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The Hands of Time: Temporal gestures in English speakers

Abstract: Do English speakers think about time the way they talk about it? In spoken English, time appears to flow along the sagittal axis (front/back): the future is ahead and the past is behind us. Here we show that when asked to gesture about past and future events deliberately, English speakers often use the sagittal axis, as language suggests they should. By contrast, when producing co-speech gestures spontaneously, they use the lateral axis (left/right) overwhelmingly more often, gesturing leftward for earlier times and rightward for later times. This left-right mapping of time is consistent with the flow of time on calendars and graphs in English-speaking cultures, but is completely absent from conventional spoken metaphors.

English speakers gesture on the lateral axis even when they are using front/back metaphors in their co-occurring speech. This speech-gesture dissociation is not due to any lack of lexical or constructional resources to spatialize time laterally in language, nor to any lack of physical resources to spatialize time sagittally in gesture. We propose that when speakers are describing sequences of events, they often use neither the Moving Ego nor Moving Time perspectives. Rather, they adopt a "Moving Attention" perspective, which is grounded in patterns of interaction with cultural artifacts, not in patterns of interaction with the natural environment. We suggest possible pragmatic, kinematic, and mnemonic motivations for the use of a lateral mental timeline in gesture and in thought. Gestures reveal an implicit spatial conceptualization of time that cannot be inferred from language.

Keywords: gesture, metaphor, space, time

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1 Introduction

When people talk, they usually gesture (Goldin-Meadow 2003). When people talk about time, they usually use spatial metaphors (Alverson 1994; Clark 1973; Evans 2004; Lakoff and Johnson 1980; Moore 2006; Traugott 1978). Do people gesture about time the same way they talk about it? Here we compared the space-time metaphors that American English speakers use in speech and in gesture.

To preview our conclusions, although people use space to represent time both in speech and in gesture, these spatial representations differ across modalities. Spontaneous gestures reveal an implicit space-time mapping that is absent from English, and has not been attested in any of the world's spoken languages. On the basis of spontaneous gestures, it appears that the dominant space-time mapping in English speakers' minds is different from the mapping they express in language.

1.1 The sagittal timeline in English

Nearly every aspect of time can be expressed in spatial words: instants in time can be *points*; durations can be *long* or *short*; events can be *moved forward* or *pushed back*. Linguistic analyses of English space-time metaphors are abundant (e.g., Alverson 1994; Clark 1973; Evans 2004; Lakoff and Johnson 1980; Moore 2006; Núñez and Sweetser 2006; Radden 2004; Traugott 1978). Since extensive analyses are available, we analyze only the most relevant aspects of English space-time mappings here, focusing on their spatial direction and orientation.

1.1.1 Directionality in deictic space-time metaphors

Prototypically in English metaphors, time appears to flow along the speaker's sagittal (front-back) axis: deadlines lie *ahead of us* or *behind us*; we can *look forward* to our golden days or *look back* on our childhood. Time is metaphorized as a horizontal line extending indefinitely ahead of and behind the speaker (Clark 1973; Núñez and Sweetser 2006). These expressions are deictic insomuch as earlier and later times are located on a mental timeline with respect to a speaker who stands metaphorically at a 'now' point, facing toward the future (which is ahead) and away from the past (which is behind the speaker).

Deictic expressions about earlier and later times often use spatial terms that specify a direction on the sagittal axis (1a–b).

(1) a. It will happen *far ahead* in the future.
b. It happened *way back* in the past.

It is possible, however, to express these ideas using spatial metaphors that leave direction unspecified (2a–b).

(2) a. It will happen *far from* now in the future.
b. It happened in the *distant* past.

The italicized expressions (1) and (2) are all spatial metaphors, but only those in (1) specify that the past is in back of the deictic origo and the future in front of it.

It would be unsurprising for a speaker to mix together 'directional' and 'non-directional' spatial metaphors within a discourse, or even within the same utterance (3a–b).

(3) a. I like to dream about what will happen *far ahead* in the future and about what happened in the *distant* past.
b. I like to dream about what will happen in the *distant* future and about what happened *way back* in the past.

In (3), all of the italicized expressions are spatial metaphors, but only the underlined words specify a spatial direction. Words like "distant" specify spatial extent but not orientation or direction. Directional and non-directional metaphors can be used interchangeably, or even in combination with one another, as in (3). It is natural to assume, therefore, that the future stands in the same spatial relation with respect to the origo in non-directional expressions like *in the distant future* as in directional expressions like *far ahead in the future*.

1.1.2 Directionality in sequence space-time metaphors

Some expressions describe sequences of events that are located in time relative to one another, and not relative to a deictic origo (4).

(4) a. Monday comes *before* Tuesday.
b. Tuesday comes *after* Monday.

Purely spatial uses of "before" and "after" are rare, but arguably the temporal expressions in (4) are metaphors from spatio-temporal scenarios like (5).

(5) a. Maple Street comes *before* Elm Street.
b. Elm Street comes *after* Maple Street.

Although "Maple Street" and "Elm Street" have fixed locations in space, whether one street comes before or after the other depends on the experiencer's direction of travel (i.e., if Maple is west of Elm, then Maple comes before Elm for an experiencer traveling from the West, but Elm comes before Maple for an experiencer traveling from the East).

For events like days of the week, however, there is no such deictic reversal of before and after. People can only travel through time in one direction, away from the past and toward the future, therefore there is no ambiguity about whether Monday comes before or after Tuesday: This before/after relationship is the same for all experiencers.

Does the before/after relationship imply that sequences of events are spatialized along a particular axis? It does if we assume that language users conceptualize themselves as facing forward, toward the future, as implied by deictic space-time metaphors (1–3). On this assumption, experiencers should encounter events described by sequence metaphors (4) serially, as they move forward through time (when they adopt an ego-moving perspective) or as events approach them from the front (when they adopt a time-moving perspective). Analogously, it is natural to assume that experiencers should encounter the streets in (5) as they travel along a sagittally-oriented path through space. (This sagittal orientation is implied but not necessary; Maple could still be said to come before Elm if the westbound traveler were riding sideways in a bus or walking sideways like a crab, in which case "before" is defined with respect to the direction of motion, not the body's intrinsic front.) On the basis of sequence metaphors like (4), it is possible to infer that events follow one another along a sagittally-oriented mental timeline, but this sagittal orientation is implied more strongly by deictic metaphors (1) than by sequence metaphors (4).

1.1.3 Are there any other timelines in English?

Standard English makes systematic use of only one timeline: the sagittal timeline, with the future ahead and the past behind. In isolated idioms, it appears that time may be metaphorized on the vertical axis in English (as in Mandarin Chinese, e.g., Scott 1989). For example (6):

(6) a. We're *coming up* on the deadline.
b. The deadline is *coming up*.

Yet, upon examination, it is clear that these expressions in (6) are not systematic: The "up" metaphors are not complemented by "down" metaphors with opposite temporal meanings (see Casasanto 2009a). Sagittal metaphors are systematic. Metaphors referring to later times (e.g., *moving the meeting forward*) are inferentially linked to metaphors referring to earlier times (e.g., *moving the meeting back*). This is not the case on the vertical axis. It is sensible to *move a meeting up* but not to *move a meeting down*. Conversely, heirlooms can be *handed down* the generations but not *handed up* them.

Furthermore, the "up" in (6) may not be a metaphorical projection from vertical space, at all: There are uses of "up" that imply horizontal (probably sagittal) motion (7).

(7) a. The driver should *pull up* to the curb.
b. Elm Street is *coming up*.

In example (7a), the speaker does not expect the car to levitate. "Pulling up" to the curb means driving the car forward, horizontally, along the driver's sagittal axis. In (7b), arguably "coming up" may have temporal (i.e., aspectual) meaning, but to the extent that it refers to the spatial location of Elm Street relative to the speaker's origo, it signals that the street is nearby in horizontal distance (Casasanto 2009b).

This leaves one axis to consider, the lateral (left-right) axis. Consideration can be brief: there are simply no expressions in English that specify orientation, direction, location, or motion in time on the lateral axis. This is not for lack of lexical or constructional resources. *Monday is to the left of Tuesday* is syntactically well formed, but this expression is not an acceptable substitute for expressions that imply a sagittal spatialization of time (4) or for purely temporal expressions (e.g., *Monday is earlier than Tuesday*; see Clark 1973; Cienki 1998; Evans 2004).

Not every space-time metaphor in English specifies a direction or orientation in space (2). But when orientation and direction are specified, the metaphors imply a sagittal mental timeline.

1.2 Evidence for a laterally-oriented mental timeline

Despite the total absence of left-right metaphors in spoken language, there is strong evidence that English speakers have an implicit mental timeline that runs along the lateral axis, with earlier times on the left and later times on the right of body-centered space. In one experiment (Weger and Pratt 2008), participants judged whether celebrities had become famous before or after the participant was

born, as quickly as possible. To respond, participants pressed a button either on the left or the right of the keyboard. For half of the experiment the "before" key was on the left and the "after" key on the right, and for the other half the key mapping was reversed. Responses were fastest when the key mapping was consistent with the left-to-right time mapping.

The direction in which time is arranged along people's lateral mental timeline varies systematically across cultures. In one study, Tversky and colleagues (1991) asked children and adults to place stickers on a page to indicate where breakfast and dinner should appear relative to the lunch sticker, in the middle of the page. Whereas English speakers placed breakfast on the left and dinner on the right of lunch, Arabic speakers preferred the opposite arrangement, consistent with the direction of reading and writing in English and Arabic, and with the lateral organization of time on calendars in English- and Arabic-speaking cultures. Similar patterns have been found in reaction time tasks comparing English with Hebrew speakers (Fuhrman and Boroditsky 2010) and comparing Spanish speakers with Hebrew speakers (who, like Arabic speakers, read and write from right to left; Ouellet et al. 2010).

The left-right flow of time in people's minds is not merely correlated with the direction of orthography: Reading and writing direction can also play a causal role in shaping people's implicit lateral timelines. Casasanto and Bottini (2010) showed Dutch-speakers phrases like 'a year before' (*een jaar daarvoor*) or 'a decade after' (*een decennium daarna*). Participants pressed a button on the left or right of a keyboard (with the key mapping reversed mid-experiment) to indicate whether the phrases referred to a time in the past or the future. For half of the participants, the phrases were presented in standard Dutch orthography. For the other half, phrases appeared in mirror-reversed Dutch. Participants in the Standard Dutch condition were fastest to judge past-oriented phrases by pressing the left button and future-oriented phrases by pressing the right button. By the second presentation of the stimuli, however, participants in the Mirror-Reversed Dutch condition showed the opposite pattern of reaction times, consistent with results found previously in native Arabic and Hebrew speakers. Experience reading a reversed orthography is sufficient to reverse the flow of time in readers' minds, at least transiently.

From this experiment, we conclude that the flow of time along the lateral timeline can change independently of any change in people's use of linguistic metaphors (which were the same across Casasanto and Bottini's Standard Orthography and Mirror-Reversed Orthography conditions). Furthermore, these results suggest that people automatically activate lateral space-time mappings even while they are using before/after metaphors in language (4), which are commonly analyzed as projections from the sagittal axis (Clark 1973; Evans 2004;

Lakoff and Johnson 1980; Moore 2006; Núñez and Sweetser 2006; Radden 2004; Traugott 1978).

1.3 What is the dominant timeline in English speakers' minds?

When English speakers use space-time metaphors in language, what spatial representations are they activating in their minds? Is it possible that people think about time using different spatial schemas than they use to talk about it? Specifically, do English speakers tend to spatialize time on the lateral axis implicitly, even while they are producing sagittal space-time metaphors in language, explicitly?

To address these questions, we conducted quantitative studies of co-speech gestures in English speakers (for related qualitative studies see Cienki 1998; Cooperrider and Núñez 2009). In Experiment 1, we asked participants to make deliberate gestures (i.e., gesture demonstrations) that they thought would most naturally accompany speech about earlier and later times. In Experiment 2, we analyzed the spontaneous gestures speakers produced as they told brief stories with pastward or futureward narrative trajectories.

2 Experiment 1: Deliberate gestures about time

2.1 Methods

Thirty-two English speakers volunteered to participate in a brief experiment on gesture when approached by the experimenter on the University of Minnesota campus.

Four pairs of questions were constructed to elicit deliberate gestures about events happening in the past and the future (Table 1). Each participant was asked two pairs of questions. One pair used deictic reference, describing events with respect to a 'now' point. The other pair referred to sequential events whose temporal relationships could be understood irrespective of a deictic 'now'. Half of the subjects heard questions worded with directional language, and the other half heard non-directional language. The order of mention for Past/Future and Deictic/Sequence versions of questions was counterbalanced across subjects. The experimenter recorded the orientation and direction of the gestures that participants produced in response to each question.

Deictic reference, directional language:
(Future) . . . will happen a long time from now, *far ahead* in the future?
(Past) . . . happened a long time ago, *way back* in the past?
Deictic reference, non-directional language:
(Future) . . . will happen a long time from now, *in the distant* future?
(Past) . . . happened a long time ago, *in the distant* past?
Sequence reference, directional language:
(Future) . . . will happen in your children's generation, and then a generation *after* that?
(Past) . . . happened in your parents' generation, and then a generation *before* that?
Sequence reference, non-directional language:
(Future) . . . will happen in your children's generation, and then a generation *later* than that?
(Past) . . . happened in your parents' generation, and then a generation *earlier* than that?

Table 1: Questions posed to participants. Each question began with "How would you gesture about things that . . ." (see continuations above).

2.2 Results and discussion

First gesture strokes were tabulated according to the hand(s) used to produce them (Left, Right, Bimanual), orientation (Lateral, Sagittal, Vertical), and direction: Upward, Downward, Leftward, Rightward, Away (from the body), Toward (the body), Back (over the shoulder), In (both hands moving toward each other), or Out (both hands moving away from each other) (McNeill 1992).

Of the 128 first gestures that the participants produced, 99 gestures (77%) were on the axes of interest and had a stroke direction that could be coded clearly: 41 lateral gestures (19 leftward, 22 rightward) and 58 sagittal gestures (33 away, 1 toward, 24 back). The remaining 29 gestures (23%) were either on the vertical axis or had no single codable direction. These were excluded from further analysis.

Lateral and sagittal gestures were coded as congruent or incongruent with the lateral mappings of time suggested by graphic conventions in English-speaking cultures (earlier = leftward, later = rightward) and sagittal mappings suggested by linguistic metaphors in English (earlier = toward or back, later = away). The rate of congruent gestures was compared, overall, and as a function of Axis (lateral, sagittal) and Temporal Reference (deictic, sequence) using repeated measures binary logistic regression.

The majority of gestures (83%) were congruent with the predicted mapping for the axis on which they were produced. Overall, the proportion of congruent gestures was significantly greater than the proportion of incongruent gestures

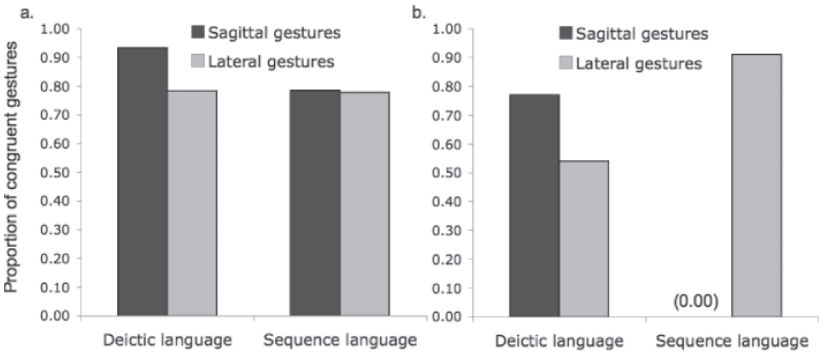

Fig. 1: Results of Experiment 1 (1a, left panel) and Experiment 2 (1b, right panel). Dark bars: Proportion of sagittal (front-back) gestures congruent with space-time mappings found in English linguistic metaphors, produced during deictic temporal language (left columns) and sequence-based temporal language (right columns). Light bars: Proportion of lateral (left-right) gestures congruent with space-time mappings found in English speakers' cultural conventions, produced during deictic temporal language (left columns) and sequence-based temporal language (right columns).

(Wald $\chi^2 = 16.02$, df = 1, p = 0.0001), and the congruity rate did not differ significantly between axes (Wald $\chi^2 = 0.92$, df = 1, p = 0.34). There was a marginally significant association of Temporal Reference with Congruity (Wald $\chi^2 = 2.99$, df = 1, $p = 0.08$), and Temporal Reference also interacted marginally with Axis to predict Congruity (Wald $\chi^2 = 2.65$, df = 1, $p = 0.10$). To investigate these relationships further, we analyzed lateral and sagittal gestures separately. For the lateral axis, there was no effect of Temporal Reference on the rate of congruent gestures produced (Wald $\chi^2 = 0.004$, df = 1, $p = 0.95$). For the sagittal axis, however, the rate of congruent gestures was higher when participants were prompted to gesture about events with deictic reference than when they were prompted to gesture about a sequence of events (Wald $\chi^2 = 4.30$, df = 1, $p = 0.04$; Figure 1a).

Why do people gesture more systematically on the sagittal axis when prompted with deictic language? Deictic metaphors seem to orient the experiencer more strongly on a sagittal mental timeline than sequence metaphors do (§§1.1.1–2). This effect did not depend on using explicit front/back language in the prompt. Congruity was about equally high when participants were prompted using non-directional language (i.e., *in the distant past/future*; Congruity = 93%) and when they were prompted using directional language (i.e., *far ahead in the future, way back in the past*; Congruity = 94%). It appears to be temporal deixis, *per se*, that encourages schema-congruent gestures on the sagittal axis, not the explicit directionality of the spatial metaphors used in speech.

In summary, the majority of gesture demonstrations were congruent with space-time mappings predicted either by linguistic metaphors in English (i.e., sagittal space-time mappings) or by graphic conventions in English speakers' culture (i.e., lateral space-time mappings). Although there are no lateral space-time metaphors in language, participants were about equally likely to produce gesture demonstrations that were congruent with the established timelines on the lateral and sagittal axes. The highest rate of congruity was found for sagittal (front-back) gestures prompted by deictic temporal language (see §§1.1.1–2), suggesting that deictic language may encourage people to conceptualize time as flowing along the sagittal axis, and to gesture accordingly.

However, prompting participants with deictic space-time metaphors did not guarantee that they would spatialize time sagittally in their gestures – not even when the prompts strongly implied a particular direction on the sagittal axis (e.g., *far ahead* in the future; *way back* in the past). When prompted with these phrases (see Table 1), participants produced 18 congruent sagittal gestures (i.e., gesturing forward for futureward or back for pastward times), but they also produced 11 congruent lateral gestures (i.e., gesturing right for futureward or left for pastward times). If people were conceptualizing time sagittally as implied by the verbal prompts, they should have gestured ahead of them for *ahead in the future* and back for *back in the past*. They did this sometimes, but they were also likely to gesture *right* when prompted with "ahead" and *left* when prompted with "back".

Overall, participants were no more likely to make congruent sagittal gestures for time than to make congruent lateral gestures. These data offer little support for the proposal that people think about time the way they talk about it, given that language only suggests a sagittal spatialization of time, and not a lateral spatialization (e.g., Cienki 1998; Clark 1973; Radden 2004).

3 Experiment 2: Time in spontaneous gestures

Experiment 1 tested English speakers' intuitions about how they gesture. In interpreting these data, there is an important caveat to consider: Deliberate gesture demonstrations reflect conscious spatializations of time. When asked to gesture deliberately, people may activate the spatial schemas that are encoded in linguistic metaphors for time, and are therefore available for conscious reflection. These schemas might not be the same as the schemas people use when spatializing time in gesture unconsciously. Spontaneous gestures are often produced without the gesturer's awareness (Goldin-Meadow 2003), and therefore provide a window

on space-time representations in speakers' "cognitive unconscious" (Khilstrom 1987).

In Experiment 2, we investigated how English speakers gesture about time spontaneously, when they are unaware that their gestures are of interest. We developed an objective method of coding and analyzing both the speech and co-speech gestures which allowed us to compare the rates at which participants made schema-congruent sagittal and lateral gestures while producing various kinds of temporal expressions (i.e., deictic reference, sequence-based reference, metaphorical spatial language, and non-spatial language).

3.1 Methods

Stanford University students (N = 28) were recruited and tested in pairs. They participated in exchange for course credit.

Four brief stories were constructed (50–100 words), two with a pastward narrative trajectory and two with a futureward trajectory. Half of these stories used primarily deictic temporal reference and the other half described sequences of events whose temporal reference could be understood independent of a deictic 'now' point. Two versions of each story were constructed, one using space-time metaphors (e.g., *before*; *long ago*; *in the near future*) and the other using non-spatial, purely temporal language with approximately the same meaning (e.g., *earlier*; *many years ago*; *soon*).

Participants were seated on stools facing one another across a small table, and took turns telling stories. They studied each story for one minute before retelling it to their partner, as closely to verbatim as possible. Stories were written in the second person (e.g., *You're thinking about* . . .), but participants were instructed to retell them in the first person, as if they were relating their own thoughts and experiences (e.g., *I'm thinking about* . . .) Each pair of participants received only one version of each story, with either metaphorical spatial or non-spatial wording; each partner told one story of each type. The order of stories was randomized.[1]

Participants were told that the experiment was "about storytelling". They knew they were being videotaped, but did not know their gestures were of

1 In addition to the two temporal stories, each participant told one warm-up story and four stories testing for literal spatial gestures or metaphorical gestures on the vertical axis, in other conceptual domains. These non-temporal stories served as fillers for the time stories reported here.

interest. When debriefed about the purpose of the experiment, no participant reported guessing that it had anything to do with gestures. Several expressed concern that they "didn't gesture" (which was not the case), confirming that spontaneous gestures are often produced without the gesturer's awareness (Casasanto in press; Goldin-Meadow 2003).

3.2 Results

Gestures and speech were coded separately. Independent coding of the speech (blind to the gestures) and of the gestures ("deaf" to the speech) allowed us to test speech-gesture relationships objectively (Casasanto and Jasmin 2010).

3.2.1 Coding of spoken text

The goal of the text analysis was to determine the temporal content of each spoken clause. Stories were transcribed and parsed into clauses. Each clause was rated for its temporal content: if it contained language that referred to pastward or futureward events, the temporal 'direction' of the clause (Past/Future) was recorded and it was classified as a 'target clause'. If a clause did not refer to temporal events, or referred to a mixture of past and future events, it was classified as a 'non-target' clause. Target clauses were further classified as using either Metaphorical Spatial or Non-Spatial (purely temporal) language, and as using either Deictic or Sequence-based temporal reference. These classifications were based on the written transcript; the coder was blind to the gestures that accompanied them.

3.2.2 Coding of gestures

The goal of the gesture analysis was to determine the direction of each gesture stroke, and then to correlate the stroke direction with the "direction" in time implied by the co-occurring spoken clauses.

Gestures were analyzed by two independent coders. Coder 1 performed an initial non-blind coding, viewing the entire video with the accompanying audio. All gestures were parsed into gesture phrases (McNeill 1992), one spoken clause at a time (so that gestures and clauses could be aligned for later stages of the analysis). The stroke phase of each gesture was coded for the orientation and direction of motion, as in Experiment 1 (§2.1). Many gesture strokes have more

than one directional component; the coder recorded the direction that appeared to be dominant.

Coder 2 recoded all of the gestures, blind to the written transcript and "deaf" to the accompanying audio. Using ELAN software, the beginning and end of each spoken clause was marked, dividing the video into clause-length segments. For each segment, Coder 2 recorded the orientation and direction of each stroke, using the same procedure as Coder 1. Stories were presented to Coder 2 in a random order, and there was no way the coder could infer their content from the silent videos. "Agreement" between the two coders meant that they both assigned a gesture stroke the same direction out of the 9 possible directions listed in §2.2. Inter-coder agreement for the stroke direction was 74 percent. To be maximally conservative, we only conducted further analyses of those gestures for which both coders agreed.

The rate of congruent gestures was analyzed, overall, and as a function of Axis (lateral, sagittal) and Temporal Reference (deictic, sequence) using repeated measures binary logistic regression. Participants produced a total of 53 gestures on either the lateral axis (39 gestures, 74%) or the sagittal axis (14 gestures, 26%) during clauses with clearly codable temporal reference (30 gestures during pastward clauses, 23 during futureward clauses). The majority of gestures (74%) were congruent with the predicted space-time mapping for the axis on which they were produced.

Overall, the proportion of congruent gestures was significantly greater than the proportion of incongruent gestures (Wald $\chi^2 = 4.60$, $df = 1$, $p = 0.03$). Axis interacted significantly with Temporal Reference to predict Congruity (Wald $\chi^2 = 4.07$, $df = 1$, $p = 0.04$). Congruent lateral gestures were more strongly associated with sequence language, and congruent sagittal gestures with deictic language. This interaction amplifies the relationship between axis and temporal reference found in Experiment 1, and echoes the organization of the sequence and deictic timelines in American Sign Language (ASL; Emmorey 2001).

To investigate this relationship further, lateral and sagittal gestures were analyzed separately. For the lateral axis, there was a significant effect of Congruity (Wald $\chi^2 = 6.31$, $df = 1$, $p = 0.01$) and an effect of Temporal Reference on Congruity (Wald $\chi^2 = 4.48$, $df = 1$, $p = 0.03$). For the sagittal axis, however, there was neither an effect of Congruity (Wald $\chi^2 = 0.47$, $df = 1$, $p = 0.49$) nor an effect of Temporal Reference on the rate of congruent gestures (Wald $\chi^2 = 0.91$, $df = 1$, $p = 0.34$).[2]

2 For the purpose of the regression analyses in Experiment 2, one gesture was added to the cell representing congruent sagittal gestures during sequence language in order to correct a singularity in the Hessian matrix (this addition works against the significant interaction we report for the main analysis).

Although some schema-congruent gestures were observed on the sagittal axis during clauses with deictic language, none were found during clauses with sequence language (Figure 1b).

Participants produced a similar number of gestures during target clauses with metaphorical spatial language (e.g., *back*; 29 gestures) as during clauses with non-spatial equivalents (e.g., *earlier*; 24 gestures). The type of wording (metaphorical spatial, non-spatial) was not a significant predictor of gesture congruity (Wald $\chi^2 = 0.01$, df = 1, p = 0.97) or of the axis used (Wald $\chi^2 = 0.44$, df = 1, p = 0.51).

A final set of analyses compared the distribution of lateral and sagittal gestures across Experiments 1 and 2. Overall, there was no main effect of Axis (Wald $\chi^2 = 0.58$, df = 1, p = 0.45), but Axis (lateral, sagittal) interacted with Experiment (Experiment 1, Experiment 2) to predict the total number of gestures (Wald $\chi^2 = 4.48$, df = 1, p = 0.03). During the deliberate gesture task (Experiment 1), sagittal gestures were slightly more frequent, but during the spontaneous gesture task (Experiment 2) lateral gestures were much more frequent: by a ratio of about 3 to 1.

Greater use of the sagittal axis in the deliberate gesture task could be a result of directing people's attention to the relationship between space and time, thereby encouraging them to activate the sagittal mappings that are explicit in language: When asked to think about space and time explicitly, people tend to activate the mappings they use to talk about space and time. Alternatively (or in addition), greater use of the lateral axis in Experiment 2 could be a result of exposing participants to written (rather than oral) instructions and prompts (see Casasanto and Bottini 2010 for evidence of rapid influences of orthography on space-time mappings; §1.2). Further experiments comparing space-time mappings in deliberate versus spontaneous gestures are needed to evaluate these possibilities.

To summarize the results of Experiment 2, spontaneous gestures accompanying temporal speech were much more common on the lateral axis than on the sagittal axis. The production of lateral gestures was associated with sequence language (see §1.1.2), whereas the production of sagittal gestures was associated with deictic language (see §1.1.1). A significant majority of lateral gestures were congruent with the left-right mapping of time predicted by graphic conventions for time in English-speaking cultures. By contrast, we found no significant congruity effect for gestures on the sagittal axis, in part because there were so few gestures on this axis, in total. Participants were no more likely to gesture forward for the future and backward for the past than the reverse, contrary to predictions based on sagittal space-time metaphors in spoken English.

4 General discussion

English speakers made systematic use of space to represent time, both when producing deliberate gesture demonstrations (Experiment 1) and when producing spontaneous co-speech gestures (Experiment 2). In both experiments, however, the space-time mappings found in gesture diverged strikingly from the mappings found in language.

In Experiment 1, participants were about equally likely to produce gestures that were congruent with the lateral timeline (predicted by nonlinguistic cultural conventions) as with the sagittal timeline (predicted by linguistic metaphors). This was true even though sagittal metaphors for time are common in spoken English but lateral space-time metaphors are completely absent (§§1.1–2). In Experiment 2, the pattern of gestures diverged even farther from language-based expectations. Lateral gestures outnumbered sagittal gestures by about 3 to 1, and a significant effect of congruity with the established timelines was found for lateral gestures but not for sagittal gestures.

Prior to this study, little was known about the orientation of English speakers' spontaneous time gestures. In a footnote, Núñez and Sweetser mentioned that "gesture researchers generally agree on the presence of the front-back timeline pattern in English, though it has not been explicitly analyzed very much" (2006: 444; see also Parrill and Sweetser 2004). Cienki (1998) observed lateral time gestures, but did not report any sagittal gestures or compare gesture rates across axes. Cooperrider and Núñez (2009) observed primarily lateral gestures for time in English speakers who were recounting the history of the universe based on an illustrated cosmological timeline, which was oriented laterally. Given that their stimulus was a lateral representation of time, it was natural for Cooperrider and Núñez to conclude that their "observed imbalance between sagittal and transversal gestures is almost certainly due to the specifics of our paradigm" (2009: 188).[3] Yet based on the present data, the left-to-right mental timeline appears to be dominant in English speakers' spontaneous co-speech gestures, more generally.

We note that it remains an open question whether the pattern of sagittal vs. lateral gestures that we observe in English speakers will generalize to speakers of other languages that use left-to-right orthography, when evaluated using similar

3 Cooperrider and Núñez (2009) present a detailed taxonomy of lateral time gesture types. Here we collapse over all types, focusing only on gestures' orientation and direction. We therefore sacrifice the descriptive richness of complementary methods of analysis, where gestures' form and function are interpreted subjectively in light of the co-occurring speech, in exchange for a method that allows us to pursue objective answers to the questions posed in §1.3.

quantitative methods (for qualitative analyses of French and German time gestures see Calbris 1985; Müller 2000).

The dominance of the lateral axis for time in English speakers' spontaneous co-speech gestures runs counter to decades of theorizing in linguistics and psychology. Since Clark's (1973) seminal analysis, linguists and psychologists have generally assumed that the sagittal axis is the dominant axis (if not the *only* axis) that English speakers use to talk and think about time. Here Radden summarizes the modal view:

> Of the three geometrical axes, the longitudinal axis with its front-back orientation apparently captures our experience of time better than either the vertical axis with a top-down orientation or the lateral axis with a left-right orientation. *The latter does not seem to offer any sensible spatial basis for our understanding of time at all*. The preference for the longitudinal axis may be due to our spatial experience of motion, which is almost invariably directed to the front. The front-back orientation of time shows up in expressions such as the "weeks ahead of us" or "the worst behind us". In Western cultures, the front-back orientation predominates in temporal scenes. We do not see a vertical or lateral movement underlying temporal expressions such as "this coming month", "the days gone by" or "the following week", i.e., we do not visualize a month approaching from above or from the left side (2004: 3, italics added).

According to Radden and others, the lateral axis is not used for time, in language or thought. But this conclusion is difficult to maintain in light of the present data, and of other data showing lateral space-time congruity effects. In the experiments by Casasanto and Bottini (2010) described in §1.2, comprehenders activated lateral spatial representations even when processing temporal phrases much like those that Radden points to above (i.e., Dutch phrases meaning "a month after", "a day before", etc.)

The conclusion that the mental timeline is sagittal has been based primarily on analyses of metaphors in language. In addition, Clark (1973) offered a reason why sagittal space-time metaphors should exist in language and thought – and why lateral metaphors should not – on the basis of physical and perceptual asymmetries. The body is asymmetric front to back, but relatively symmetric left to right. Continuums in language and cognition that are based on asymmetrical aspects of the body naturally acquire polarity. The positive pole of the front-back continuum is the front, as determined by the direction in which people can ordinarily see, and the direction in which they usually move through space. The negative pole is the back. By contrast, continuums based on symmetrical aspects of the body do not have any natural polarity. (Although most people have a dominant hand, the differences in appearance and functionality between people's left and right sides are small compared to the differences in appearance and functionality between their front and back sides.)

Polarity is useful. The ends of polar continuums can be labeled unambiguously. Therefore, time is metaphorized in English exclusively in terms of the polarized front-back continuum (and in other languages like Chinese, also in terms of the up-down continuum, which has natural polarity (Clark 1973; Scott 1989).

4.1 Why do English speakers gesture laterally for time?

Why, then, would English speakers predominantly use the lateral axis for temporal gestures? The first challenge is to explain how the lateral axis could be used systematically, at all. If it has no clear polarity then the pastward and futureward directions cannot be assigned unambiguously. As Radden suggested, it would then offer no sensible spatial basis for the understanding of time.

We propose that the lateral axis *does* have polarity in English speakers' implicit mental representations, and this polarity has a clear experiential basis. Whereas polarity on the sagittal axis is given by the body, polarity on the lateral axis is determined by culture. The habit of reading and writing in English makes the right the positive pole and the left the negative pole of the left-right continuum; its polarity is determined by the direction in which people ordinarily move through space, not with the body, but rather with the eyes or the pen. As on the sagittal axis, the positive pole of the lateral axis corresponds to later times and the negative pole to earlier times.

Because graphic conventions in English-speaking cultures have an implicit rightward directionality, English speakers have a polarized left-right spatial continuum which can be co-opted for time. However, the availability of this continuum does not, in itself, explain why speakers gesture laterally *more than they gesture sagittally*, contrary to the way they talk about time. Here we sketch several possible explanations for the dominance of the lateral timeline in English speakers' spontaneous gestures, motivated by (partly overlapping) pragmatic, kinematic, and mnemonic constraints.

One possible pragmatic motivation has been suggested previously: Perhaps speakers gesture laterally to avoid putting their hands in others' personal space (Cienki 1998). Although this remains a possibility, our data offer little support for this proposal. Politeness should encourage lateral gestures most strongly when (a) people are aware of their gestures and (b) they are standing close to their interlocutor. Yet, we found more sagittal gestures in Experiment 1, where people were conscious of their gestures and were standing face-to-face with a stranger, than in Experiment 2, where speakers were often unaware of their gestures and were separated from their interlocutor by a table.

Alternatively, perhaps speakers tend to use the lateral axis because of its greater *information value*. During face-to-face communication, a change in depth on the sagittal axis is harder for an interlocutor to perceive than a change in lateral position of the same size. Lateral movements optimize the visibility of gestures, conveying more information for the same amount of physical motion.

The kinematics of lateral hand movements may further motivate lateral gestures, in two ways. First, one's reach extends about twice as far on the lateral axis as on the sagittal axis. This allows for a greater number of discriminable points (or intervals) in time to be illustrated. Second, although the body divides both the lateral and sagittal axes into poles, both poles of the lateral axis are available motorically, whereas only one pole on the sagittal axis can be used easily. Our data show productive use of an analog spatial continuum on the lateral axis. For example, within the same utterances, speakers sometimes gesture leftward for one timepoint in the past, and then farther leftward for an even earlier timepoint. It would be difficult to create such an analog spatialization of past events on the sagittal axis that takes advantage of the body as midpoint, reaching behind one's head for one point in time, and then even farther behind it for the next.

On the sagittal axis, in order to create an analog mapping of events extending progressively farther back into the past, it would be necessary to establish an *ad hoc* reference point somewhere in front of the speaker's body. This creates a mnemonic demand, both for the sender and the recipient: An imaginary reference point created on the sagittal axis is only useful if its location is remembered. On the lateral axis, the body can provide a permanent, visible reference point, the location of which can be observed (so it does not have to be remembered).

The lateral axis may also provide an imaginary timeline that is easier for speakers to inspect with the mind's eye. To "view" the past and future on a lateral mental timeline, the experiencer only needs to turn the mind's eye to the left and the right. To view both poles of a sagittal mental timeline however, where the future is in front and the past in back of the experiencer, it would be necessary for the imaginary experiencer to turn around 180 degrees (or to have a second set of the mind's eyes in the back of the mind's head!)

The pragmatic and kinematic considerations suggested above seem to motivate lateral gesturing. The mnemonic and imagistic considerations, moreover, also motivate laterally-oriented *thinking*. The lateral mental timeline may be easier for people to inspect in their imagination than the sagittal timeline for the reasons we suggest above, and also because people have frequent experience inspecting lateral physical timelines (e.g., calendars, graphs), which provide a concrete and highly systematic grounding for temporal representations. Ultimately, speakers may gesture laterally not only because the lateral axis is better for gesturing about time, but also because it is better for thinking about time.

4.2 Do people think about time the way they talk about it?

In spoken English, the past is behind the speaker (§§1.1–2). Consistent with this mapping, participants in Experiment 1 produced 22 deliberate backward, over-the-shoulder gesture demonstrations for the past. By contrast in Experiment 2, participants produced 18 spontaneous gestures during pastward clauses that were congruent with one of the established timelines, but not a single gesture was directed backward, over the shoulder: 1 gesture was in front of the speaker and directed toward the body; 17 were leftward. These spontaneous gestures did not provide any evidence that participants were conceptualizing the past as behind them – not even when they were using clauses containing the word "back" (8).

(8) a. "... what it would have been like to live *back* then."
b. "... and then I found a letter ... from even *farther back*."

Participants gestured leftward while producing these utterances (8), challenging the natural assumption that speakers are conceptualizing time on a sagittal axis when they produce front/back spoken metaphors.

Lateral gestures during clauses like (8) raise the question: What kinds of nonlinguistic spatial representations do English speakers activate when using sagittal space-time metaphors in language? Below we consider three possibilities.

4.2.1 Maybe speakers create both lateral and sagittal representations?

Speakers could activate both lateral and sagittal timelines simultaneously, one corresponding to speech and the other to gesture. This would be consistent with the present data, but in order to motivate this unparsimonious account, it would be necessary to suggest a reason why people activate two timelines at once, and to explain how coherence between them is achieved and conflict avoided. Behavioral experiments suggest that depending on the context, people tend to activate either a lateral or a sagittal representation of time: not both types of representations simultaneously (Torralbo et al. 2006).

4.2.2 Maybe speakers create rotated sagittal representations?

Alternatively, language users could activate a rotated sagittal representation when gesturing on the lateral axis. Perhaps lateral gestures are evidence for a

sagittal mental timeline viewed from the deictic perspective of an imaginary experiencer rotated 90 degrees rightward from the speaker? Although leftward gestures corresponding to words like "back" are not sensible with respect to the front and back of the speaker's body, they could correspond to the back of a rightward-rotated imaginary person. This suggestion is consistent with the present data, but it is also unparsimonious and *post hoc*. The observation that people are capable of reasoning about rotated spatial frames of reference (Levinson 2003) suggests that it should be *possible* for people to reason about a rotated sagittal timeline, but this does nothing to motivate this suggestion. Nothing in language motivates this suggestion, either. On the contrary, decades of analyses of space-time metaphors explicitly posit a sagittal spatial schema for time aligned with *our own body's* sagittal axis, grounded in the experience of the kinds of front-back locomotion that our bodies afford (Clark 1973; Lakoff and Johnson 1980; Radden 2004). Furthermore, nothing in spoken language can motivate or explain why a 90' rotation of the sagittal axis should be rightward for English speakers but leftward in speakers of other languages.

4.2.3 Maybe speakers create only lateral spatial representations?

When speakers produced lateral gestures for temporal sequences, clearly some sort of lateral spatio-motor representation was activated, since a gesture cannot be produced without activating a motor program for a directed action. That is, gestures provide unequivocal evidence that a spatial representation with a certain directionality was activated in the speaker's mind; spoken space-time expressions do not provide clear evidence that a spatial representation has been activated (i.e., it is possible that words like "ahead" and "back" could be processed purely temporally, and not as spatial metaphors). Therefore, on the simplest account of these data, perhaps speakers activated *only* a lateral mental timeline. The word "back," on this account, did not correspond to any active metaphorical mapping from sagittal space in speakers' minds. Does this mean that, much of the time, gesturers' "thinking" does not match their "speaking" (cf., Slobin 1996)?

Evaluating whether lateral time gestures should be analyzed as contradicting the co-occurring speech requires an analysis of the spatial frame of reference participants were adopting, and how they were conceptualizing the events. In our data, lateral gestures were used most systematically during language about sequences of events, the temporal succession of which can be understood independent of a deictic origo (e.g., see 8b). Earlier events are on the left and later events on the right of one another: They are not necessarily on the right and left of the

body or of a deictic "now" (although this sometimes appears to be the case, as well). Importantly, when temporal reference is determined based on inter-event relationships, there is not necessarily an "ego" represented (Núñez and Sweetser 2006), in which case the speaker cannot adopt a Moving Ego perspective (Clark 1973).

According to traditional analyses, if speakers are not adopting a Moving Ego perspective, this should mean they are assuming a Moving Time perspective (Clark 1973). If so, perhaps events moving along a lateral timeline could acquire "fronts" and "backs" as a function of their direction of motion (see §1.1.2). At first glance, this would seem to provide a reconciliation between speech and gesture: When people gesture left for events that are "back" in time, they are indicating the functional back (i.e., the trailing edge) of a moving event.

But this interpretation is impossible given the direction that the river of time flows: from the future to the past, not the other way around. Because time is unidirectional, an event that occurs in the present can only get older, moving farther into the past: it cannot get newer. As Radden (2004) points out, this is contrary to many people's intuitions about the flow of time, which reflect a Moving Ego perspective. On the sagittal axis, this means that time (and events in time) move from the front to the back of the experiencer. By analogy, if time flows from the future to the past along the lateral axis, it moves from the right to the left. As such, the *fronts* of events are on the left and the *backs* are on the right: contrary to the systematic left-right gestures we observed during expressions like (8b).

4.3 Lateral representations: the Moving Attention perspective

Could lateral gestures for temporal sequences indicate that speakers are conceptualizing time from neither a Moving Ego nor a Moving Time perspective? Both the Moving Ego and Moving time perspectives place the experiencer on a sagittal timeline, facing toward the future. Other spatial perspectives that have been proposed to account for the way people talk and think about sequences of events also place the experiencer on a sagittal timeline, facing either toward the future or toward the past (e.g., see Evans 2004; Radden 2004). In all standard analyses, either time moves along the experiencer's sagittal axis, or the experiencer moves sagittally through time.

The prominence of the lateral axis in spontaneous gestures, and the details of these gestures, suggest a different perspective on time, which we will call the Moving Attention perspective (Figure 2). Time is viewed as a static line extending indefinitely to the left and right of the viewer. The experiencer is not located on the timeline. Rather, he/she views it from an external position, canonically from

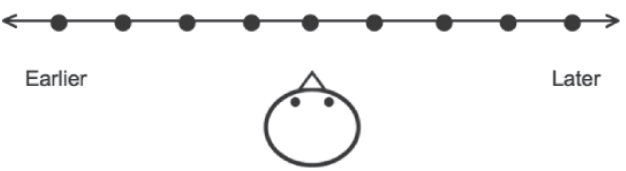

Fig. 2: Diagram of an experiencer viewing static events on a static lateral mental timeline from the Moving Attention perspective. From this perspective, locations (i.e., events) are fixed points in time, the observer is external to the fixed lateral timeline, and only the observer's attention moves to the points on the line that the gestures indicate.

the middle of the "visible" (i.e., imaginable) portion of the laterally-oriented continuum. Events are typically conceptualized as points on the line. For English speakers, the leftmost of a series of points is the farthest in the past, and the rightmost the farthest in the future.

When people represent and reason about temporal sequences from the Moving Attention perspective, neither Time nor Ego moves. Rather, the experiencer's attention moves over the static events on the static line, from their static vantage point, with their own sagittal axis oriented perpendicular to the axis on which time is represented. The way experiencers interact with the mental timeline from the Moving Attention perspective is, therefore, closely analogous to the way they interact with external physical timelines (e.g., calendars, graphs, and graphic timelines).

The gestures and gesture demonstrations we observed on the sagittal axis often appeared consistent with Time- or Ego-Moving perspectives insomuch as they clearly indicated motion. During utterances like "in the future", the hand waved forward in a movement similar to a relaxed throw: As the arm extended forward the hand was hyperextended with the fingers pointing upward (slightly curled), then curling down as the hand extended and the stroke reached its maximum extent. A similar, dynamic, waving-throwing motion was sometimes observed on the lateral axis during utterances like "way back", where the leftward gesture appeared to indicate a point too far to the left to represent precisely.

But the majority of the lateral gestures for temporal sequences were quite different, and appeared most consistent with the proposed Moving Attention perspective. The hand was often rotated medially with the fingers extended in a relaxed karate-chop posture, then moved leftward or rightward during the preparation/stroke phase, which often ended abruptly with a hold (and sometimes a superimposed beat) over a certain point on the lateral timeline. This point was often contrasted with a loose karate chop to another point on the timeline

corresponding to another clause with contrasting temporal reference. These points appeared fixed on the mental timeline, just as points are fixed on a printed timeline of events. The loose karate chops were sometimes executed with the index finger or index and middle fingers extended, but they were not typical pointing gestures. Still, they appeared to function indexically, similarly to the way pointing would function if the gesturer were picking out locations in time on a physical, graphic timeline.

If the Moving Attention perspective best captures the way people think about temporal sequences (at least while they are talking and gesturing about them), this seems to preclude any sensible spatial-metaphorical interpretation of words like "back" and "ahead" during leftward and rightward gestures. These words cannot refer to points in back of or ahead of a rotated sagittal experiencer's ego, because there is no ego perspective present in sequence-based time representations. They cannot refer to the functional fronts and backs of points in time because, by definition, a point is 0-dimensional, and has no front or back. Attributing a front or back to a point in time would be a violation of Lakoff's (1993) metaphorical Invariance Principle.

In some cases, events on the lateral timeline may be mentally represented as line segments rather than points (e.g., when the experiencer zooms in attention on an event and its duration), and segments could in principle acquire directionality via motion. However, this observation does not provide any easy reconciliation between people's sagittal words and their lateral gestures, for two reasons. First, the line segment for an event is not in the process of being extended when the gesturer picks it out on a lateral mental timeline; it has already been "drawn" on the timeline. As the segment exists when the gesturer indexes it, there is no motion. Second, since attention is free to move both leftward and rightward along the timeline, the motion of attention cannot induce a stable front or back for an event: The fronts and backs of two events, as defined by the motion of attention, would change depending on whether attention was directed first to the earlier event and then to the later event or vice versa.

Various aspects of the proposed Moving Attention perspective will need to be developed, tested empirically, and integrated with other theorizing about space and time in language, mind, and gesture. One challenge (or apparent challenge) for this proposal concerns people's ability to think about one span of time and then rapidly switch to thinking about a different span, on a different timescale. For example, while discussing the origins of some cognitive ability, one might wish to represent (in language, mind, and gesture) a succession of stages during child development, and then quickly switch to representing a succession of time points in cultural evolution. It seems unlikely that a single static mental timeline could effectively represent both timespans: if the scale were fine grained enough

to represent developmental stages, it would be far too fine grained for reasoning about archaeological periods.

How do experiencers systematically transition from one timespan on one scale to another, preserving the spatial metric structure of the first static mental timeline when transitioning to the second? We suggest the answer is: They don't. It is tempting to accord to mental timelines the same kind of continuity, systematicity, and precision that is found in physical timelines, but we would suggest this is a mistake. Following Tolman (1948), many psychologists embraced the notion that our spatial representations are "cognitive maps," which provide an internal replica of the external environment. Yet, in the ensuing half century of research on spatial cognition, the "cognitive map" metaphor was replaced by what Tversky (2005) called a "cognitive collage," on the basis of abundant evidence that our spatial representations are "fragmented, schematized, inconsistent, [and] incomplete" (2005: 12). Our mental timelines have these characteristics, as well as being fleeting. We would suggest that mental timelines are constructed and used *ad hoc*: that they are always incomplete and schematic, containing no more detail or metric precision than is required by the context. Just as they are rapidly created, they are also rapidly dissolved, and may be immediately supplanted by a new (discontinuous) timeline.

To summarize our analysis of English speakers' lateral sequence gestures: (a) It appears that people are using neither the Moving Ego nor the Moving Time perspective for temporal sequences. Rather, we propose they are using a Moving Attention perspective, according to which experiencers interact with an imaginary lateral timeline in ways closely analogous to the ways they interact with external graphically represented timelines. (b) People cannot use a Moving Ego perspective to conceptualize sequences of events whose temporal reference is determined by inter-event relationships rather than by their relationship to a deictic ego. (c) People cannot be using a Moving Time perspective, either, when gesturing so as to represent sequences of events as points in space along the lateral axis. If they were using a Moving Time perspective, this would mean that the motion-induced front of an event is on its *left* and the motion-induced back is on its *right*, given the unidirectional flow of time in the mind (Radden 2004). If people's lateral gestures for "back" refer to the side on which the backs of events are located, this would predict the exact opposite pattern of left-right gestures from what we and others have observed.[4] (d) Neither the Moving Ego, the Moving Time, nor the

4 In principle it is possible that people gesture from the perspective of a face-to-face interlocutor, but this *post hoc* account is unlikely to be correct for two reasons. First, taking another person's perspective creates problems of audience design: Whose perspective should a gesturer take when in the common situation of talking with two people who are facing one

Moving Attention perspectives allows the "front-back" language people use for temporal sequences to be interpreted as corresponding to active metaphorical mappings from sagittal space – neither with respect to the sagittal axis of the speaker's body, nor to the sagittal axis of an imagined rotated experiencer, nor to motion-induced fronts and backs of the events on the lateral timeline.

In short, in the majority of cases, English speakers do not appear to gesture (or think) about temporal sequences using the same spatial representations that space-time metaphors in language suggest they do.

4.4 Reconciling space-time metaphors in langauge with co-speech gesturing and thinking

Can the spatialization of time in spoken English and in co-speech gesture be reconciled? We consider two possibilities. It may be possible to reconcile people's front-back speech with their left-right sequence gestures by considering representations on the lateral sequence timeline to be produced by the conceptual blending (Turner and Fauconnier 2002) of the Moving Attention perspective with the Moving Ego perspective. In this blended model, the timeline and the observer's relationship to it are as described by the Moving Attention perspective. The events on the timeline are also as described by the Moving Attention perspective, with one exception: They have stable, intrinsic fronts (facing the future) and backs (facing the past) – which cannot be constructed based on the logic of the Moving Attention perspective, but could be imported from Moving Ego. In this blended event representation, points in time have implicit fronts and backs in our conceptualizations, despite the fact that this violates constraints of the spatial source domain. Left-right gestures, then, could be considered to be consistent with the intrinsic fronts and backs of the rightward-facing events on a static mental timeline, viewed from the Attention Moving perspective. If so, words like "back" used systematically during leftward gestures could be interpreted as active metaphorical projections from a 90°-clockwise-rotated, event-centered, sagittal spatial representation.

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another, one rotated 90° rightward and the other 90° leftward with respect to the gesturer? Second, in other conditions of this study, participants' gestures typically indicated the arrangements of physical objects arranged in literal left-right space from their own perspective, not from their interlocutor's perspective. We believe that all gestures in this study were made from the character viewpoint (C-VPT), as participants related narratives in the first person. It remains an open question whether observer-viewpoint gestures (O-VPT; McNeill 1992) follow the same pattern of lateral vs. sagittal orientation.

We advance this account because we believe it *could* be correct, while urging the utmost caution: Given the (lack of) fit between the present data and existing theoretical models of time representation, this kind of explanation lies outside the boundaries of scientific inference. This blended Attention Moving/Ego Moving account is totally *post hoc* (we could call it *post-post-hoc*, to illustrate the layers of *post-hoc* inference needed); it does not follow from any *a priori* predictions based on language, or any straightforward interpretation of the gestures. It requires attributing directionality (and implicit motion) to people's event representations even though these attributes are absent from their typical lateral sequence gestures: Based on the gestures, events look like points. It also requires positing a metaphorical representation of an event that violates a core tenet of metaphor theory, the Invariance Principle: Points in space (and therefore in time) cannot have fronts and backs – except in a blended mental world where the laws of the physical source domain are partly suspended. In short, this conceptual blending account has the appearance of a desperate attempt to maintain the compatibility of front-back speech and left-right gestures for temporal sequences, even though the data seem to demonstrate their incompatibility – both *prima facie* and after thorough analyses conducted within the constraints of metaphor theory and of the basic laws of physics. At minimum, this blended Moving Attention/Moving Ego account would require further experimental validation.

On a simpler alternative account, temporal speech and co-speech gesture can only be *partly* reconciled. It appears that temporal speech and gesture may sometimes be tightly coupled, but are often dissociated: sagittal gestures toward and away from the body during deictic temporal expressions about the past and future appear consistent with traditional Moving Ego or Moving Time analyses of spoken space-time metaphors (albeit we observed few spontaneous sagittal gestures, overall – too few to establish the statistical significance of the pattern predicted by language). By contrast, lateral gestures during speech about temporal sequences were comparatively frequent and highly systematic, but they were simply not consistent with spoken metaphors. Rather, these gestures, which were the most common, were consistent with graphic representations of time; people appear to construct an implicit lateral mental timeline from a Moving Attention perspective, and to interact with it much like they interact with explicit physical timelines. Based on their gestures, it appears that even when speakers were saying "back" for events in sequences, they were thinking *left*. The gestures indicated that speakers were activating mental metaphors from lateral space to time. In these cases, words like "back" and "ahead" did not activate any sagittal spatial representations (from any perspective).

On many analyses, highly conventional linguistic expressions that show a diachronic link between source and target domains can be processed synchronic-

ally in one of two ways: either as live metaphors (i.e., processed as active source-target mappings) or dead metaphors (i.e., processed as "pure" target domain representations). On the basis of the present data, words like "back" and "ahead" do not seem to fit into either category. Rather, their behavior may be captured best by Müller's (2008) notion that metaphors can be "sleeping" or "waking". The sagittal spatial representations associated with "back" and "ahead" are sleeping when these words are used to describe laterally-oriented temporal sequences (i.e., no mental representation of sagittal space is activated), and waking when the same words are used for sagittally-oriented deictic temporal scenarios.

4.5 Why don't English speakers talk about time laterally?

These data and analyses raise a question that merits further investigation. If English speakers habitually gesture for time laterally, and if the lateral axis has acquired polarity on the basis of left-right graphic conventions, and if indeed the lateral axis is better for *thinking* about time than the sagittal axis is (see §4.1), then why is the lateral axis not used for any conventional temporal expressions, in English or any other known spoken language?

One reason may be that the words and concepts "left" and "right" are acquired later than many other basic spatial terms and categories, and their use is more error prone (as is evident from expressions like, "no, your *other* left"). Spatial terms like "ahead" and "behind" that are grounded in salient bodily asymmetries (Clark 1973) may be preferred for time because they are easier to learn and use correctly than "left" and "right."

More compellingly, here we argue that the lateral mental timeline revealed by gestures is based on experience with cultural artifacts like calendars, graphs, and written text (see also Cienki 1998; Tversky et al. 1991). Widespread literacy and the pervasive use of lateral spatio-temporal graphic conventions probably emerged much more recently than the English language did, and certainly more recently than the languages on which the lexicon of modern English is based (e.g., the first printed timeline is often attributed to Joseph Priestley, an inventor from the late 18th century). Time may not be metaphorized laterally in language because the cultural artifacts that provide the experiential basis for people's implicit lateral timelines did not exist – or were not widely used – when our conventions for talking about time were developing.

This proposal makes a prediction: left-right metaphors for time in language may develop in cultures that make frequent use of left-right graphic conventions for time, as speakers talk about the events that are typically diagrammed on a lateral axis. Graphic conventions shape the way people think about time, which

could in turn influence the way they talk about it. It appears that such a development may be in progress within a particular English-speaking community: members of the US Army (Lera Boroditsky, personal communication, 24 January 2012; Andrew Poler, personal communication, 24 April 2012).

Reportedly, the shifts that soldiers are scheduled to work within a day are diagrammed on a chart with 24 columns, numbered from 0000 to 2300 (hours), left to right. Laterally oriented rectangles are superimposed on the columns to represent shifts for which a team of workers is scheduled (e.g., a rectangle that spans 6 columns indicates a 6 hour shift). Moving a rectangle one column leftward (due to a revision in the schedule) would indicate that the team's shift has been rescheduled to begin one hour earlier than in the previous draft of the schedule.

According to one informant, when workers are rescheduled for an earlier shift, it is common to say they are "shifting left," and when they are rescheduled for a later shift that they are "shifting right." "Shifting" can be applied to inanimate objects as well as to people: A team's "timeline" can be said to be "shifted left" or "shifted right." These novel left-right metaphors for time in English have yet to be studied systematically, within or beyond the US Army. But neologisms such as these should be expected, now that the cultural artifacts that people use frequently (and in many cases, obligatorily) provide the basis for a systematic left-right conceptualization of time.

5 Conclusions

When English speakers talk about time they often gesture, but their spoken space-time metaphors may not reflect the implicit mental metaphors revealed by their co-speech gestures. Whereas English metaphors suggest that time flows along the sagittal axis, spontaneous gestures show that time is also spatialized on the lateral axis, with earlier points on the left and later points on the right of an imaginary mental timeline. Based on the relative frequency of systematic lateral and sagittal gestures, it appears that the left-right mapping of time is not just an "alternative" way of conceptualizing time; it may be the dominant spatial schema for time in English speakers' minds, at least for reasoning about sequences of events. Although this left-right mapping of time is present in nonlinguistic cultural artifacts such as calendars and graphs, it is completely absent from standard spoken English, and has not been attested in any other known spoken language.

The type of temporal reference speakers used (deictic vs. sequence-based language) co-varied with the type of gestures they produced (sagittal vs. lateral

gestures). Front-back gestures were more common during clauses with deictic temporal reference, and left-right gestures during clauses with sequence-based temporal reference (see §§1.1.1–2). This pattern echoes the sagittal "deictic timeline" and lateral "sequence timeline" used in ASL (Emmorey 2001). The causal relationship between deixis in temporal language and the orientation of spontaneous temporal gestures requires further investigation, but the results of Experiment 1 suggest that using deictic language can encourage people to produce sagittal gestures that are consistent with front-back metaphors in English.

Importantly, however, there was no relationship between the metaphoricity of people's speech and the way they gestured. They did not gesture more systematically for time when they used spatial metaphors (e.g., *a year back*) than when they used non-spatial equivalents (e.g., *a year ago*). They did not gesture more often on the sagittal axis when they used front-back spoken metaphors: In fact, they sometimes gestured *left* for earlier events while saying "back". These gestures provide evidence against the intuitive claim that temporal uses of words like "back" correspond to an active metaphorical mapping from sagittal space in speakers' minds. On the most straightforward interpretation of these data, it appears that people often think about time laterally, even while they are talking about it sagittally.

We propose that when English speakers gesture left while saying "back", they are forming mental representations of events as points on a static lateral timeline, viewed from an external Attention Moving perspective. These representations reflect the way people interact with and reason about points on laterally-oriented physical timelines, and are different from the spatial representations suggested by linguistic space-time metaphors. Sagittally-oriented mental metaphors for time, which correspond to conventional linguistic metaphors, are presumably grounded in the experience of moving the body forward through space (and time) during locomotion. Laterally-oriented mental metaphors for time, which correspond to conventions in graphic representations, are grounded in the experience of moving the eyes or the hand rightward through space (and time) during culture-specific activities like reading, writing, and using calendars.

The dissociation between speech and gesture we report has implications both for theories of the mental representation of time and for the methods used to construct and test these theories. Lateral co-speech gestures corroborate a growing catalog of evidence that people conceptualize time on the lateral axis, in a direction consistent with graphic conventions in their culture (e.g., Boroditsky et al. 2010; Casasanto and Bottini 2010; Fuhrman and Boroditsky 2010; Ouellet et al. 2010; Tversky et al. 1991). The finding that people spontaneously gesture laterally even though they *could* gesture sagittally suggests that the left-right mapping of time found in earlier studies cannot be dismissed as an artifact of

testing people on a 2-dimensional piece of paper or a computer screen. The finding that deliberate gestures showed a different pattern (more similar to language) than spontaneous gestures did urges caution about interpreting elicited gesture demonstrations as indices of peoples habitual, implicit mental representations; it appears that people may not spontaneously gesture the way they think they do.

The left-right mapping of time could never have been discovered by analyzing patterns in language, alone. This mapping is just one of the implicit mental metaphors that is evident in people's behavior in the laboratory, and also in their spontaneous gestures, but not in their speech (e.g., see Casasanto 2009a, 2011; Casasanto and Henetz 2012; Casasanto and Jasmin 2010, for evidence of a "good is left" metaphor in left-handers' minds which contrasts with the "good is right" mapping found in linguistic expressions). Implicit mental metaphors do not always correspond to explicit linguistic expressions: People do not always think the way that language suggests they do.

Space-time metaphors in language have inspired decades of fruitful research, but space and time are linked in the mind in more ways than linguistic analyses alone can reveal. This suggests that metaphors in language should be treated as a source of *hypotheses* about nonlinguistic mental representations, rather than a source of conclusions. Evaluating these hypotheses – determining when a linguistic metaphor reflects an implicit mental metaphor – requires both linguistic and extra-linguistic methods, and calls for cooperation across the linguistic and cognitive sciences.

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