CENTER FOR RESEARCH IN LANGUAGE

April 2013 **Vol. 25, No. 1**

CRL Technical Reports, University of California, San Diego, La Jolla CA 92093-0526
Tel: (858) 534-2536 • E-mail: editor@crl.ucsd.edu • WWW: http://crl.ucsd.edu/newsletter/current/TechReports/articles.html

TECHNICAL REPORT

Investigating Spatial Axis Recruitment in Temporal Reckoning Through Acoustic Stimuli and Non-Spatial Responses

Esther J. Walker[1], Benjamin K. Bergen[1], and Rafael Núñez[1]

[1]Department of Cognitive Science, University of California, San Diego

Address for correspondence:

Esther J. Walker, Department of Cognitive Science, 0515

9500 Gilman Drive, La Jolla, CA, 92093-0515

Phone: (858) 534-6775 Fax: (858) 534-1128 Email: e1walker@ucsd.edu

EDITOR'S NOTE

This newsletter is produced and distributed by the **CENTER FOR RESEARCH IN LANGUAGE**, a research center at the University of California, San Diego that unites the efforts of fields such as Cognitive Science, Linguistics, Psychology, Computer Science, Sociology, and Philosophy, all who share an interest in language. We feature papers related to language and cognition (distributed via the World Wide Web) and welcome response from friends and colleagues at UCSD as well as other institutions. Please visit our web site at `http://crl.ucsd.edu`.

SUBSCRIPTION INFORMATION

If you know of others who would be interested in receiving the Newsletter and the Technical Reports, you may add them to our email subscription list by sending an email to `majordomo@crl.ucsd.edu` with the line `"subscribe newsletter <email-address>"` in the body of the message (e.g., `subscribe newsletter jdoe@ucsd.edu`). Please forward correspondence to:

Tristan Davenport, Editor
Center for Research in Language, 0526
9500 Gilman Drive, University of California, San Diego 92093-0526
Telephone: (858) 534-2536 • E-mail: editor@crl.ucsd.edu

Back issues of the the CRL Newsletter are available on our website. Papers featured in recent issues include:

In search of Noun-Verb dissociations in aphasia across three processing tasks
Analía Arévalo, **Suzanne Moineau**
Language and Communicative Disorders, SDSU & UCSD, Center for Research in Language, UCSD
Ayşe Saygin
Cognitive Science & CRL, UCSD
Carl Ludy
VA Medical Center Martinez
Elizabeth Bates
Cognitive Science & CRL, UCSD
Vol. 17, No. 1, March 2005

Meaning in gestures: What event-related potentials reveal about processes underlying the comprehension of iconic gestures
Ying C. Wu
Cognitive Science Department, UCSD
Vol. 17, No. 2, August 2005

What age of acquisition effects reveal about the nature of phonological processing
Rachel I. Mayberry
Linguistics Department, UCSD
Pamela Witcher
School of Communication Sciences & Disorders, McGill University
Vol. 17, No.3, December 2005

Effects of Broca's aphasia and LIPC damage on the use of contextual information in sentence comprehension
Eileen R. Cardillo
CRL & Institute for Neural Computation, UCSD
Kim Plunkett
Experimental Psychology, University of Oxford
Jennifer Aydelott
Psychology, Birbeck College, University of London)
Vol. 18, No. 1, June 2006

Avoid ambiguity! (If you can)
Victor S. Ferreira
Department of Psychology, UCSD
Vol. 18, No. 2, December 2006

Arab Sign Languages: A Lexical Comparison
Kinda Al-Fityani
Department of Communication, UCSD
Vol. 19, No. 1, March 2007

The Coordinated Interplay Account of Utterance Comprehension, Attention, and the Use of Scene Information
Pia Knoeferle
Department of Cognitive Science, UCSD
Vol. 19. No. 2, December 2007

Doing time: Speech, gesture, and the conceptualization of time
Kensy Cooperrider, Rafael Núñez
Depatment of Cognitive Science, UCSD
Vol. 19. No. 3, December 2007

Auditory perception in atypical development: From basic building blocks to higher-level perceptual organization
Mayada Elsabbagh
Center for Brain and Cognitive Development, Birkbeck College, University of London
Henri Cohen
Cognitive Neuroscience Center, University of Quebec
Annette Karmiloff-Smith
Center for Brain and Cognitive Development, Birkbeck College, University of London
Vol. 20. No. 1, March 2008

The Role of Orthographic Gender in Cognition
Tim Beyer, Carla L. Hudson Kam
Center for Research in Language, UCSD
Vol. 20. No. 2, June 2008

The Role of Orthographic Gender in Cognition
Tim Beyer, Carla L. Hudson Kam
Center for Research in Language, UCSD
Vol. 20. No. 2, June 2008

Negation Processing in Context Is Not (Always) Delayed
Jenny Staab
Joint Doctoral Program in Language and Communicative Disorders, and CRL
Thomas P. Urbach
Department of Cognitive Science, UCSD
Marta Kutas
Department of Cognitive Science, UCSD, and CRL
Vol. 20. No. 3, December 2008

The quick brown fox run over one lazy geese: Phonological and morphological processing of plurals in English
Katie J. Alcock
Lancaster University, UK
Vol. 21. No. 1, March 2009

Voxel-Based Lesion Analysis of Category-Specific Naming on the Boston Naming Test
Juliana V. Baldo, Analía Arévalo, David Wilkins
Center for Aphasia and Related Disorders, VA Northern California Health Care System
Nina F. Dronkers
Department of Neurology, UC Davis
Center for Research in Language, UC San Diego
Vol. 21. No. 2, June 2009

Investigating Spatial Axis Recruitment in Temporal Reckoning Through Acoustic Stimuli and Non-Spatial Responses

Esther J. Walker[1], Benjamin K. Bergen[1], and Rafael Núñez[1]

[1]Department of Cognitive Science, University of California, San Diego

Abstract

We talk about time using spatial terms ("ahead", "behind") and spatial gestures (front-back, left-right). Experimental investigation of such space-to-time mappings has focused primarily on the space *in front of* the participant, likely driven by the convenience of screen presentation and button responses. This has had two consequences: the disregard of the space *behind* the participant (exploited in language and gesture) and the creation of potential task demands produced by the spatialized manual button-presses. We present a new paradigm that addresses these issues. Participants, responding *vocally*, made temporal judgments about deictic (past, future) or sequential (earlier, later) relationships presented *auditorily* along a full front-back or left-right axis. Results involving the left-right axis replicated previous work. Participants mapped past and earlier judgments onto the left and future and later judgments to the right. Surprisingly, deictic judgments did not use the front-back axis but sequential judgments did, in a novel way. Participants mapped earlier judgments onto the space *in front of them* and later judgments onto the space *behind them*, which, to our knowledge has never been demonstrated. These findings suggest that different time concepts recruit space differently, mediated by meaning, stimulus modality and response mode.

Keywords: semantics, conceptual organization, temporal lobe, neuroimaging, aphasia, anomia

Introduction

Around the world, people talk about time using spatial terms (Clark, 1973; Haspelmath, 1997), as in the English expression *I'm looking <u>forward</u> to tomorrow*. This spatialization of time also shows up in gesture, as when one points in front of the body when talking about the upcoming weekend (Núñez & Sweetser, 2006). But what is the psychological reality of these spatial construals of time?

Researchers have conducted a variety of psychological experiments that have looked for space-time compatibility effects along two axes: left-right (transversal) and front-back (sagittal). The transversal axis is systematically associated with time in a manner consistent with cultural technologies such as writing direction (Ouellet, Santiago, Israeli, & Gabay, 2010). For example, English speakers are faster to respond to past events on their left and future events on their right, but this pattern is reversed for Hebrew speakers, who read and write from right to left (Fuhrman & Boroditsky, 2010). While the sagittal axis is used in language and gesture, experimental results along this axis do not simply mirror patterns in language whereby speakers systematically talk about the future as located in the space in front of their bodies (e.g., *The future ahead looks bright*) and about the past as located behind their bodies (e.g., *When I look back on my past….*). Rather, some studies detect compatibility effects, with participants responding faster to the future in front and past behind, (e.g., Experiment 1: Sell & Kashak, 2010) while others do not (Experiment 2: Sell & Kashak, 2010; Fuhrman et al., 2011).

But there are limitations to previous studies. First, many of them, likely driven by the convenience of screen presentation and button responses, require participants to respond only using the part of the sagittal axis *in front* of them, which does not reflect the full extent of the front-back axis as manifested in language and gesture. Moreover, the use of button presses imposes the use of space onto participants' responses, which may introduce task demands. Second, many studies have blurred the distinction between deictic and sequential time, making the results difficult to interpret. While deictic time reflects past/future relationships with respect to the present moment, as in *The week <u>ahead</u> looks promising*, sequence time captures "earlier" or "later" relationships in time, as in *Spring <u>follows</u> winter*. This distinction, as old as it is (McTaggart, 1908), has been largely overlooked in the psychological literature, leaving open the question of whether these two types of time concept are spatially construed in systematically different manners. To address these concerns, we propose a novel paradigm to investigate, via compatibility effects, the link between space and time along the full extent of both axes. We use auditory stimuli and vocal responses, which allow for non-spatial responses and presentation of stimuli that surround the participant, and investigate compatibility effects with respect to the type of temporal concept involved—deictic or sequential (Evans, 2003; Núñez & Sweetser, 2006).

Different approaches regarding the use of spatial metaphors for time lead to contrasting predictions about the role space plays in structuring our thinking about time. For instance, the ‘Career of Metaphor Hypothesis’ (Bowdle & Gentner, 2005) and the ‘Structural Similarity Hypothesis’ (Murphy, 1996, 1997) propose that the use of spatial terms to talk about time becomes highly conventionalized over a lifetime of exposure such that speakers do not actively think about space when talking about time in conventional ways. Consistent with these proposals, reckoning about future and past events (deictic time), for which there are abundant front-back conventional metaphorical expressions (e.g., *Back in my childhood*), might not trigger associations with sagittal space. By contrast, ‘Conceptual Metaphor Theory’ (Lakoff & Johnson, 1980) views spatio-temporal mappings as occurring at the level of thought, manifesting themselves in language and gesture. According to this view, reckoning about deictic events should exhibit space-time compatibility effects along the sagittal axis, concordant with metaphorical language and gesture (future-front; past-behind). Sequential predictions for these theories are unclear, as sagittal language is not used to describe sequential time as systematically as for deictic time.

Predictions regarding the transversal axis pertain more to task or writing conventions (Bergen & Lau, 2012) than metaphor theory. Many studies have found right-future and left-past congruency effects, and yet English contains no metaphorical expressions that describe time in transversal terms (e.g., *the week to the right looks promising* does not mean “next week”). But all three metaphor approaches under consideration can accommodate such effects. Conceptual Metaphor Theory would predict that despite an absence of metaphorical language about the future on the right or left, gesture patterns index a cognitive mapping between time and the transversal axis that will lead to past/left and future/right compatibility effects. Both the Career of Metaphor Hypothesis and the Structural Similarity Hypothesis could interpret previously observed space-time compatibility effects along the transversal axis as resulting from forced spatialization of responses (e.g., left and right response keys), which compels participants to respond in a manner consistent with learned external representations of time (e.g., timelines). In the present paradigm, responses are not spatialized and therefore it remains an open question whether, for the transversal axis, the previously documented compatibility effects are still observed when responses are not overtly spatial. The present study investigates these questions.

Methods

Participants were presented with a series of linguistic phrases referring to typical life events and performed one of two tasks. They were asked to vocally report either whether each event occurred in the past or will occur in the future (deictic judgment) or whether one event occurred earlier or later than another event (sequential judgment) by saying the appropriate word (e.g., “past”). The stimuli were presented from one of four speakers—in front of, behind, to the left, and to the right of the participant (see Figure 1).

Participants

Sixty-four participants from the University of California, San Diego received partial course credit for participating in the study. Thirty-two participants were randomly assigned to make deictic judgments, with the rest making sequential judgments. In a post-experiment questionnaire, thirteen subjects reported not being able to hear sound from at least one of the four speakers and were thus excluded from analysis. Two other participants were excluded due to low levels of accuracy (<80%). Additional participants were recruited to return the number of participants to 32 in each condition.

Materials

For the deictic judgments, we generated forty life events likely to have happened in the past (e.g., “your birth”) or the future (e.g., “your retirement”) for an undergraduate student in the United States. The sequential stimuli were composed of forty pairs of the life events used for the deictic judgments. Events in the sequential task were preceded with “her” rather than “your” (e.g., “her high school graduation”, “her college graduation”). Examples of deictic and sequential stimuli are listed in Table 1.

Design

The experiment was run using a Mac Pro computer and was programmed in MATLAB (2009) using Psychtoolbox (Brainard, 1997). Stimuli were presented via one of four computer speakers. Each participant only made one type of temporal judgment (either deictic or sequential), but all participants heard stimuli along both spatial axes (transversal and

Table 1. *Stimuli*

Deictic stimuli belonging to the categories "past" or "future".

Past Events	Future Events
Your birth	Your death
Your prom	Your wedding
Taking your SATs	Starting on medicare
Starting kindergarten	Your child's baby shower
Getting your baby teeth	Having a mid-life crisis
Getting your driver's permit	Your high school reunion
Learning to walk	Writing your will
Learning to read	Having grandchildren
Starting college	Getting dentures
Taking gym class	Your retirement
Speaking your first word	Your first mortgage
Having your first crush	Starting your first career
Your first day in high school	Having a child
Your first time shaving	Getting your first gray hair
Your first part time job	Paying off your loans
Starting to crawl	Being middle-aged
Getting chicken pox	Taking your last college exam
Starting elementary school	Being a senior citizen
Being in sixth grade	Your forty-fifth birthday
Your twelfth birthday	Getting promoted

Examples of pairings of events for sequential stimuli.

	Reference Event	Test Event
"Later" judgments	Her high school graduation	Her college graduation
	Starting her first career	Her retirement
"Earlier" judgments	Having grandchildren	Having a child
	Taking her SATs	Starting kindergarten

sagittal). Vocal response times were measured from the offset of the auditory stimulus.

Participants were each presented with 5 practice trials, followed by two blocks of 80 randomly presented experimental trials. Over the course of the experiment, each subject heard each stimulus once from each of the four speaker locations. In each block, subjects only made judgments along either the transversal or sagittal axis. Axis order (sagittal or transversal first) and type of judgment (deictic or sequential) were counterbalanced across participants. Each trial began with either a short tone (for deictic judgments) or another life event (for sequential judgments) that was simultaneously presented from both speakers along the axis being tested. Participants then heard the critical stimulus from a single speaker along that axis and made the corresponding judgment.

Analyses

Vocal 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). Trials that were not picked up by the microphone, that were spoiled (e.g., coughing), were incorrect, or were 2.5 standard deviations from each subject's or item's mean were excluded from analysis (deictic: 5.7%; sequential: 6.8%). To compare deictic to sequential judgments, a linear mixed-effects model with type of judgment (deictic or sequential), axis (sagittal or transversal), and congruency (congruent: future or later responses in front or to the right; past or earlier responses in back or to the left) as fixed effects was fitted to the response times. Furthermore, to examine how each temporal concept was

Table 2. *ANOVA analyses.*

By subject ANOVA results. By items results in parentheses.

Deictic Sagittal	***F*** **(by-items)**	***MSE*** **(by-items)**	***p*** **(by-items)**
Temporal Reference	64.47 (4.25)	5526 (33333)	<.001 (.045)
Location	.44 (1.05)	3623.3 (23120)	.51 (.31)
Temporal Reference x Location	.57 (.28)	2117.5 (33333)	.46 (.60)
Deictic Transversal			
Temporal Reference	41.28 (15.99)	6478 (64397)	<.001 (<.001)
Location	.001 (.25)	1140.8 (37878)	.97 (.25)
Temporal Reference x Location	4.28 (.28)	2581.7 (64397)	.047 (.012)
Sequential Sagittal			
Temporal Reference	6.34 (.0028)	4800.6 (1927.2)	.017 (.96)
Location	.0059 (1.58)	4539.8 (14197)	.94 (.217)
Temporal Reference x Location	5.42 (5.32)	2701 (1927.2)	.027 (.027)
Sequential Transversal			
Temporal Reference	2.69 (.724)	6120.3 (16046)	.11 (.40)
Location	1.16 (1.01)	3064.2 (2141.3)	.29 (.036)
Temporal Reference x Location	3.51 (4.72)	3206.9 (2141.3)	.071 (.036)

associated with each spatial axis, the deictic and sequential results, as well as results from each axis, were analyzed separately with temporal reference (past/earlier or future/later) and location (left or right for the transversal axis, front or back for the sagittal axis) as fixed effects. Models were all significantly different from their respective null models. Corresponding ANOVA analyses are reported in Table 2.

Results

Results are summarized in Figure 2. Overall, participants were much faster to make deictic judgments than sequential judgments, β=109.33, SE = 51.45, p=.009. Furthermore, there was a marginal interaction between type of temporal concept and axis, β=-8.66, SE = 13.90, p=.076. For deictic judgments, participants were just as fast to respond along the transversal as along the sagittal axis, p=.38. For sequential judgments, however, participants were faster to respond along the transversal than the sagittal axis, β=32.34, SE=10.27, p=.0016.

Contrary to predictions from language and gesture that there are systematic future-in-front and past-behind construals, our paradigm did not find evidence of deictic judgments eliciting an interaction between temporal reference and speaker location along the sagittal axis, p=.46. Results, however, revealed an unexpected interaction along this axis between temporal reference and spatial location for sequential judgments, β=-40.33, SE = 20.96, p=.054. Participants were faster to make later than earlier judgments presented behind them, β=-51.47, SE=28.64, p=.072.

Results along the transversal axis replicated previous work. An interaction between temporal reference and spatial location was observed for deictic judgments, β=-35.25, SE = 16.49, p=.033 and for sequential judgments, β=-37.51, SE = 18.92, p=.048. Participants were faster to make “later” judgments to stimuli presented to their right than to their left, β=-26.3, SE=13.74, p=.055. Participants were also faster to respond to past events than to future events during deictic judgments along both axes (sagittal: β=58.77, SE = 20.66, p=.005, transversal: β=119.39, SE = 19.54, p<.001).

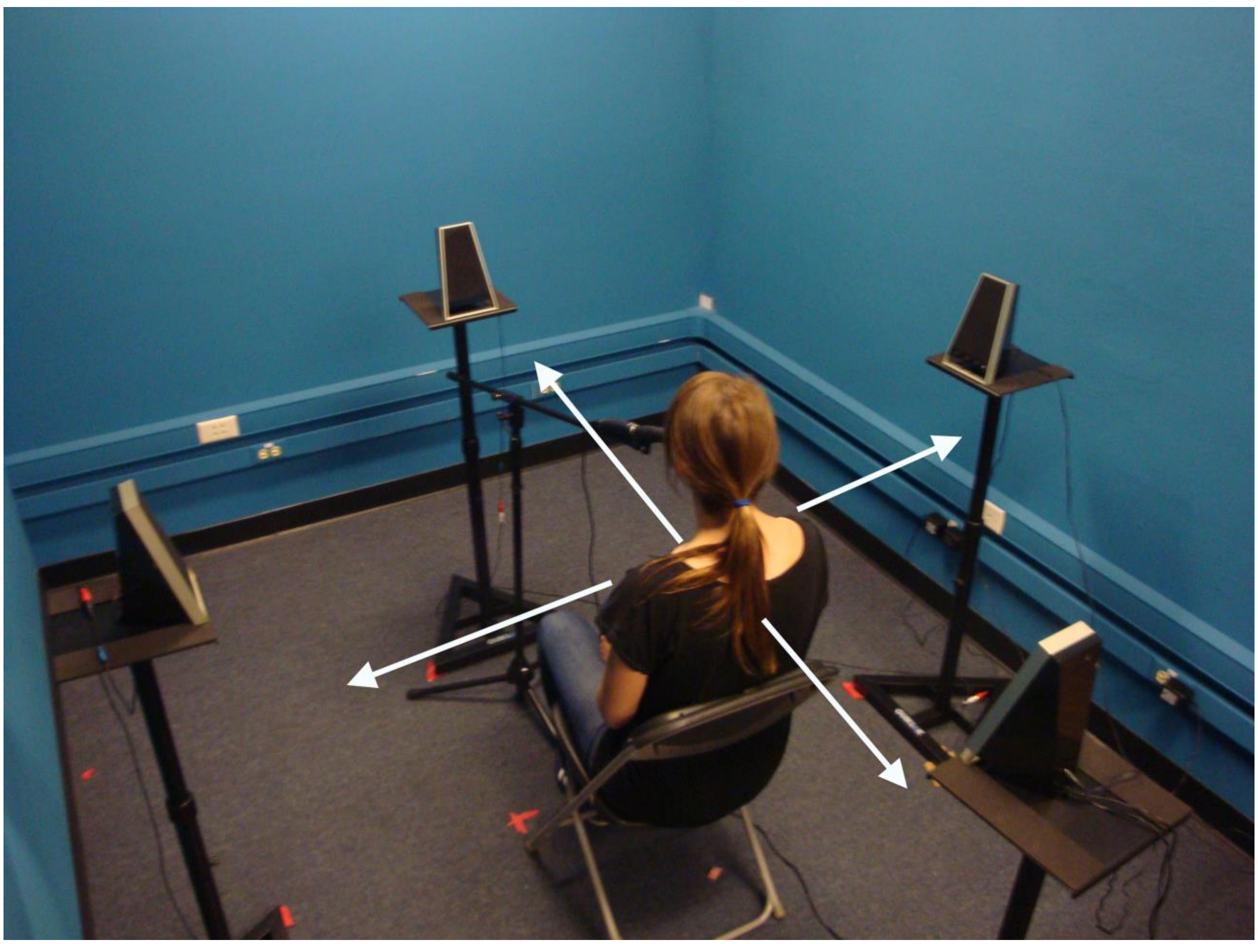

Figure 1. Experimental set-up to investigate deictic and sequential judgments along the sagittal (front-back) and transversal (left-right) axes.

DISCUSSION

We introduced a novel paradigm that uses auditory stimuli and vocal responses to investigate the psychological reality of spatial construals of time. We replicated previous work involving the transversal axis for both deictic and sequential judgments—people were faster to make judgments about past and earlier events presented on their left and future and later events presented to their right. Along the sagittal axis, however, results were surprising. Compatibility effects were *not* observed for deictic judgments, but *were* observed for sequential judgments. Participants mapped earlier events to the space in front of them and later events to the space behind them during sequential judgments, a mapping that, to our knowledge, has not been previously reported in the experimental literature. Globally, our results are consistent with the idea that people exhibit a diversity of space-time associations, as compatibility effects were observed along both axes.

The absence of an effect for sagittal deictic judgments appears consistent with approaches like the Career of Metaphor Hypothesis and Structural Similarity Hypothesis. But it is also in principle compatible with a Conceptual Metaphor Theory account if the present paradigm failed to capture the right properties of space. Indeed, only studies involving imagined or actual motion in space appear to find compatibility effects for deictic time along the sagittal axis (Sell & Kashak, 2011; Ulrich et al., 2012). Perhaps *motion*—and not just location—is key to the representation of past/future relationships along the sagittal axis (Boroditsky & Ramscar, 2002; Sell & Kashak, 2011). Our results are consistent with this idea, as we found that non-spatialized responses failed to elicit a clear sagittal deictic mapping. Future work must carefully investigate to what extent and in what ways the motor system may be involved when using a sagittal axis centered around the participant.

While no deictic sagittal effect emerged, participants *did* recruit the sagittal axis when making sequential judgments—mapping earlier events in front of them and later events behind them. This surprising aspect of our results finds some affinity with a Conceptual Metaphor Theory account. The front-earlier mapping is consistent with a deictically neutral field-based perspective of sequences in language (Moore, 2011), evidenced in expressions like *The incumbent was in a strong position <u>ahead</u> of the election.* Participants may have used their body to anchor the first event they heard. Then, after aligning their fronts and backs with the metaphorically oriented sequence of events, they may have placed the second event either in front of them (earlier) or behind them (later). Along the transversal axis, we found robust mappings of both deictic and sequential time, which squares with previous work. Importantly, the present results make the novel contribution of showing that these transversal effects are independent of stimulus modality and response mode, which points to the transversal axis as a stable and robust candidate for the spatialization of time.

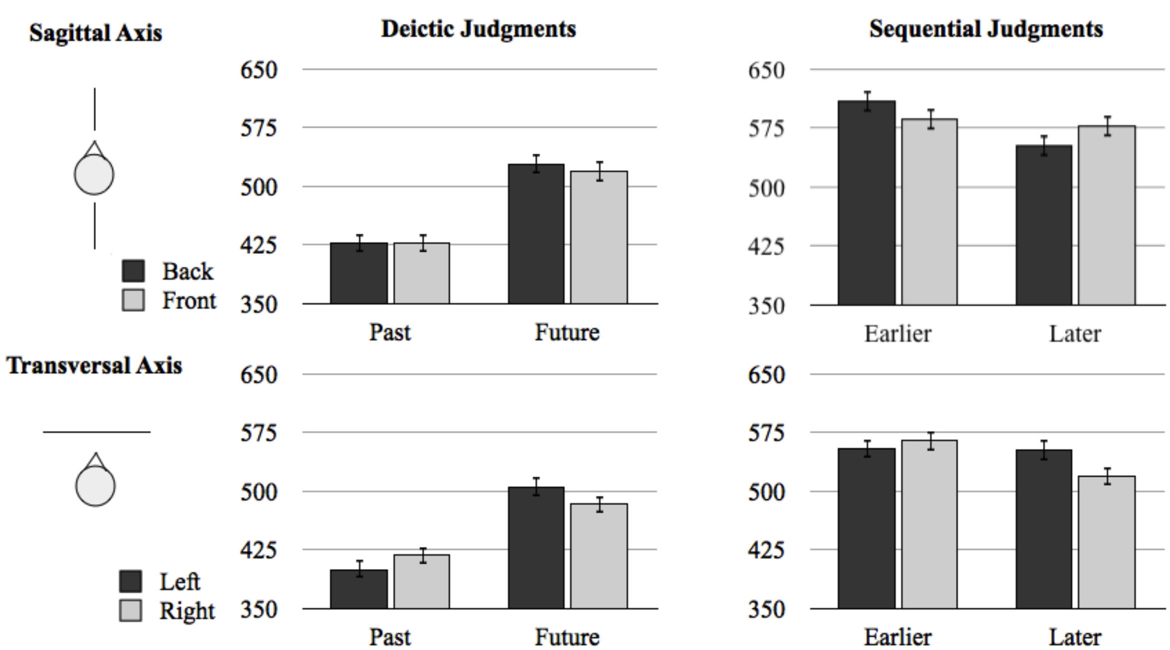

Figure 2. Reaction times to deictic and sequential judgments (columns) along the sagittal and transversal axes (rows). Error bars indicate standard error.

Overall, deictic and sequential time appear to be two different types of temporal concept (Núñez & Sweetser, 2006). In our work, this difference was reflected in two distinct ways. First, participants were much faster to make deictic judgments than sequential judgments. This difference likely reflects the relative difficulty of the two tasks, as participants found it more challenging to compare one event in time relative to another event in time than comparing one event to the present moment. Second, deictic and sequential time recruited space in fundamentally different ways. While both temporal concepts recruited the transversal axis as expected—likely due to cultural conventions (Cooperrider & Núñez, 2009)—deictic and sequential time displayed different patterns along the sagittal axis. Furthermore, while there was no difference in the timing of responses for deictic judgments between the two axes, participants were faster to make sequential judgments along the transversal than the sagittal axis.

This suggests that though deictic judgments can easily be made along either axis, the transversal axis may be the default way of thinking about temporal sequences, consistent with how sequences are often presented in the culturally constructed world around us.

In sum, there are different types of temporal concept that recruit different spatial axes in manners that are not always consistent with patterns in language and are affected by stimulus modality and response mode. These findings highlight the importance of disentangling the various elements involved in the realization of spatial construals of time and suggest that time is a multifarious concept that recruits spatial properties in nuanced, context-dependent ways.

Acknowledgements

The authors would like to thank Acacia Overoye, Lucas Medeiros de Paula, Amanda Natsuhara, and Colleen Takahashi for helping with data collection. This work was supported by a National Sciences and Engineering Research Council of Canada PGS-D awarded to EJW.

References

Baayen, R.H. (2011). languageR: Data sets and functions with "Analyzing Linguistic Data: A practical introduction to statistics". R package version 1.2. http://CRAN.R-project.org/package=languageR

Bates, D., Maechler, M., & Bolker, B. (2011). lme4: Linear mixed-effects models using S4 classes. R package version 0.999375-42. http://CRAN.R-project.org/package=lme4

Bergen, B. & Lau, T.T.C. (2012). Writing direction affects how people map space onto time. *Frontiers in Psychology, 3,* 1-5.

Boroditsky, L., & Ramscar, M. (2002). The roles of body and mind in abstract thought. *Psychological Science, 13,* 185-189.

Bowdle, B.F., & Gentner, D. (2005). The career of metaphor. *Psychological Review, 112,* 193-216.

Brainard, D. H. (1997) The Psychophysics Toolbox, *Spatial Vision 10*:433-436.

Casasanto, D., & Jasmin, K. (2012). The hands of time: Temporal gestures in English speakers. *Cognitive Linguistics, 23, 4,* 643-674.

Clark, H. (1973). Space, time, semantics, and the child. In: Moore, T.E. (Ed.), Cognitive Development and the Acquisition of Language. Academic Press, New York, pp. 27-63.

Cooperrider, K., & Núñez, R. (2009). Across time, across the body: Transversal temporal gestures. *Gesture,* 9, 181– 206.

Evans, V. (2003). *The structure of time*. Philadelphia, PA: John Benjamins.

Fuhrman, O., McCormick, K., Chen, E., Jiang, H., Shu, D., Mao, S., & Boroditsky, L. (2011). How linguistic and cultural forces shape conceptions of time: English and Mandarin time in 3D. *Cognitive Science, 35,* 1305- 1328.

Haspelmath, M. (1997). *From space to time: Temporal adverbials in the world's languages.* Munich: Lincom Europa.

Kranjec, A. & McDonough, L. (2011). The implicit and explicit embodiment of time. *Journal of Pragmatics, 43,* 735-748.

Lakoff, G. & Johnson, M. (1980). *Metaphors we live by.* Chicago: University of Chicago.

Moore, K.E. (2011). Ego-perspective and field-based frames of reference: Temporal meanings of FRONT in Japanese, Wolof, and Aymara. *Journal of Pragmatics, 43,* 759-776.

Murphy, G.L. (1996). On metaphoric representation. *Cognition, 60,* 173-204.

Murphy, G.L. (1997). Reasons to doubt the present evidence for metaphoric representation. *Cognition, 62*, 99-108.

Núñez, R. E., & Sweetser, E. (2006). With the future behind them: Convergent evidence from Aymara language and gesture in the cross-linguistic comparison of spatial construals of time. *Cognitive Science, 30,* 401-450.

Ouellet, M., Santiago, J., Israeli, Z., Gabay, S. (2010). Is the future the right time? *Experimental Psychology*, 57, 308-314.

R Development Core Team (2005). R: A language and environment for statistical computing. R

Foundation for Statistical Computing, Vienna, Austria. URL, http://www.R-project.org.

Santiago, J., Lupiáñez, J., Perez, E., Funes, M.J. (2007). Time (also) flies from left to right. *Psychonomic Bulletin & Review*, 14, 512-516.

Sell, A.J., & Kashak, M.P. (2011). Processing time shifts affects the execution of motor responses. *Brain and Language, 117,* 39-44.

Ulrich, R., Eikmeier, V., de la Vega, I., Fernandez, S.R., Alex-Ruf, S., & Maienborn, C. (2012). With the past behind and the future ahead: Back-to-front representation of past and future sentences. *Memory and Cognition, 40,* 483-495.

Weger, U., & Pratt, J. (2008). Time flies like an arrow: Space time compatibility effects suggest the use of a mental time-line. *Psychonomic Bulletin & Review,* 15, 426–430.