they do not require a deictic center, and do not change if an observer's perspective changes. For example, Moore (2011) considers people waiting in line: no matter which way you look at the line, there is a front and back to that line, dictated by convention. Those in front of others will be served earlier than those who are later in line. This can also be seen in the linguistic example, "Polls showed a widening lead for the Democrats *ahead* of last month's elections" (example from Moore, 2011). From this frame of reference, "ahead" is interpreted to mean "ahead of some reference event", which is subsequently interpreted as "*earlier* than some reference event". Thus, how sequences of events in time map onto space in language appears to depend on the frame of reference from which they are interpreted.

While patterns in language suggest that these two perspectives differ in how they use spatial terms such as "ahead", does this mean that speakers are actually using space differently when thinking about these sequences of events? Recent work has shown that, at least in deictically neutral settings, the earlier-in-front/later-in-back mapping observed in field-based frames in language emerges in experimental paradigms. Walker et al. (2013) had participants listen to a series of two events presented from a speaker that was either in front of or behind them. Participants were then asked to vocally respond whether the second event they heard happened earlier or later than the first event they heard (e.g., after hearing *her high school graduation, her college graduation,* participants would respond "later" into the microphone). Results indicated that participants were faster to make earlier judgments to stimuli presented in front of them and faster to make later judgments that were presented behind them. However, the stimuli in that study all used the pronoun "her", and thus it is unclear whether the results reflect how sequences generally map onto the sagittal axis or whether they were due to the use of deictically neutral stimuli, which, according to patterns in language, elicit such a mapping. Thus, in order to determine whether perspective influences how one interprets the relationship between earlier/later and sagittal space, we'd need to know whether manipulating the perspective from which participants interpret deictically-neutral sequences changes the pattern of space-time mappings.

In the present study, we used the same basic design as described above (Walker et al., 2013). However, stimuli were presented visually instead of auditorily and participants responded using a mouse click instead of responding vocally. Participants made judgments about deictically-neutral sequences along the sagittal axis. Critically, we manipulated the pronoun that preceded each of the events in order to examine whether differences in person perspective induces differences in the frame of reference that participants use to think about the sequences of events. Participants received the pronoun "her" for two blocks, while in the other two blocks they received the pronoun "your".

If temporal sequences are simply mapped onto space in a manner consistent with a field-based frame of reference, we would expect to see *no difference* in the time-space mappings recruited for each of the pronouns—both pronouns would elicit a clear earlier-in-front, later-in-back sequential mapping. Alternatively, the use of different pronouns may lead to the use of different space-time mappings. While making a judgment about whether *your* high school graduation is earlier or later than *your* college graduation need not involve any deixis or reference to the present moment, the inclusion of the pronoun "your" may automatically bring forth thoughts about your location in time. Conversely, the use of the pronoun "her" in sequences would keep them deictically neutral. If this is the case, then the use of the pronoun "her" should lead to time-space mappings consistent with a field-based interpretation (earlier-in-front/later-in-back) while the use of the pronoun "your" should encourage the use of time-space mappings consistent with an ego-perspective (earlier-in-back/later-in-front). More specifically, we would expect a three-way interaction between the pronoun used, temporal reference, and location of response.

Methods

Participants

Forty-two undergraduates at the University of California, San Diego participated for partial course credit. Eight participants were removed due to low levels of accuracy (<80%), leaving 36 participants for analysis.

Materials and Design

The stimuli were composed of forty pairs of typical life events (e.g., "her/your high school graduation, her/your college graduation"). Twenty pairs required "earlier" judgments while twenty required "later" judgments. Stimuli for earlier judgments were no different in length than those presented for later judgments, p=.72.

The experiment was programmed using E-Prime (Psychology Software Tools, Pittsburgh, PA, USA). Each participant completed a total of four blocks of forty trials of sequential judgments. During two of the blocks, each event was preceded with the pronoun "her" and during the other two blocks, events were preceded with "your". Participants completed two blocks of trials (one block for each response mapping) with each pronoun, followed by another two blocks of trials using the other pronoun. Response mappings and pronoun order were counterbalanced across participants.

Procedure

Participants held two computer mouses, one in each hand, with each of their thumbs over one of the mouse buttons. One mouse's button was covered with red tape, while the other mouse's button was covered with yellow tape. Participants held one mouse directly in front of their body and the other mouse behind their back (see Figure 1). Which hand was in front (right or left) was counterbalanced across participants.

Before each block, participants were presented with instructions that explained the stimulus-response mappings they would use for that block. The yellow mouse was always in front of the participant, while the red mouse was always behind the participant. Which judgment required pressing a button on which mouse was changed after each block. Participants were instructed to judge whether the second event they saw in a sequence was earlier or later than the first event, and to indicate their decision by pressing either the yellow or red mouse. They were told to complete the judgments as quickly and accurately as possible. They then completed four practice trials, followed by forty randomly ordered experimental trials. There were a total of 160 trials (four blocks of 40 trials) and 16 practice trials (four practice trials per block).

On each trial, participants were presented with a fixation cross for 1000ms, followed by the first event in the sequence. After 2000ms, the first event was removed from the screen and a white screen was presented for 500 ms. The second event was then presented and remained on the screen until the participant responded, up to a maximum of 5000 ms. Reaction times were measured from the onset of the second event. After each block, participants received new instructions for how to respond during the next block.

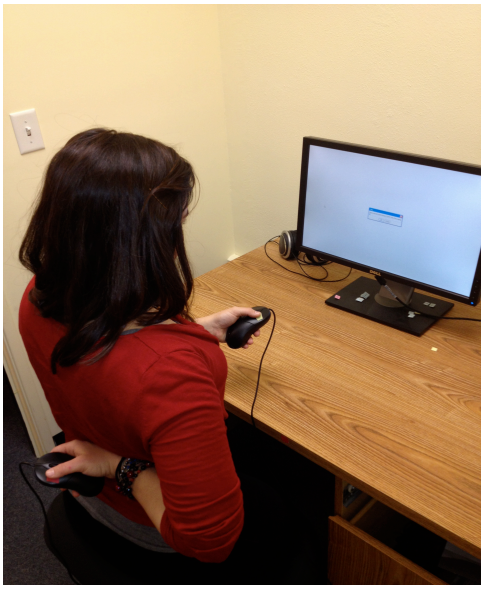

Figure 1: Participants held one mouse in front of their body and one mouse behind their body. Which hand was in front was counterbalanced across participants.

Analyses

All analyses were conducted in *R* (R Development Core Team, 2005). Incorrect trials (5.8% of the data) as well as trials that were 2.5 standard deviations from each subject or item's mean (3.7% of the data) were excluded from analysis. Response times were fitted with a series of linear mixed-effect models with subjects and items as crossed random effects using the *lme4* library (Bates, Maechler, & Bolker, 2011) in *R* (R Development Core Team, 2005). P-values were obtained using the *pvals.fnc* function in the *languageR* package (Baayen, 2011). To investigate whether the different pronouns elicited different spatial construals of temporal sequences, a linear mixed-effects model with temporal reference (earlier, later), response location (front, back), and pronoun (her, your) as fixed effects was fitted to the response times. As needed, appropriate follow-up tests were conducted, as reported below. Models were all significantly different from their respective null models.

Results

The overall model revealed a two-way interaction between temporal reference and response location, β=253.53, SE=43.14, p<.001. Follow-up tests indicated that overall, participants responded faster to later events when responding on the mouse located behind them than the mouse in front of them (β =90.36, SE=22.17, p<.001) and responded faster to earlier events when responding in front than in back (β = -69.86, SE=20.97, p<.001). There was also

a main effect of response location, β=-88.78, SE=43.14, p<.001. Participants were overall faster to respond by clicking on the mouse in front of them than the mouse behind them. No other main effects were significant.

Critically, there was also a three-way interaction between pronoun, temporal reference, and response location, β=-184.70, SE=60.99, p=.003. Follow-up analyses indicated that this interaction was driven by a strong interaction between temporal reference and response location on trials using the pronoun "her", β=254.03, SE=41.71, p<.001. This interaction was not reliably significant for the pronoun "your", β =69.63, SE=42.15, p=.10 (see Figure 2).

To examine whether participants' responses were affected by which pronoun they received first, we ran further exploratory analyses. We divided the data by which pronoun participants received first (her or your) and then created a model with spatial location and temporal reference as fixed effects and subject and items as random effects. Results are presented in Figure 3. For participants who were presented with the pronoun "her" first, there was no longer a three-way interaction between temporal reference, location, and pronoun, p=.31. However, the interaction between temporal reference and location remained, β=279.48, SE=61.38, p<.001, and the earlier-in-front/later-in-back mapping was revealed for both "her" (β =274.42, SE=60.65, p<.001) and "your" (β=198.38, SE=59.09 p<.001). On the other hand, participants who were tested with the pronoun "your" first demonstrated a three-way interaction between pronoun, temporal reference, and location, β=-283.32, SE=83.58, p<.001. While the earlier-in-front/later-in-back pattern remained for the pronoun "her", β=231.73, SE=57.53, p<.001, no clear pattern emerged for the pronoun "your", p=.38.

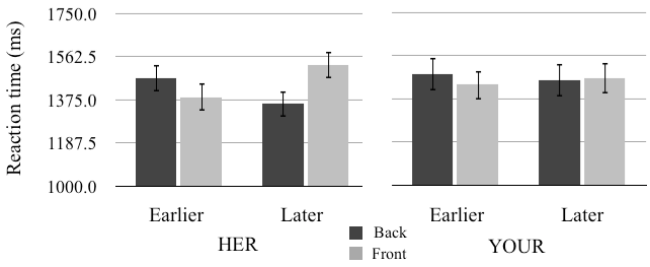

Figure 2: Mean response times for earlier and later judgments along the sagittal axis. The left graph displays the results for the pronoun "her". The interaction between response location and temporal reference is significant. The right graph displays the results for the pronoun "your". Error bars represent standard error.

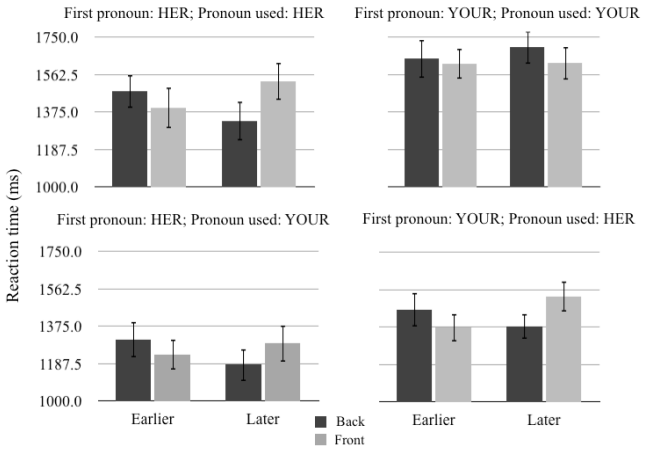

Figure 3: Mean response times for earlier and later judgments along the sagittal axis when split by which pronoun participants received first: the top-left graph shows responses to the pronoun "her" when it came first; the bottom-left graph shows responses to the pronoun "your" when it came after "her"; the top-right graph shows responses to the pronoun "your" when it came first; the bottom-right graph shows responses to the pronoun "her" when it came after "your".

General Discussion

We investigated whether the use of different pronouns ("her", "your") would lead participants to interpret temporal sequences from different perspectives and therefore lead to differences in how individuals mapped temporal sequences onto space. If participants simply systematically map sequences of events onto the sagittal axis in a manner consistent with patterns in language (earlier-in-front/later-in-back), the use of different pronouns should have no effect on the space-time mappings used by the participants. However, we observed a three-way interaction between pronoun, response location, and temporal reference: space-time mappings recruited for temporal sequences involving "her" were different than those recruited for the pronoun "your".

The spatialization of temporal sequences along a body-centered sagittal axis in the present study is intriguing for multiple reasons. First, sequence time does not make reference to the present moment (as in deictic time). As a result, events in a sequence are generally not co-located with a speaker's body in gesture as they are in deictic time. Indeed, sagittal gestures are rarely observed when talking about sequential time (Casasanto & Jasmin, 2012). Second, even though sagittal language (e.g., *ahead*) is used to talk about sequences of events, this language is often used to refer to the location of one event with respect to another event, independent of the speaker's location in space (or time, for that matter) and thus does not reflect a sagittal axis that is centered around the speaker's body. Rather, sequential time is often talked about from an external perspective (Núñez & Cooperrider, 2013). However, it is

interesting to consider what may be happening in the present experiment, where one's body is, by virtue of the experimental design, forced into the same sagittal axis as the rest of the events in the sequences. One potential outcome as a result of this design is that participants simply map the types of responses (earlier, later) onto the spatial locations (back, front) in a manner consistent with deictic time, which *is* associated with a body-centered sagittal axis. However, the present data, as well as the results of previous work by Walker et al. (2013) do not support such an interpretation. Rather, it appears that the body may be acting as an anchor for the first event in the sequence, leading participants to map earlier or later events on to the inherent "frontness" and "backness" of their bodies, with earlier events lying ahead of their body and later events lying behind, consistent with the "earlier events lie ahead of later events" structure found in deictically neutral sequential language. This finding is consistent with findings by Núñez, Motz, and Teuscher (2006), who demonstrated that participants appear to interpret sequential relationships in time by using the front-back relationship that is intrinsic to the spatial organization of whatever is anchoring the sequential construal, which, in the case of the present experiment, is the body. However, as revealed in the present study, this pattern of mappings can be flexible.

While we predicted a three-way interaction between pronoun, temporal reference, and response location, we did not observe the exact interaction pattern we expected. Though participants recruited an "earlier-in-front, later-in-back" mapping for the pronoun "her", we did not see *a reversal* of this mapping when the stimuli were preceded with "your". What might explain the lack of an interaction between response location and temporal reference for the "your" stimuli? One possibility may be due to the fact that the pronoun "you" in English can be interpreted in two ways: either as the second person "you", referring to the interlocutor, or as the indefinite pronoun "you", which refers to a generic person (or people), as in "exercise is good for you". Thus, while some participants may be interpreting the sequence "your high school graduation, your college graduation" relative to their own lives, others may interpret it from a third person perspective, similar to "her high school graduation, her college graduation". Any effects for the pronoun "your" would then be masked by averaging and thus no interaction would emerge.

One potential factor that could have pushed participants to adopt either a personal or an indefinite interpretation of "your" could have been the order in which they completed the blocks in the experiment. Participants who started the experiment by making judgments to events that used the pronoun "her" might have been primed by that experience to subsequently interpret the sequences using "your" as not pertaining to themselves, but rather to be indefinite. By contrast, participants who started by making judgments to "your" events might have been more likely to adopt a personal second-person interpretation.

When the present data were divided by which pronoun participants received first, as described above, this very pattern of results emerges. Participants who received "her" first demonstrated an earlier-in-front/later-in-back mapping for events containing both "her" *and* "your". On the other hand, no consistent space-time mapping was observed for "your" events by participants who received "your" first while the earlier-in-front/later-in-back pattern was again demonstrated for the "her" events. Though these analyses are exploratory and must be interpreted with caution, they provide preliminary evidence that the pronoun that was presented first influences the pattern of space-time mappings for each of the pronouns in a manner consistent with the explanation offered above. Future investigations may want to examine whether a between-subjects design elicits a clearer difference in space-time mappings for each of the pronouns.

One question that remains from this pattern of results is why, even when "your" is presented first, the pronoun "your" does not reveal space-time mappings consistent with an ego-perspective. If "your" can be interpreted from these two different perspectives *and* can be primed by the pronoun "her", as the data above suggests, then it is plausible that no clear effect emerged because participants are interpreting the "your" in different manners from the beginning. Thus, in order to better understand the nature of these mappings, future work must examine what factors are responsible for this lack of effect. For example, teasing apart whether "your" is interpreted from second person as opposed to the indefinite may resolve some of the ambiguities expressed here.

In conclusion, the present study demonstrates that participants are sensitive to the perspective from which temporal sequences are framed. While the pronoun "her" encourages a strong pattern of space-time mappings for sequential time, consistent with a field-based perspective (Moore, 2011), the pronoun "your" does not. This observed difference in how participants map sequences of time onto the sagittal axis reveals that while time often recruits space in systematic and regular patterns *in language,* these mappings are flexible and interact with the spatial perspective from which one *thinks* about time.

Acknowledgments

The authors would like to thank Lucas Medeiros de Paula, Amanda Natsuhara, and Colleen Takahashi for helping with data collection as well as Tyler Marghetis and two anonymous reviewers for helpful comments on previous versions of this work. This work was supported by an NSERC PGS-D awarded to EJW.

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