

THE SPACE-TIME TOPOGRAPHY OF ENGLISH SPEAKERS

by

STEVE DUMAN

B.A., Willamette University, 2004

M.A., Universität Bern, 2009

A thesis submitted to the

Faculty of the Graduate School of the

University of Colorado in partial fulfillment

of the requirement for the degree of

Doctor of Philosophy

Department of Linguistics, Institute of Cognitive Science

2016

This thesis entitled:
The Space-time Topography of English Speakers
written by Steve Duman
has been approved for the Department of Linguistics

Dr. Bhuvana Narasimhan

Dr. Laura Michaelis-Cummings

Date _____

The final copy of this thesis has been examined by the signatories, and we find that both the content and the form meet acceptable presentation standards of scholarly work in the above mentioned discipline.

IRB protocol # 14-0497

Duman, Steve (Ph.D., Linguistics & Cognitive Science)

The Space-time Topography of English Speakers

Thesis directed by Associate Professor Bhuvana Narasimhan

ABSTRACT

English speakers talk and think about Time in terms of physical space. The past is behind us, and the future is in front of us. In this way, we ‘map’ space onto Time. This dissertation addresses the specificity of this physical space, or its topography. Inspired by languages like Yupno (Núñez, et al., 2012) and Bamileke-Dschang (Hyman, 1980), languages that encode temporal events through physical downhill/uphill topography or through fine-grained proximal-distal grammatical forms, this dissertation revisits our understanding of English by asking the extent to which English speakers, too, construe temporal events as physically proximal or distal with relation to a deictic center.

Through seven experiments featuring two novel paradigms with physical space both behind and in front of the deictic center, this dissertation shows that English speakers construe Time through fine-grained topographical space, with *tomorrow* physically closer to a deictic center than *next year*. Since thought and language are inextricably connected, it also addresses the extent to which grammaticalized constructions, such as future forms (*be going to* vs. *will*) and epistemic modal verbs (*may* vs. *might*) encode proximal-distal temporal distinctions (Comrie, 1985; Langacker, 2008).

English speakers have multiple means of construing fine-grained past or future events, co-locating the present either with the ego (e.g., *The past is behind me*) or with an external locus, like a square on a calendar (Núñez and Cooperrider, 2013). Therefore, this dissertation also examines the conditions under which English speakers adopt an external deictic center or default to an internal one, essentially demonstrating the contextual flexibility of speakers’ space-time construals.

Finally, English speakers have also been shown to recruit representations of physical motion when processing temporal events (e.g., *We’re approaching summer*) (Boroditsky & Ramscar, 2002). Using a novel paradigm in which participants estimate physical distances behind and in front of them, this dissertation shows that English speakers recruit representations of motion when co-locating the present with the ego, but not when they co-locate the present with an external locus.

In these ways, this dissertation serves as a first map of English speakers’ space-time topography, providing a new perspective on the interaction of language and cognition when speakers cognize temporal events.

DEDICATION

For Susanne, who is equally deserving of a Ph.D. for her inventiveness, encouragement, and sense of adventure. This dissertation simply would not exist without you.

For Ellie & Bennett, my inspiration.

For Mom & Dad, who never had a doubt.

ACKNOWLEDGEMENTS

This dissertation is a collaborative effort. It represents much more than the completion of my doctorate—it represents the ways that people around me have shaped my thinking and improved my craft over the years. I could not be more grateful.

My advisor, Bhuvana Narasimhan, has pushed me to become a better scientist in every possible way. She has enthusiastically encouraged every project that I've concocted—even my early, outlandish strikeouts that yielded no effects. She pushes me to ask difficult questions and raises an eyebrow when my answers are not yet satisfactory. She sees the world through a rigorous lens, and she has made everything I do—particularly this dissertation—better because of it.

Laura Michaelis-Cummings has been one my biggest supporters, and I would not be in the program without her. From our first meeting on the streets of Paris, Laura has gotten me excited about the work I do, even when my own faith has faltered. If something goes well, she's the first to wave a flag to point people to my accomplishments. Her warmth is matched by her incredible wit; our conversations—which can switch from metaphor to the Beatles in the blink of an eye—are always a delight. She has broadened the scope of this dissertation and refined its arguments with every conversation.

Barbara Fox is also directly responsible for me coming to the University of Colorado. Her kindness is infectious, and there is not a person in the department who does not love her. Her knowledge of linguistic domains knows no bounds, and she has directed me to research projects pivotal to my dissertation time and time again. She has examined my research from every possible perspective, and I always look forward to our next meeting.

Eliana Colunga was enthusiastic about this dissertation from the first moment I presented it to her. Her excitement has translated into my excitement, and I am incredibly appreciative of her time and effort in shaping it. Speaking with her has truly helped me concentrate on the bigger picture and how to frame my results.

Jim Martin has provided incredible insight into this dissertation; in particular, the data visualizations are directly attributable to his observations during my prospectus defense. His encouragement to think of metaphor beyond the obvious sources has made this a better study.

I cannot thank Esther Brown enough for her brilliant observations about my work, especially given the very limited amount of time she had to do so. She has given me an infinite amount of ideas for future directions, and I can't imagine a better contribution to a thesis.

Teenie Matlock jumped to the rescue in my hour of need, and I still can't believe it. I am eternally grateful for her encouragement and feedback, and it is absolutely inspiring to have the support of someone I so greatly admire.

Of course, this dissertation is the destination from a trajectory that began years ago. David Douglass, my professor at Willamette University, first introduced me to metaphor in his incredible class. I've been hooked ever since. Miriam Locher, my instructor at University of Berne, fanned the flames and co-wrote my first publication. This dissertation would not be possible without them. I am also in debt to everyone who contributed to the technical aspects of this study. Sarah Menzel, an outstanding artist, put together all of the necessary artwork. Melanie Shaffer provided all voice recordings—her first professional voice acting gig, by my understanding. Jayne Williamson-Lee and Jamison Ducey provided all kinds of lab support, particularly in their analysis of the final videos. Thank you so much.

Lastly, I cannot say enough positive things about the students in the Department of Linguistics. You have all created such an incredibly positive, nurturing environment, and this breathed life into my work. From the early days of the Secret Colorado Underground Linguistics Laboratory to its more recent iteration with Jill Duffield and Susan Brown, I salute you and your storytelling ways. Les Sikos, super hero, came up with the idea to use a laser. Linguist extraordinaire Sam Beer helped invent the spatial perception paradigm over happy hour. Kevin Gould has provided constant inspiration, as there is no one more inventive or fun. I love you all.

TABLE OF CONTENTS

ABSTRACT	iii
DEDICATION	iv
ACKNOWLEDGEMENTS	v
TABLE OF CONTENTS	vii
LIST OF TABLES	ix
LIST OF FIGURES	x
Chapter I: Space-time Topography	1
Chapter II: Discovering Time: What We (Don't) Know	9
2.1 Introduction	9
2.2 Time Types	12
2.3 Crosslinguistic Variation	18
2.3.1 English	18
2.3.2 Non-Indo-European Languages	20
2.4 Temporal Expressions in English	24
2.4.1 Adverbials	26
2.4.2 Past Constructions	26
2.4.3 Future Constructions	29
2.4.4 Modal Verbs	31
2.4.5 More on Grammaticalization & Metaphor	34
2.4.6 Temporal Expressions in English Summary	36
2.5 Psycholinguistic Studies of Space-Time Mapping	37
2.5.1 Space-time Mapping Asymmetry	41
2.5.2 Psycholinguistic Studies of Space-time Mapping Summary	47
2.6 Chapter Summary	48
Chapter III: External Deictic Time and Adverbials	51
3.1 Introduction	51
3.2 Experiment 1a – Adverbials on the Street	56
3.2.1 Method	57
3.2.2 Results	59
3.2.3 Discussion	68
3.3 Experiment 1b – Adverbials on the Beach	69
3.3.1 Method	70
3.3.2 Results	72
3.3.3 Discussion	79
3.4 General Discussion	80
Chapter IV: External Deictic Time and Constructions	83
4.1 Introduction	83
4.2 Experiment 2a – Constructions on the Street	86
4.2.1 Method	86
4.2.2 Results	87
4.2.3 Discussion	93
4.3 Experiment 2b – Constructions on the Beach	94
4.3.1 Method	95
4.3.2 Results	96
4.3.3 Discussion	102

4.4 Experiment 3 - Non-spatial Time Estimation with Constructions	103
4.4.1 Method	106
4.4.2 Results.....	108
4.4.3 Discussion	111
4.5 General Discussion	112
Chapter V: External Deictic Time and Modal Verbs	115
5.1 Introduction	115
5.2 Experiment 4a – Modals on the Street	119
5.2.1 Method	119
5.2.2 Results.....	120
5.2.3 Discussion	126
5.3 Experiment 4b – Modals on the Beach.....	127
5.3.1 Method	128
5.3.2 Results.....	128
5.3.3 Discussion	134
5.4 Experiment 5 – Non-spatial Time Estimation with Modals	135
5.4.1 Method	136
5.4.2 Results.....	137
5.4.3 Discussion	142
5.5 General Discussion	143
Chapter VI: Internal Deictic Time and Spatial Perception.....	147
6.1 Introduction	147
6.2 Experiment 6.....	152
6.2.1 Methods	153
6.2.2 Results.....	158
6.2.3 Discussion	162
6.3 Experiment 7.....	163
6.3.1 Methods	164
6.3.2 Results.....	165
6.3.3 Discussion	168
6.4 General Discussion	168
Chapter VII: The Map	175
7.1 Overview	175
7.2 The Past & Future.....	179
7.3 Grammaticalized Constructions & Modality	184
7.4 External Deictic Centers.....	187
7.5 Physical Space & Motion.....	189
7.6 Abstract-to-Concrete Effects.....	191
7.7 Limitations & Future Directions	191
7.8 Final Words	193
REFERENCES	194
Appendix A: Statistical Models	201
Appendix B: Stimuli & Fillers.....	208
Appendix C: Post-surveys.....	210
Appendix D: Pilot Studies.....	211

LIST OF TABLES

Table 2.1. Tense system of Bamileke-Dschang.....	25
Table 2.2. Study outline.....	50
Table 3.1. Experiment 1a Relative Location for tense.....	64
Table 3.2. Experiment 1a Relative Location for past sentences.....	66
Table 3.4 Experiment 1b Relative Location for tense.....	75
Table 3.5. Experiment 1b Relative Location for past sentences.....	76
Table 3.6. Experiment 1b Relative Location for future sentences.....	77
Table 4.1. Experiment 2a Relative Location for tense.....	91
Table 4.2. Experiment 2a Relative Location for past sentences.....	92
Table 4.3. Experiment 2a Relative Location for future sentences.....	93
Table 4.4. Experiment 2b Relative Location for tense.....	99
Table 4.5. Experiment 2b Relative Location for past sentences.....	100
Table 4.6. Experiment 2b Relative Location for future sentences.....	102
Table 4.7. Experiment 3 Time Estimates by tense.....	109
Table 4.8. Experiment 3 Time Estimates by temporal distance.....	110
Table 5.1. Experiment 4a Relative Location for tense.....	124
Table 5.2. Experiment 4a Relative Location for past sentences.....	125
Table 5.3. Experiment 4a Relative Location for future sentences.....	126
Table 5.4. Experiment 4b Relative Location for tense.....	132
Table 5.5. Experiment 4b Relative Location for past sentences.....	133
Table 5.6. Experiment 4b Relative Location for future sentences.....	134
Table 5.7. Experiment 5 Time Estimates by form.....	139
Table 5.8. Experiment 5 Time Estimates by tense.....	139
Table 5.9. Experiment 5 Likelihood Estimates by form.....	141
Table 5.10. Experiment 5 Likelihood Estimates by tense.....	141
Table 6.1. Experiment 6 Estimated Distances (in cm).....	160
Table 6.2. Experiment 7 Estimated Distances (in cm).....	166
Table A. Experiment 1a statistical models.....	201
Table B. Experiment 1b statistical models.....	202
Table C. Experiment 2a statistical models.....	203
Table D. Experiment 2b statistical models.....	204
Table E. Experiment 4a statistical models.....	205
Table F. Experiment 4b statistical models.....	206
Table G. Experiment 6 statistical model.....	207
Table H. Experiment 7 statistical model.....	207

LIST OF FIGURES

Figure 2.1. Time Types	13
Figure 3.1. Man on the street images	58
Figure 3.2. Segments on the street.....	59
Figure 3.3. Experiment 1a results.	61
Figure 3.4. Experiment 1a results.	62
Figure 3.5. Chair on the beach images.....	71
Figure 3.6. Segments on the beach	71
Figure 3.7. Experiment 1b results	73
Figure 3.8 Experiment 1b results	74
Figure 4.1. Experiment 2a results.	89
Figure 4.2. Experiment 2a results	90
Figure 4.3. Experiment 2b results.....	97
Figure 4.4. Experiment 2b results	98
Figure 4.5. Experiment 2b assumptions versus participant responses.....	103
Figure 4.6. Realizations of the Time is Space/Motion conceptual metaphor	105
Figure 4.7. Experiment 3 results for past forms.	108
Figure 4.8. Experiment 3 results for future forms.....	109
Figure 5.1. Experiment 4a results	122
Figure 5.2. Experiment 4a results	123
Figure 5.3. Experiment 4b results	130
Figure 5.4. Experiment 4b results	131
Figure 5.5. Experiment 5 results for past sentences.	138
Figure 5.6. Experiment 5 results for future sentences.....	138
Figure 5.7. Experiment 5 likelihood results for past sentences	140
Figure 5.8. Experiment 5 likelihood results for future sentences.....	140
Figure 5.9. Correlation between Time Estimate/Likelihood Estimate of events.	142
Figure 6.1. The moveable cart and track.....	155
Figure 6.2. Example of a participant in Experiment 6 and 7	156
Figure 6.3. Sequence of the experimental procedure for Experiments 6 and 7	157
Figure 6.4. The cart with Ryobi laser and iPhone 6 attached.	157
Figure 6.5. Estimated distances after past sentences in Experiment 6	160
Figure 6.6. Estimated distances after future sentences in Experiment 6.....	161
Figure 6.7. Estimated distances after past sentences in Experiment 7	167
Figure 6.8. Estimated distances after future sentences in Experiment 7.....	167
Figure 7.1. Results related to external Deictic time	176
Figure 7.2. Results related to internal Deictic time	177
Figure 7.3. Images with loci that participants used as deictic centers	178

Chapter I:

Space-time Topography

Caltech researchers have discovered a new planet in our solar system. They're calling it Planet X, and it is roughly ten times the size of Earth (Hand, 2016). It was only recently discovered because of its immense distance from us: nearly 2.8 billion miles away. This discovery is evidence that, even 500 years after Copernicus observed that our solar system is heliocentric, we are still mapping space. This dissertation aims to do the same, but on a much smaller scale. Rather than chart the heavens, it turns the telescope inwards to map the space-time topography in the minds of English speakers.

Space-time topography is a new way of thinking about Time. Note that I capitalize the word Time, because I am not referring to Time as an objective entity, but rather as a mental representation, or concept. For decades, researchers have shown that humans *think* about Time similarly: through the recruitment of physical space and motion. Since Time is abstract and cannot be directly experienced, humans recruit these concrete mental representations when processing temporal events (Boroditsky, 2000, 2001; Boroditsky, Fuhrman, & McCormick, 2011; Casasanto, 2009; Lakoff & Johnson, 1980). This process of mapping concrete representations of physical space and motion onto the abstract representation of Time is known as space-time mapping, and it is present in our everyday expressions to talk about past and future events. For example, in English, we can say that *a tragedy is behind us* or that *winter is just*

ahead. We talk and think of the past as physically behind us and the future as physically in front of us. The notion of space-time topography, as proposed in this dissertation, suggests that there is more to English speakers' spatial representations than simple front-back space; rather, there is nuance and detail. In other words, the space in space-time mapping is not categorical—it is fine-grained, like a topographical map.

This dissertation is thus rooted in the theory of embodied cognition, or the notion that humans recruit multi-modal representations—such as visual and motor-based simulations—when processing language (Barsalou, 1999; Johnson, 1990; Lakoff & Johnson, 1980). So, for example, when processing sentences, people rapidly and unconsciously simulate the depicted situation (Bergen, 2012; Bergen et al., 2007; Matlock, 2004). This is even the case when people process metaphorical language, or non-literal sentences, about Time, Emotions, or Thought (Desai et al., 2011; Lacey et al., 2012; Sell & Kaschak, 2011).

Take the first paragraph of this chapter. Unless you are an astronaut or from the future, you have never physically seen a planet other than Earth—you've seen pictures or a tiny dot of light in the sky. Nevertheless, it is likely that you mentally simulated Planet X instantaneously, maybe even gave it a particular color, and even compared it to the size of Earth. You then employed a simulation of physical space, trying to calculate the impossible distance at which Planet X is flying around us.

Here's where things get interesting. Like Copernicus' contemporaries, you had a choice to make. When calculating the distance of Planet X from 'us,' you necessarily used a frame of reference for 'us.' And you had multiple options. If you are heliocentric, you estimated the distance from the sun. If you are geocentric, you calculated the distance from Earth. If you are egocentric, you simply calculated the distance from yourself. Maybe you even calculated

multiple distances, comparing a more proximal distance like the sun to Earth with a longer distance like the sun to Planet X.

As if that wasn't enough, you also located the discovery of Planet X in time. The first sentence uses the Present Perfect construction, stating that astronomers "have discovered" a planet. Just as you compared the distance of Planet X with reference to a physical location, you also processed the discovery as a past event with relation to the present moment. In other words, "have discovered" makes no sense unless you compare it to another point in time, the present. We place events in time with relation to the context of the utterance, and this 'placement' is known as deixis. If you have been keeping up with astronomical news, you know the date the discovery was announced: January 20, 2016. But, if you did not know the date, where did you place the event in time, and with reference to which present—the time this chapter was written, or the moment in which you are reading these words? In other words, how did you choose a deictic center?

As mentioned above, there is a large body of literature demonstrating that we process past and future events through the recruitment of mental representations of physical space and motion. This recruitment, of course, is often in relation to a deictic center (Núñez and Cooperrider, 2013). For English speakers, past events are frequently processed as physically behind the ego (the reference point, or the present) and future events are located in front of the ego. But English speakers have been shown to be relatively dynamic in the ways that we adopt a deictic center. For example, English speakers can co-locate the present with an external locus, like a square on a calendar or a dash on a timeline. When we do so, we tend to conceptualize Time not in terms of back and frontness, but with the past to the left and the future to the right (Flumini & Santiago, 2013). Because of its vital role in space-time mapping, deictic anchoring is

another focus of this dissertation. I examine the flexibility of English speakers' space-time mapping by showing the conditions under which we adopt a deictic center—both external and internal. The overall findings from the set of seven studies in this dissertation show that English speakers are remarkably fluid in our adoption an external deictic center when interpreting temporal sentences. For example, we consistently co-locate the present with an external locus under certain conditions, even when that locus does not feature left to right space or is incongruent with our own internal conceptualization of Time (past behind ego, future in front of ego). These findings thus speak to the dynamicity of human cognition and the extent to which people can shift their construal of Time under varying conditions. In other words, conceptualizing temporal events is not a static, restricted process. It is highly contextually dependent (Brown, 2012; Torralbo, Santiago, & Lupiáñez, 2006).

Examining how and when English speakers adopt external versus internal deictic centers provides the ideal means with which to observe space-time topography, or the extent to which we think about fine-grained physical space behind and in front of a deictic center when construing past and future events. For example, we may conceptualize events that are described as closer in time (e.g., 'tomorrow') as physically closer to a deictic center than events that are distal in time (e.g., 'next year'). That is, we not only understand temporal events with reference to physical space, but this physical space has nuance and detail, like an actual physical landscape. This possibility is inspired by experimental research showing that fine-grained space is recruited in time-related word and sentence processing (Bar-Anan, Liberman, Trope, & Algom, 2007, 2006; Ulrich et al., 2007) as well as field research in languages like Yupno, spoken in Papua New Guinea, which involves the construal of specific topographical space with reference to the speakers' immediate physical environment when referring to temporal events

(the past is *down* towards the river basin, the future is *up* the mountain) (Núñez, Cooperrider, Doan, & Wassmann, 2012).

Space-time topography is a means to observe the interaction of thought and language. English, whether through explicit references to time via adverbials (e.g., ‘tomorrow’ and ‘next year’) or more grammaticalized constructions like past and future tense forms, makes constant use of temporal reference. It is nearly impossible to make a statement of English that does not encode time in some way, whether referring to the past (*They discovered a planet*), the present (*They are gathering data*), or the future (*They are going to declare it the ninth planet in the solar system*). But when we speak of temporal events using grammaticalized forms, we have multiple constructions at our disposal. For example, we could say *They are going to declare it the ninth planet* or *They will declare it the ninth planet*. Some linguists have suggested that such differences in form denote differences in proximal versus distal temporal events (Brisard, 2001, Langacker, 2008). If we say that an event is *going to* happen, we may be expressing that this event is more proximal in time than when we say it *will* happen. In other words, English expressions may encode more fine-grained temporal distinctions than the categorical tense distinctions of past, present, and future.

Therefore, this dissertation also addresses the extent to which fine-grained space-time topography is encoded in everyday linguistic constructions. It examines whether using grammaticalized constructions about the past and future involves the construal of fine-grained physical space. The past constructions under examination are the Present Perfect (e.g., *They have discovered a planet*) and the Simple Past (e.g., *They discovered a planet*). Both of these constructions describe events that occurred prior to speech time; however, the Present Perfect purportedly encodes the current relevance of the described event, thus suggesting that it encodes

a more proximal temporal event than the Simple Past (Comrie, 1985; Langacker, 2008). As mentioned above, I also analyze the *Be Going to Future* (e.g., *They're going to discover a planet*) and the *Will future* (e.g., *They will discover a planet*). Of these two forms, Langacker (2008) argues that the *Be Going to Future* encodes perceptually available evidence of a future event, and thus may encode a more proximal future event than the *Will Future*.

Of course, English can do more than assert past or future events. A speaker can also express varying degrees of certainty about those events. We do so through various constructions, and epistemic modal verbs are a particularly robust means of achieving this effect (e.g., *can*, *could*, *may* *might*, etc.) (Palmer, 2001). Certainty about an event could modulate the topography of English speakers' Time representations, because speaking of potential instead of factive events is necessarily more abstract. If we assume that interpreting abstract concepts involves the activation of physical space, then processing sentences with modal verbs may require greater recruitment of physical space than sentences without modal verbs (Fernández de Lara, 2012; Kaup et al., 2007). Moreover, epistemic modal verbs may also encode fine-grained spatial distinctions. Langacker (2008), for example, claims that the verb *may* (e.g., *They may discover a planet*) encodes greater certainty than *might* (e.g., *They might discover a planet*), because *may* encodes the speaker's perceptually-available evidence for the event. In this way, an event's likelihood and temporal proximity may go hand in hand, where speakers conceptualize likely events as more temporally proximal (because of evidence associated with the present) and less likely events as more temporally distant.

This dissertation thus examines the psychological reality of fine-grained space-time topography in the minds of English speakers. English speakers have a dynamic, fine-grained physical representation of Time given a particular temporal event, and the studies presented here

begin to map the topography of this representation. Therefore, this dissertation tells us not only more about how we process language, but also the way that we think about Time and the interaction between temporal language and thought. Since nearly every event we speak of or encounter is entrenched in time, it thus tells us something about everyday human cognition and how we negotiate events that we perceive as well as events that we do not perceive. It tells us about the embodiment of certain concepts, and the role our everyday interactions with our environment play in human thought.

To that end, this dissertation presents seven experiments to more completely map the space-time topography of English speakers. It extends previous work in the space-time mapping literature by (1) disentangling external and internal Deictic time, (2) separately examining both spatial and motion mental representations, and (3) using paradigms with both front *and* back physical space relative to a deictic center. With two novel experimental paradigms, it shows that English speakers do, indeed, construe temporal events using fine-grained space-time topography. Sentences with adverbials yield the most robust findings, where participants reliably locate sentences with ‘tomorrow’ closer to the deictic center than sentences with ‘next year.’ Interestingly, this is only the case for future sentences across paradigms. In fact, processing sentences with fine-grained topography is even shown to influence participants’ spatial perception, such that they estimate a fixed marker in front of them to be a shorter distance away after processing sentences with ‘tomorrow’ compared to their estimates after processing sentences with ‘next year.’ I also find that English speakers make a fine-grained temporal distinction between past (Present Perfect vs. Simple Past) and future (*Be Going to* Future vs. *Will* Future) constructions, but these distinctions do not seem to involve the recruitment of physical space. In contrast, English speakers do recruit physical space to process sentences with *may* or

might, but only for events in the past. Lastly, speakers are dynamic in their selection of deictic centers, as they readily co-locate the present with external loci even when those loci are not conventional, are incongruent with their own front-back orientation, or do not explicitly encourage them to think about Time in terms of physical space.

This dissertation addresses these issues in six chapters. Chapter 2 offers an in-depth discussion of the prior work in space-time mapping, particularly on the work that predicts the reality of space-time topography. This chapter also outlines the research questions that will be addressed in the subsequent chapters. Experimental work is provided in the following four chapters reporting seven studies. Chapter 3 presents Experiment 1a and 1b, two experiments using a novel ‘sentence placement’ paradigm geared toward examining space-time topography when explicit time-related adverbials are used in sentences. Chapter 4 describes Experiments 2a, 2b, and 3, which use the same paradigm as Experiments 1a and 1b but with grammaticalized past and future constructions instead of adverbials. Chapter 5 then examines sentences with epistemic modal verbs in Experiments 4a, 4b, and 5. Chapter 6 presents an entirely new experimental paradigm, one that examines the extent to which processing time-related sentences influences spatial perception and the role of motion in speaker’s mental representations. These experiments are all summarized and discussed in Chapter 7, the conclusion.

Chapter II:

Discovering Time: What We (Don't) Know

2.1 Introduction

Casasanto (2009, p. 128) argues that Time is to cognitive linguists what the fruit fly is to geneticists. It has been dissected by countless researchers, yet it continues to robustly yield new insights into metaphorical structure and processes. Moreover, Time has been observed through the lens of many microscopes: linguistic analyses, fieldwork, behavioral experiments, and, more recently, neuroscientific approaches. Despite these studies, much remains unknown about mental representations of Time, even for English speakers.

Much of the remaining mystery surrounding Time stems from the fact that, oftentimes, researchers have been observing fundamentally different space-time mapping phenomena. Núñez and Cooperrider (2013) observe that space-time mapping manifests itself in at least three different ways: (1) as a deictic system, or a system that co-locates the present with a particular reference point (e.g., *We have a meeting tomorrow*, where ‘tomorrow’ only makes sense with reference to a deictic center, the present), (2) as a sequential system, or a system that describes temporal events with relation to each other (e.g., *Thursday follows Wednesday*) and (3) as a duration system, or a system that describes the ‘length’ of a particular event (e.g., *The afternoon was short*). As the authors argue, understanding the space-time mapping research to date—and developing new research questions—requires disentangling these particular time types. This

dissertation largely concentrates on the differences between internal Deictic time, where speakers co-locate the present with the ego, and external Deictic time, where they co-locate the present with an external locus. Specifically, I examine the conditions under which English speakers co-locate the present with an external locus as opposed to an internal one.

In addition, linguistic fieldwork is still revealing new and surprising space-time mapping systems, ranging from languages like Amondowa , which does not demonstrate mapping of any kind (Sinha, Sinha, Zinken, & Sampaio, 2011), to languages like Yupno, which displays remarkably fine-grained mapping (Núñez, Cooperrider, Doan, and Wassmann, 2012). These different systems serve as much more than novelties; they are evidence of the interaction of language, culture, and cognition, as well as a reminder that universals—particularly when it comes to language—are a slippery notion. More specifically, these languages encourage a re-examination of the granularity of space-time mapping in English, which, until this point, has been primarily treated as categorical (i.e., past is backward, future is forward).

Examining crosslinguistic variation simultaneously encourages the examination of intra-language differences in how temporal notions are expressed. English has multiple language forms for describing past and future events, ranging from lexical items, like adverbials, to more grammaticalized forms, like the *Be Going to* Future or the Simple Past. Some researchers argue that these linguistic forms encode slight variations in space-time mapping (Brisard, 2001; Langacker, 2008). Moreover, English speakers may express varying degrees of certainty about past or future events through the use of epistemic modal verbs like *may* and *might*. In this way, modality likely interacts with English-speakers' conceptualizations of Time (Fernández de Lara, 2012).

Fieldwork and linguistic analyses serve as a backdrop for the extensive number of psycholinguistic experiments that have been conducted in the space-time mapping domain. Primarily aimed at explaining the psychological reality of space and motion recruitment for understanding Time as a mental and linguistic representation, these experiments provide a relatively comprehensive picture of the extent to which English speakers (as well as Arabic, Mandarin, and Hebrew speakers) do or do not *think* about Time in terms of space and motion. As with any field, the results are largely conflicting. In addition, many such experiments have examined the asymmetry of the relationship between abstract and concrete domains like Time and space, where the concrete domain of space maps to the abstract concept of Time but not vice versa (Casasanto & Boroditsky, 2008). Recent studies, however, are showing that this relationship may be *symmetrical*, where processing metaphorical utterances, such as those describing temporal events, may also influence sensorimotor perception (Slepian & Ambady, 2014). Given these conflicting studies, a survey of the work that has been done provides a springboard to address several unanswered questions in the field.

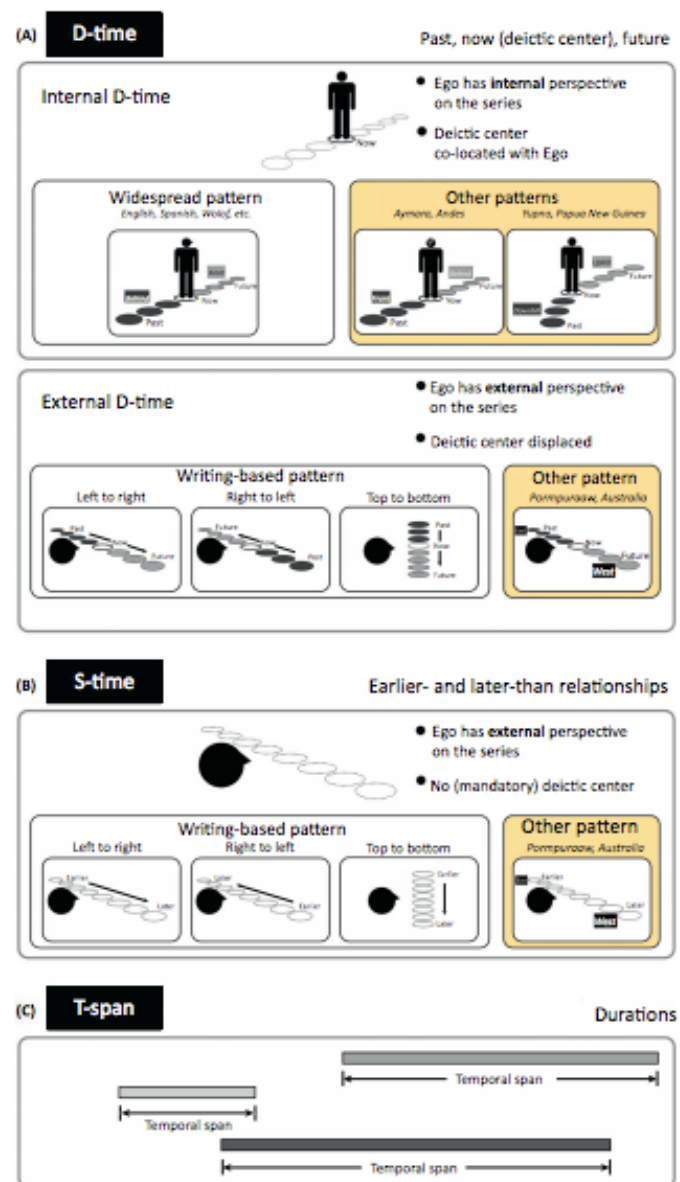
Since the goal of this dissertation is to map English speakers' space-time topography, it is necessary to disentangle the myriad of results in the domain of space-time mapping and develop a clear picture of the unanswered questions in the field. To that end, this chapter will provide a background of the above-outlined domains in the space-time mapping literature: (1) Time Types, (2) Crosslinguistic Variation, (3) Temporal Expressions in English, and (4) Psycholinguistic Studies of Space-time Mapping. Each section will end with open research questions within that domain. In this way, this dissertation aims to examine the fruit fly from a new angle, effectively providing answers to these research questions.

2.2 Time Types

To begin, linguists and cognitive scientists who work on space-time mappings often treat Time as a monolithic concept. However, this treatment is problematic. To remedy this, Núñez and Cooperrider (2013) provide a useful taxonomy with which to disentangle ‘time types,’ or the different possible construals of Time. Following work by McTaggart (1908), Núñez and Cooperrider (2013) draw a careful distinction between Deictic time (D-time), Sequential time (S-time), and Temporal Span (T-span). Outlined in Figure 2.1 below, Deictic time refers to temporal references where the present (or now) is the deictic center, and past or future states or events exist with relation to that deictic center. So, for example, in the sentence *Yesterday was beautiful*, ‘yesterday’ refers to a temporal entity with relation to the present deictic center (Fillmore, 1966, 1982; Levinson, 1983; Lyons, 1977).

Deictic time can be realized both internally and externally (Núñez & Cooperrider, 2013). With internal Deictic time, the present is co-located with the ego. For English speakers, the past is conceptualized as behind the ego and the future is conceptualized as in front of the ego. Though there are variations of this basic conceptualization, this is a predominant schema, particularly in European languages (Núñez & Cooperrider, 2013). With external Deictic time, the speaker co-locates the present with an external deictic center. That is, speakers are able to adopt an external locus as a deictic center when construing temporal events. Núñez & Cooperrider (2013, p. 223) compare internal and external Deictic time in terms of perspective taking, where internal Deictic time is similar to being aboard a moving train, and external Deictic time is similar to viewing that train from a distance. For example, external Deictic time manifests itself on Western calendars with the ‘now’ as a square on a page, with ‘yesterday’ to the left and ‘tomorrow’ to the right.

Sequential time, on the other hand, refers to situations where temporal entities are described in relation to one another. For example, *The meeting follows a short brunch* describes a sequence of temporal events with no reference to a deictic center. There is no required reference to the present in Sequential time. Temporal span describes the duration of a described temporal entity (e.g., minutes, hours, days, etc.). Again, when referring to Temporal span, reference to the present is not necessary, nor is reference to another event in time.



TRENDS in Cognitive Sciences

Figure 2.1. Time Types. Deictic time (D-time) (internal and external), Sequential time (S-time), and Temporal span (T-span). Reprinted from Núñez and Cooperrider (2013).

The difference between these time types—internal Deictic time, external Deictic time, Sequential time, and Temporal span—is critical to research in space-time mapping, as each may involve the recruitment of fundamentally different cognitive resources. Moreover, contemporary research suggests that speakers are relatively unpredictable with regard to the conceptualization that they will recruit when processing temporal events. In her analysis of Tzeltal, spoken in Tenejapa, Southern Mexico, Brown (2012) shows that speakers may recruit any number of spatial representations to accomplish a nonlinguistic task. In two nonlinguistic tasks that required Tzeltal speakers to depict the temporal order of events using space (e.g., order flashcards depicting the life cycle of a chicken), Brown found no consistent strategy being employed, with some speakers recruiting sequential relative space strategies (e.g., left to right relative to the ego) and others using sequential strategies through recruiting absolute directions (e.g., downhill/uphill, east to west). Tzeltal speakers, in other words, are not consistent in their recruitment of space to order temporal events. This suggests that close attention to time type is critical and, in addition, the physical task required of participants may strongly influence the linguistic and neural mechanisms that speakers employ. This observation is echoed by Núñez and Cooperrider (2013, p. 225), who argue:

In cases where multiple SCTs [spatial construals of time] are available to express a given time concept, such as D-time in English [...], a mix of situational and pragmatic factors may determine which one an individual uses in a given moment. As seen in gesture, for example, the choice could be modulated by the temporal granularity required – front–back for coarse-grained material and left–right for fine-grained.

In other words, a language's system for space-time mapping, time type, and situational factors may all play a role in a speakers' contextual space-time mapping.

This dissertation is concerned with some of the factors that influence alternations in space-time construals, particularly between internal and external Deictic time. In English,

internal Deictic time seems to be a more basic or primal means of construing temporal events. This is evident from ‘back’ and ‘front’ spatial terms for temporal events (given our front-back orientation as embodied beings) as well as co-speech gestures backward (from the ego) for past events and forward (from the ego) for future events (Casasanto & Jasmin, 2012). However, if we assume that internal Deictic time is more basic than external Deictic time, then there must be certain conditions under which English speakers adopt an external deictic center. We arrive, then, at a critical question in the field:

RQ1. Under what conditions do English speakers construe temporal events with an external deictic center (as opposed to an internal one)?

There are multiple factors that could influence speakers’ adoption of an external deictic center. The experiments described in this dissertation examine three different factors through the following manipulations: (1) an image with front-back physical space as opposed to left-right physical space, (2) an external locus that is congruent or incongruent with the participant’s internal Deictic time representation, and (3) an image that explicitly encourages participants to think about Time in terms of physical space versus one that does not.

First, this dissertation’s use of an image with front-back space is a novel contribution to the literature. External Deictic time in English is most often examined with paradigms that involve left-to-right physical space (Flumini & Santiago, 2013; Santiago et al., 2007; Weger & Pratt, 2008). This is because English speakers map the left to the past and right to the future, presumably due to writing left to right and other cultural conventions, such as calendars and timelines. However, English speakers do not regularly engage in cultural activities that require them to construe temporal events using front-back space with an external locus. Construing temporal events using an image with front-back physical space would represent a dynamic projection of one’s internal Deictic time onto an external locus, one that is not necessarily

motivated by cultural practices (Torralbo, Santiago, and Lupiáñez, 2006). In other words, this projection would answer the following research question:

RQ1a. Do English speakers construe external Deictic time using an image with front-back physical space (as opposed to left-right physical space)?

Using an image with front-back physical space allows a second manipulation: the use of an external locus that is either congruent or incongruent with speakers' representations of internal Deictic time. Torralbo, Santiago, and Lupiáñez (2006) show that front-back and left-right congruency influence Spanish speakers' construal of external Deictic time. In a first experiment, speakers viewed visual stimuli of a silhouette that was 'thinking' of a temporal event. Participants verbally responded 'past' or 'future' to describe the temporal event. The event was written in a bubble either to the left or right of the silhouette, thus either congruent or incongruent with the silhouette's front-back orientation. Since the silhouette was on a computer screen, stimuli were simultaneously oriented left or right with reference to the participant. Participants reliably responded faster when the temporal event was congruent the front-back orientation of the silhouette (faster when a past temporal event was behind the silhouette) as compared to the incongruent condition. However, the left-right orientation with regard to the participant did not yield an effect. In a second experiment, the researchers asked participants to perform the identical experiment but changed their response: rather than respond verbally, participants responded by manually pressing a left button on a keyboard for 'past' and a right button for 'future.' This manipulation reversed the effect of the first experiment, where participants showed a left-right congruency effect (left on the computer screen for past, right for future) but no front-back congruency effect with reference to the silhouette. Torralbo et al. (2006) thus show that participants can manipulate their construal of a temporal event depending on the task they are performing. Importantly, however, both manipulations involve space-time

construals congruent with front-back orientation or left-right orientation. This dissertation extends these findings by examining whether or not English speakers also construe external Deictic time in a scenario that is entirely incongruent with their internal Deictic time (front-back) representation or external Deictic time (left-right) representation by using an external locus that faces toward the participant. In other words, this dissertation asks the following question:

RQ1b. Do English speakers adopt a deictic center that is incongruent with their own internal Deictic time?

Third, some researchers claim that speakers only map space to Time—which may involve the adoption of a deictic center—when they are explicitly encouraged to think about Time in terms of physical space. In a series of experiments that will be more thoroughly described in section 2.5 below, Ulrich and Maienborn (2010) and Ulrich, Eikmeier, de la Vega, Fernández, Alex-Ruf, and Maienborn (2012) show that space-time mapping effects disappear when participants are not explicitly asked to respond to a sentence based on whether or not it takes place in the past or future. The authors refer to this phenomenon as ‘activating a mental timeline.’ For example, Ulrich et al. (2012), using a manual board that required participants to move their hands backward or forward in response to sentences, asked participants to move their hands backward for past sentences and forward for future sentences (the congruent condition) and the reverse for the incongruent condition. The researchers find a space-time mapping effect, where participants respond faster to future sentences when moving their hands forward and faster for past sentences when moving their hands backward. However, this effect disappears when participants move their hands backward or forward simply by judging the sensibility of the sentences. That is, in this case, participants are not faster to respond to future sentences when moving their hands forward (compared to backward) when not responding to the time of the event. In essence, by asking participants in any study to respond with a time judgment (e.g.,

‘past,’ ‘future’) that corresponds with physical space, (e.g., backward, forward), the researcher is explicitly encouraging the participant to think about Time in terms of space (see also Kranjec & McDonough, 2011). Without this encouragement, speakers may not construe temporal events with physical space. This dissertation addresses this problem by using a manipulation that explicitly encourages participants to think about Time in terms of space and one that does not. In other words, it address the following research question:

RQ1c. Does the adoption of an external deictic center require explicit reference to Time in terms of physical space, or the explicit activation of a mental timeline?

Answering these research questions requires a paradigm that manipulates the spatial conditions of the task and provides a viable external locus for speakers to co-locate the present with. This paradigm will be thoroughly described in Chapter 3.

2.3 Crosslinguistic Variation

In addition to the several time types that can be conceptualized, linguistic fieldwork has also demonstrated that space-time mapping is not uniform across languages and cultures. Instead, languages of the world demonstrate a wide variety of spatial recruitment strategies—and non-spatial strategies—when referring to past or future events. Starting with English as a reference point, this section outlines some of the known space-time mapping strategies in languages of the world. Though this discussion centers on deictic time conceptualization, much of the literature conflates time types but will be included regardless.

2.3.1 English

For internal Deictic time, English speakers conceptualize the past as behind the ego and the future as in front of the ego. This is reflected in sentences such as *He’s looking forward to the summer* and *She looked back on her life*. This spatial configuration of past as back/future as front

has been well documented in the linguistics literature (Clark, 1973; Lehrer, 1990; Lakoff & Johnson, 1980; Lakoff, 2008, 1993; Traugott, 1978; Radden, 2003).

In addition to the front-back spatial axis, English speakers also recruit two diametrically opposed conceptualizations of motion when referring to events of internal Deictic time (Clark, 1973; Lakoff & Johnson, 1980; see also McGlone & Harding, 2008 for an alternative explanation). In the first conceptualization, the ego is conceptualized as moving over a static Time landscape. This is called the ego-moving perspective, and it is reflected in the sentence *We are rapidly approaching Thanksgiving*. The ego-moving perspective contrasts with the time-moving perspective, where Time events are conceptualized as in motion towards a static ego. The time-moving perspective is reflected in the sentence *Thanksgiving is rapidly approaching*.

English speakers have also been shown to use external Deictic time, co-locating the present with an external locus. For English speakers, external Deictic time has primarily been demonstrated along a left-right axis, where speakers conceptualize the past on the left of a deictic center and the future on the right (Casasanto & Jasmin, 2012; Chan & Bergen, 2005; Flumini & Santiago, 2013; Santiago, Lupáñez, Pérez, & Funes, 2007). As mentioned above, the left as past/right as future spatial mapping has been attributed to cultural practices, such as weekly calendars, timelines, and writing, but the left/right axis can also be realized with internal Deictic time¹ (Walker, Bergen, & Núñez, 2014).

Clearly, English has been well documented in terms of space-time mapping, and English's patterns are reflected in many other related languages (Núñez & Cooperrider, 2013). However, the last few decades have brought an extensive amount of fieldwork of Non-Indo-European languages that recruit space and motion in dramatically different ways.

¹ To examine the left to right mapping of internal Deictic time, the paradigm must involve space to the physical left and right of the participant's body (that is, relative to the ego), not just on the left or right of a character on a screen (Walker, Bergen, & Núñez, 2014).

2.3.2 Non-Indo-European Languages

Data suggest that space-time mapping can be understood in terms of a spectrum, with some languages providing no evidence of space-time mapping on one side, and others providing evidence of robust, specific topographical space and motion construal on the other.

On the first end of the spectrum, Sinha et al. (2011) argue that Amondowa, a language spoken in the Amazon, does not demonstrate space-time mapping in any way. In other words, terms in Amondowa that are used to describe space and motion are not used to describe temporal events. Instead, speakers use event-based seasonal and diurnal systems, making reference to the seasons with changes in weather (e.g., translated ‘time of the sun’ for summer and ‘time of rain’ for winter) or time of day with the day’s activities (e.g., translated ‘when we start work’ for early morning and ‘when we eat’ for lunchtime) (Sinha et al., 2011, p. 24-26). The authors use this evidence to suggest that space-time mapping is not a universal phenomenon.

Further along the spectrum, languages exhibit space-time mapping, but with alternative construals to English or with different spatial axes. Núñez, Neumann, and Mamani, (1997) and Núñez and Sweetser (2006) describe Aymara, an Amerindian language spoken in the Andes, that also uses a front-back axis for temporal events. However, Aymara maps the past in front of the ego and the future behind the ego. This is exactly the opposite of English, and there is a simple logic to the difference. The past is composed of events that have already been experienced; figuratively, they are visible. In contrast, the future is unknown and therefore not visible. Aymara speakers thus move backwards into the unknown future. The past as front/future as back conceptualization is evident in both linguistic and gestural data from native speakers.

Like English speakers, Mandarin speakers conceptualize internal Deictic time (and external Deictic time) using a front-back axis. However, Mandarin speakers also conceptualize

Time using a vertical axis for external Deictic time, with the past above a deictic center and the future below (Boroditsky 2001, 2000; Boroditsky, Fuhrman, & McCormick 2011; Chen 2007; Scott 1989). The morpheme *shàng* (up) can be used to describe earlier events and *xià* (down) can be used to describe later events. Linguistic data suggest, however, that the up-down axis is primarily recruited for Sequential time.

Boroditsky and Gaby (2010) document an Australian aboriginal language Pormpuraaw, in which speakers conceptualize Time on a cardinal direction axis from East to West, with the past to the East and the future towards the West. This is radically different from English, and it also represents a Time conceptualization that is very much in tune with the speakers' environment. Pormpuraaw speakers must attend to their own position with regard to cardinal directions in order to make reference to temporal events. This study does not address whether or not this conceptualization of Time pertains to internal or external Deictic time, though Núñez and Cooperrider (2013) describe it as external Deictic time.

This significant linguistic and cultural diversity has prompted extensive crosslinguistic comparisons of languages like Japanese and Marathi (Shinohara & Pardeshi, 2011), German, English, Mandarin, and Tongan (Bender, Beller, & Bennardo, 2010), and Japanese, Wolof, and Aymara (Moore, 2011), and these studies serve to refine our understanding of the interplay between linguistic variation and time types. Crosslinguistic study of such languages is, in fact, critical to our understanding of space-time mapping.

Moreover, these studies have been followed by the study of a language that appears to be at the other far end of space-time mapping spectrum. Núñez et al. (2012) describe the Yupno, a small community that inhabit the village Gua in Papua New Guinea. Using both linguistic and gestural data, the researchers demonstrate that the Yupno recruit yet another dramatically

different conceptualization of Time: when referring to future events (and outside), the Yupno gesture uphill towards the mountain bordering the village. When referring to past events, they gesture downhill towards the river basin (gestures are modified when indoors, such that future events are toward the house door). The evidence indicates that the Yupno are using internal Deictic time, co-locating the present with the ego, and that they are construing temporal events with reference to the specific topographical make-up of the village's immediate environment. This departs from other languages and cultures on two dimensions: (1) the past and future do not contrast along a straight line, instead following a curved contour of the land, and (2) the past and future are represented at an angle (i.e., uphill and downhill) and not a flat axis (which has also been found in Tzeltal (Brown, 2012)).

This space-time mapping spectrum, and Yupno in particular, prompts a re-analysis of English speakers' conceptualization of Time. Yupno speakers construe extraordinarily specific physical space in talking about temporal events. And, though it has not been empirically demonstrated, recruiting such physical space would be inherently non-categorical. English, in contrast, appears to be categorical. Or, as Núñez & Cooperrider, (2013, p.225) suggest, English speakers recruit the "front-back [axis] for coarse-grained material..." That is, the past is behind the deictic center and the future is in front. There is little to no granularity to this recruited space. If the Yupno recruit such fine-grained physical space, then events in Time will necessarily be located in specific physical locations. In fact, Wassmann (1994, p. 656) shows that the Yupno have a very intricate, specific means of describing local topography, amounting to a "checkerboard of named units for spatial description." For example, when referring to the West or 'steeply above,' the Yupno say *waminokaa*, or 'the place of the many tree-beetles' (Wassman, 1994, p. 657). Moreover, in order to gesture in the proper direction when construing a temporal

event, they must pay close attention to their orientation with the immediate topography.

Assuming this fine-grained attendance to nearby physical topography also applies to Time conceptualization, proximal temporal events for the Yupno will be located nearer in physical space (e.g., near the village), and distal temporal events will be located further away (e.g., nearer the mountaintop).

In fact, Lakoff & Johnson (1980) originally posited that English speakers' conceptualization of Time is not just a categorical recruitment of front-back space. Rather, they suggest that, like the Yupno, English speakers specifically recruit a landscape source domain in space-time mapping. In other words, Lakoff and Johnson argue that English speakers think about Time in terms of physical land (perhaps even with a path, rough patches, a horizon, etc.) as opposed to a categorical front-back space. If this is the case, then English speakers may well think about Time with a fine-grained proximal-distal distinction. If, on the other hand, they do not recruit physical landscape, they will exhibit no fine-grained proximal-distal distinction between temporal events. To date, evidence of such fine-grained recruitment of a landscape is limited. This prompts the next research question:

RQ2. Do English speakers construe coarse-grained (categorical front/back) or fine-grained (landscape) spatial representations when space-time mapping?

Given the need to disentangle external and internal Deictic time, as discussed in the section above, this question goes hand in hand with the following question:

RQ2a. Does this construal vary based on speakers' construal of external Deictic time or internal Deictic time?

If English speakers do have a fine-grained representation of Time, they could be said to have an internalized 'topography,' much like the Yupno. I will refer to this as **the space-time topography hypothesis**. Since this hypothesis necessarily examines the interaction of thought

(Time as a concept) and language, this dissertation also addresses the multiple temporal expressions in English that may encode fine-grained spatial distinctions.

2.4 Temporal Expressions in English

The space-time topography hypothesis, or the hypothesis that English speakers recruit a fine-grained spatial and/or motion representation when processing sentences that encode internal or external Deictic time, is also motivated by the tense and aspect systems of languages other than English. Many languages have grammaticalized fine-grained temporal distinctions such that, for example, referring to a proximal temporal event as opposed to a distal temporal event is necessitated by the grammar. Though little to no experimental work examines the extent to which speakers of these languages recruit fine-grained spatial representations when hearing or speaking, these languages offer strong evidence that speakers must (at least) constantly attend to fine-grained distinctions in time.

To begin, Comrie (1985, p. 1-6) describes tense as the “grammaticalisation of location in time,” whereas aspect is the “grammaticalisation of expression of internal temporal constituency.” As such, the difference between the following sentences, as borrowed from Comrie (1985, p. 6), is one of tense:

Present Tense	<i>John is singing.</i>
Past Tense	<i>John was singing.</i>

Tense is a deictic system, because temporal events are located with respect to a deictic center. As Comrie (1985, p. 9) observes, “In fact, all clear instances of tense cross-linguistically can be represented in terms of the notions of deictic centre [...], location at, before, or after the deictic centre, and distance from the deictic centre...” In contrast, aspect is non-deictic, because it describes an event’s internal temporal contour (Comrie, 1985, p. 14). For example, difference between the following sentences is aspectual:

Progressive	<i>John was singing.</i>
Perfective	<i>John sang.</i>

In these examples, both events occur prior to the deictic center (the present), but both describe different temporal contours. Whereas the progressive describes an ongoing event, the perfective describes a completed event.

Languages of the world demonstrate a remarkable variety of tense and aspectual systems, and these systems offer a spectrum of fine-grained temporal distinctions, especially when combined with lexical devices such as temporal adverbials. On one end of the spectrum, languages allow for very coarse-grained distinctions in time. For example, Yidiny makes no apparent distinction between ‘today’ and ‘now’ (Dixon, 1977, p. 498-499). On the other end of the spectrum, some languages display fine-grained distinctions between temporal events. Such fine-grained distinctions tend to be more frequent to describe past events than future events, though some languages have symmetrical systems (Comrie, 1985, p. 85). For example, the Bantu language Bamileke-Dschang possesses five-term contrasts denoting proximal to remote (or distal) past and proximal to remote future. This is evident in the system below, as described by Hyman (1980, p. 227-228) in Table 2.1.

Past	Future
Immediate Past	Immediate Future
Earlier Today	Later Today
Yesterday	Tomorrow
Day before Yesterday or Days Earlier	Day after Tomorrow or Days Later
Separated from Today by a Year or more	A Year or More Hence

Table 2.1. Tense system of Bamileke-Dschang. Source: Hyman, 1980, p. 227-228.

Such tense systems serve as evidence that, on a grammatical level, speakers of many languages are required to attend to fine-grained distinctions in time.

By most accounts, English has a three-term tense system: past, present, and future (Comrie, 1985). However, English also has multiple constructions for referring to temporal events either in the past or future. Given prior literature, there is reason to believe that fine-grained time is, in fact, grammaticalized in English. Below are potential candidates for lexical and grammaticalized constructions that encode fine-grained time.

2.4.1 Adverbials

English allows speakers to make reference to fine-grained past and future events through the use of adverbials. Adverbials are used specifically to locate a temporal event with relation to the present (Comrie, 1985, p. 56). Using a purely arbitrary distinction between proximal and distal events from the present, below are some examples:

Proximal Past	<i>Yesterday</i>
Distal Past	<i>Last year</i>
Proximal Future	<i>Tomorrow</i>
Distal Future	<i>Next year</i>

Adverbials thus serve as a lexical manifestation of fine-grained time as encoded in the English language. They thus prompt the research question:

RQ2b. Do lexical adverbials encode fine-grained spatial representations?

2.4.2 Past Constructions

In the absence of adverbials, English speakers have at least six constructions for speaking about past events:

Simple Past	<i>He discovered a planet.</i>
Present Perfect	<i>He has discovered a planet.</i>
Past Perfect	<i>He had discovered a planet.</i>
Past Progressive	<i>He was playing a game.</i>
Present Perfect Progressive	<i>He has been playing a game.</i>
Past Perfect Progressive	<i>He had been playing a game.</i>

Since the Past Perfect and the afore-mentioned Progressive constructions mark both tense *and* aspectual distinctions, I will concentrate on the Simple Past and Present Perfect. Comrie (1985, p. 24) argues that the Simple Past in English “refers to a situation that held at some time prior to the present moment.” In other words, sentences using the Simple Past describe events that occurred prior to speech time (Michaelis, 1994). In contrast, the Present Perfect indicates that “the past situation has current relevance” (Comrie, 1985, p. 24-25).

“Current relevance” suggests that the Present Perfect may encode a more proximal temporal event than the Simple Past. However, this supposition is not without its problems. First, Comrie (1985) suggests that the Present Perfect does not, in fact, encode proximal events. Rather, proximity to the present is simply an implicature. Comrie (1985, p. 24) provides the following sentences to illustrate:

Present Perfect	<i>John has broken his leg.</i>
Simple Past	<i>John broke his leg.</i>

Comrie (1985, p. 24-25) argues that the first sentence (Present Perfect) seems to be temporally close to the present moment, whereas the second (Simple Past) seems more distal from the present moment. Because it is more likely for more recent events to have relevance in the present, out of context, the hearer may assume that the Present Perfect occurred more recently than the Simple Past. However, if John’s leg is currently broken, then the Present Perfect can be used no matter how long ago the break took place (one week ago, six weeks ago, etc.). In addition, the Simple Past may also refer to a range of proximal and distal events, where *John broke his leg five minutes ago* and *John broke his leg five years ago* are both perfectly acceptable. Therefore, Comrie (1985, p. 84) concludes:

[T]here is often an implicature derivable from the perfect that this grammatical form has more recent time references than other past tenses, although this is not part of the meaning of the perfect but rather derivable as an implicature from its meaning of present relevance of a past situation.

Comrie then points to Spanish as an example of a language whose Perfect form includes a proximal past reading. This is evident in the following example from Comrie (1985, p. 85):

Hoy he abierto la ventana a las seis y la he cerrado a las siete.
I have opened the window at six o'clock and have closed it at seven
o'clock.

In this example, which uses the perfect form, 'opening the window' no longer has a current relevance. Instead, this is an example of the Spanish perfect encoding the proximal past.

There are two problems with Comrie's analysis of the Present Perfect in English. First, though he makes the claim that the Present Perfect's association with the present gives rise to the implicature that it encodes the proximal past, his example does not fully prove that this is solely implicature. For example, the first examples from Comrie (1985, p. 24), in relative proximal time, seem perfectly fine:

John has broken his leg. It happened yesterday.
John has broken his leg. It happened six weeks ago.

However, as the temporal event becomes progressively more distant, it also becomes more awkward:

?John has broken his leg. It happened five years ago.
?John has broken his leg. It happened twenty years ago.

This increasing strangeness may be because, the more distal an event is in time, the more implausible it becomes to construe the event as having current relevance. My intuition is that the Simple Past may be more appropriate in these particular situations, even for the existential reading (see below) of the Present Perfect. This presents the second problem with Comrie's analysis: he does not take into account what Michaelis (1994) calls the "ambiguity" of the present perfect.

Michaelis (1994, p. 113) identifies at least three meanings encoded by the Present Perfect form:

Universal/Continuative A state obtains throughout an interval whose upper boundary is speech time.	<i>We've been sitting in traffic for an hour.</i>
Existential/Experiential One or more events of a given type are arrayed within a present inclusive time span.	<i>We've had this argument before.</i>
Resultative The result of a past event obtains now.	<i>The persons responsible have been fired.</i>

The sentence *John has broken his leg* is ambiguous, where all three of these readings are possible (depending on the context of the situation). For the Universal/Continuative reading, it is clear that proximal past is encoded. For the Existential/Experiential and Resultative readings, the proximity is less well-defined. Therefore, though Comrie's argument may hold for some meanings of the Present Perfect, it does not hold for all. Consequently, it is quite possible that the Present Perfect does, in some circumstances, encode a proximal temporal event, particularly in contrast with the Simple Past.

2.4.3 Future Constructions

English speakers have four constructions for speaking about future events. These constructions are below:

Will Future	<i>He will discover a planet.</i>
Be Going to Future	<i>He's going to discover a planet.</i>
VERB-ing + PP	<i>He's playing tennis at noon.</i>
Present + PP	<i>The plane lands at 7pm.</i>

As the final two require the use of an adverbial or a prepositional phrase to place the events at a particular time, I will consider the *Will* Future construction and the *Be Going to* Future construction as the two primary candidates of English future tense markers that encode fine-grained time distinctions.

Before continuing, however, it is important to note that some argue that English does not have a future tense at all (Comrie, 1985). There are two basic arguments in support of this claim. Take, for example, the following use of *will* from Comrie (1985, p. 46):

He will go swimming in dangerous waters.

In this case, *will* is being used indicate volition, not exclusively encoding a future temporal event (particularly when *will* is stressed). Second, forms like *will* are not required to refer to the future (as indicated above). In other words, *will* does not necessarily always refer to the future, and *will* is not required to refer to the future (Comrie, 1985, p. 46-47).

These observations, however, do not necessarily prove that English does not have a future tense. Other analyses suggest not only that *will* and *be going to* encode future temporal events, but that they differentially encode more distal and proximal temporal events, respectively (Brisard, 2001; Langacker, 2008). For example, Brisard (2001, p. 283) contends that *will* encodes a “projected reality,” or a future temporal event that the hearer cannot directly perceive or verify. The *Be Going to* construction, on the other hand, encodes an “evoked reality,” or a future temporal event that is grounded in perceivable evidence from the present. Take, for example, the following sentences from Brisard (2001, p.269):

It will rain.
It's going to rain.

According to Brisard (2001), in the first sentence, the likelihood of rain is not based on perceivable elements in the present moment (perhaps, for example, it is predicted by a weather report). The second sentence, on the other hand, indicates that the speaker has perceivable evidence (e.g., dark clouds, feels sprinkles). This argument suggests that the *Be Going to* Future indicates greater certainty about a future event. I maintain that, given the *Be Going to* construction's grounding in the present, it is possible that it also encodes a more proximal

temporal event (e.g., closer to the present) than the *Will* Future, which is less grounded in the present and thus reflects a more distal future. Therefore, prior research on past and future constructions prompts the following research question:

RQ2c. Do grammaticalized past and future constructions encode fine-grained spatial representations?

2.4.4 Modal Verbs

Given these past and future constructions, Comrie (1985, p. 44) argues that there is a potentially important distinction between past and future events:

There is a fundamental difference between the future and the past, in that the past is composed of analyzable events—events that have already taken place. The future, on the other hand, is, by definition, unknowable. Consequently, some linguists describe the difference between the future and the past/present as, in fact, a difference of mood instead of tense.

In other words, particularly for the future, processing events may be as much an issue of mood, or the speaker's attitude towards the truth or reliability of the assertion (specifically, how certain they are that the event will take place). The afore-mentioned past constructions reflect the *realis* mood (Palmer, 2001). They are statements of fact, or at least the speaker believes these events to be fact. Of course, English speakers may also refer to events using *irrealis*, describing counterfactual or potential events (Palmer, 2001). One productive means of reflecting the *irrealis* in English is through the use of epistemic modal verbs.

Langacker (2008, p. 307) argues that, with modal verbs (e.g., “immediate forms” *may*, *can*, *will*, *shall* and *must*), for example, *will* and *may* are used to simulate the likelihood of potential future. These verbs, in essence, are future-oriented based on the speaker's knowledge of the present. As he argues:

At a given moment, therefore, epistemic judgments pertain to either future occurrences or present situations. But in either case a modal indicates that the grounded process is not yet accepted as real. It is future in the sense that its incorporation in the speaker's conception of reality remains to be accomplished. (Langacker, 2008, p. 307)

In this manner, epistemic modal verbs prompt speaker/hearers to simulate multiple versions of the future, and these different versions have varying degrees of likelihood. Moreover, this can be reflected in the use of “immediate” modal forms or “nonimmediate” forms (*might*, *could*, *would*, and *should*). As Langacker (2008, p. 308-309) argues, “Using *might* rather than *may* serves to distance the speaker from the circumstances that justify the latter. Through this specification of nonimmediacy, the assessment of potentiality is rendered more tenuous.” For example, (Langacker 2008, p. 308) provides the following two sentences:

They may finish the job next week.
They might finish the job next week.

Langacker contends that, in the examples above, *may* signals greater certainty/likelihood than *might*, and this certainty is based on evidence that the speaker has available when producing the utterance. In other words, Langacker (2008) posits that immediate modal forms encode a more certain temporal event (largely based on perceptually available evidence—which is why they use the present tense form), where nonimmediate modal forms encode a less certain temporal event. Or, in other words, “In using *might* instead of *may*, for example, the speaker implies that the assessment conveyed by *may* is not sanctioned by his own immediate circumstances” (Langacker, 2008, p. 308). This may translate as fine-grained mapping distinction, with *may* more proximal to the deictic center and *might* more distal.

In fact, the role of irrealis in space-time mapping—or in metaphor studies in general—has been largely overlooked. Kaup, Yaxley, Madden, Zwaan, and Lüdtke (2007) were some of the first to address this issue by showing that speakers recruit perceptual resources when processing negated sentences. Participants read negated sentences, such as *There was no eagle in the sky*. After processing the sentence, participants viewed an image that was either congruent with the negated sentence (a picture of an eagle with its wings spread, as if flying) versus a

picture that was incongruent with the negated sentence (a picture of an eagle with folded wings, as if resting in a nest). Participants were asked to respond to the image as quickly as possible, answering ‘yes’ or ‘no’ as to whether or not the image had been mentioned in the sentence. Results show that participants are faster to respond to the image if it is congruent with the negated sentence. In other words, just as perceptual resources are recruited to process declarative sentences, so, too are they recruited to process negated counterparts. This suggests that speakers mentally simulate events even if they are irrealis events that did not take place.

Fernández de Lara (2012) extends Kaup et al.’s (2007) findings to space-time mapping, providing evidence that processing sentences about potential events in the past and future (that is, sentences encoded in the irrealis mood) also activate a left-right spatial representation. Using conjugated Spanish expressions, target sentences described the Indicative Past Perfect (realis) versus the Subjunctive Past Perfect (irrealis) and the Indicative Future (realis) versus the Conditional Future (irrealis) (Fernández de Lara, 2012, p. 78). Participants were instructed to press the left button on a keyboard for past sentences and the right button for future sentences in the congruent condition, and vice versa for the incongruent condition. Results show that participants are faster to respond to congruent sentences (left button for past, right for future) even for potential (irrealis) events. In other words, native Spanish speakers map the past to left physical space and the future to right physical space, even for events that are described in the irrealis as opposed to realis.

Therefore, epistemic modal verbs are of interest in this dissertation for two reasons. First, *may* and *might* could encode proximal and distal temporal events. Second, there is little evidence that that English speakers will construe irrealis temporal events using physical space at all. In other words, they elicit the research question:

RQ2d. Do epistemic modal verbs *may* and *might* encode fine-grained spatial representations?

2.4.5 More on Grammaticalization & Metaphor

The above discussion has addressed potential lexical means (i.e., adverbials) and grammaticalized means (e.g., *Be Going to Future*, *Will Future*) of conveying fine-grained temporal events. Comrie (1985, p. 10) draws a distinction between grammaticalized items and lexical items, arguing that “grammaticalisation refers to the integration into the grammatical system of a language, while lexicalization refers merely to the integration into the lexicon of the language, without any necessary repercussions on its grammatical structure.” In other words, grammaticalized items in a language are obligatory, and they tend to be bound to morphemes. The *Be Going to Future* is an excellent example of a grammaticalized form. Bybee (2006) observes that the *Be Going to Future* derives from the verb of motion ‘to go,’ but has since become grammaticalized such that it denotes the future tense. Diachronically—specifically through frequency of use—the expression has become a grammatical feature of the language (Bybee, 2006, p. 720). In terms of time expressions, grammaticalized forms like the *Being Going to Future* contrast with lexical items, like time adverbs ‘tomorrow’ or ‘next year,’ which are not grammaticalized.

The distinction between grammaticalized forms and lexical forms is important because it allows the opportunity to address an important issue in the metaphor literature. There is a large debate as to whether or not there is a fundamental difference in how people process novel metaphors compared to more conventional metaphors (Glucksberg, 2008; Keysar & Glucksberg, 1990; McGlone, 2007; Murphy, 1997, 1996). In broad terms, novel metaphors are infrequent, creative uses of language (e.g., *Herman is a glacier when it comes to ordering ice cream*) and conventional metaphors are those that conceptual metaphor theory concerns itself with (e.g., *Time is Space*). In other words, metaphors can be understood on a conventional continuum, with

novel, infrequent metaphors on one side and conventional, frequent ones on the other. In a sense, grammaticalized items—particularly the *Being Going to Future*—could be regarded as extremely conventionalized metaphorical expressions. The *Be Going to Future* is a construction that has been abstracted from the original physical motion meaning of ‘go,’ or the source domain for Time metaphors (Bybee, 2006). In this way, in examining space-time topography, lexical items versus grammaticalized items serve as proxies for metaphorical constructions that are more directly linked to a source domain (lexicalized) compared to constructions that are less directly linked to (or more abstracted from) the source domain (grammaticalized). In other words, lexicalized versus grammaticalized expressions allow us to examine how active metaphorical mappings are for metaphors that are more or less conventionalized.

A growing body of research is, in fact, demonstrating a processing difference between novel metaphors and conventional metaphors, where novel metaphors require greater semantic processing effort than conventional ones (Lai et al., 2009; Teuscher, McQuire, Collins, & Coulson, 2008). This processing difference is nicely explained through Bowdle and Gentner’s (2005) career of metaphor hypothesis. Bowdle and Gentner (2005) argue that conventionalized metaphors diachronically abstract away from concrete origins. Take, for example, the expression *gold mine*. Originally meaning a literal hole in the ground with valuable ore inside, the expression now means any source of good things. In other words, when an English speaker processes the expression *gold mine*, they do not simultaneously activate a representation of a physical hole in the ground; rather, they only activate the abstract meaning of ‘source of good things.’

Desai et. al. (2011) expound on Bowdle and Gentner’s (2005) model through a functional magnetic resonance imaging (fMRI) experiment of sensorimotor metaphors. Participants

processed sentences in three conditions:

Literal	<i>The daughter grasped the flower.</i>
Metaphorical	<i>The jury grasped the concept.</i>
Abstract	<i>The jury understood the concept.</i>

Results show that processing both literal and metaphorical sentences activates motor cortex responsible for performing the physical task of grasping. This is consistent with the predictions of conceptual metaphor theory (Lakoff & Johnson, 1980), where the verb *grasp* is not abstracted away from motor origins, even when used metaphorically. However, when the verb *understand* is used, which presumably would also activate motor cortex (given the conceptual metaphor Understanding is Grasping), motor cortex is not activated. In other words, more abstract, conventionalized expressions of conceptual metaphors do not seem to elicit the same neural responses as more novel, less abstract ones. Given these studies, it stands to reason that grammaticalized constructions that encode temporal relationships, such as the *Be Going to* Future, are conventionalized enough that they no longer activate spatial or motion representations. So, by examining temporal expressions in English with regard to space-time topography, this dissertation is simultaneously addressing the extent to which more or less conventional metaphors encode fine-grained spatial and motion representations.

2.4.6 Temporal Expressions in English Summary

Since the primary goal of this project is to determine the extent to which English speakers recruit specific, fine-grained representations of physical space when construing temporal events, the space-time topography hypothesis is incomplete without considering multiple language forms that potentially encode proximal and distal temporal events. This encoding may manifest itself linguistically through a number of language forms, from lexical adverbials to grammaticalized past and future constructions to the irrealis epistemic modal verbs *may* and *might*. Moreover,

with the exception of a few studies (Brisard, 2001; Langacker, 2008), the role of these forms has been largely omitted from the literature. Consequently, these forms prove an excellent testing ground to observe fine-grained space-time mappings. Moreover, they also serve as a spectrum for metaphor conventionality, with adverbials serving as proxies for more novel instantiations of the Time is Space metaphor and grammaticalized constructions as more conventional ones. In this way, this dissertation also addresses the extent to which more grammaticalized temporal expressions exhibit space-time mapping effects. Given the potential temporal expressions that may encode fine-grained proximal-distal distinctions, I now turn to the experimental literature that supports the psychological reality of space-time mapping.

2.5 Psycholinguistic Studies of Space-Time Mapping

Space-time topography has also been examined through multiple psycholinguistic studies. The Psychology literature has peripherally addressed the notion of space-time topography through examining ‘psychological distance.’ Bar-Anan, Liberman, Trope, and Algom (2007) show a Stroop-like effect when participants process the words ‘tomorrow’ and ‘year’ on an image with front-back depth, where participants are faster to identify ‘tomorrow’ as near when it is presented as physically closer as opposed to further away, and vice versa for ‘year.’ In this way, Bar-Anan et al.’s (2007, 2006) work is pivotal to this dissertation, as it demonstrates that English speakers associate close physical space with proximal events (‘tomorrow’) and further physical space with distal events (‘next year’). This study’s weakness, however, is that it does not address the distinction between external and internal Deictic time, and thus it is unclear whether or not participants are co-locating the present with an external locus (on the image) or with their egos (see also Liberman & Trope, 2008; Liberman, Sagristano,

& Trope, 2002). Moreover, the study only uses the words ‘tomorrow’ and ‘year.’ It does not address temporal events, or entire sentences.

Sell and Kaschak (2011) show how past and future sentences, not just words, can influence motor responses. Using a keyboard setup that requires either backward or forward motion of the hand (i.e., hand motion towards the body or away from the body), participants were asked to respond to the sensibility of sentences within a discourse context. For example, participants viewed the following discourse sequence:

Jackie is taking a painting class.
Tomorrow, she will learn about paintbrushes.
It is important to learn paintbrush techniques. (Sell & Kaschak, 2011, p. 5)

Reaction time measures were taken on the target sentences (the middle sentence), and participants moved their hands either forward to backward (for future sentences, forward is congruent and backward is incongruent). Results show a congruency effect, where participants are faster to move their hands in a congruent direction (backward for past sentences, forward for future sentences) than an incongruent direction.

This study is important for two reasons. First, it very clearly demonstrates a strong association between the motor system and temporal relationships in sentences. Second, Sell and Kaschak (2011) include a condition featuring proximal and distal temporal events. So, for example, participants read future sentences describing the proximal future (e.g., *Tomorrow, she will learn about paintbrushes*) and sentences describing the distal future (e.g., *Next month, she will learn about paintbrushes*). Critically, proximal past and future sentences do not elicit the same congruency effect as distal ones. In other words, the reaction time difference between congruent and incongruent conditions only manifests itself for sentences describing the distal past and future. This indicates a difference in how English speakers process proximal versus distal events, but the paradigm does not specifically compare proximal and distal event

processing. Rather, the paradigm simply has a null result for proximal temporal events compared to distal events. In other words, Sell and Kaschak's paradigm does not specifically address a fine-grained difference between proximal and distal event processing; it is, however, supportive evidence congruent with Bar-Anan et al. (2007) that a difference exists.

Ulrich et al. (2012) conducted two experiments to examine space-time mapping with past and future sentences. Like Sell & Kaschak (2011), participants used a device that required hand motion either towards the body or away from the body. In the first experiment, participants were given past and future sentences—without discourse context—and they were instructed to move the device backward for past sentences and forward for future sentences. Results again show a space-time congruency effect, such that participants were faster to move their hands backward for past sentences and forward for future sentences (as opposed to vice versa). In a second experiment, Ulrich et al. (2012) tested whether the activation of a spatial representation for a temporal event is “automatic.” In the second experiment, participants did not indicate whether sentences occurred in the past or future; instead, they responded only to the sensibility of the sentences (e.g., sensible vs. nonsense sentences). In responding to sensibility instead of the time at which the event occurs, the authors hypothesized that processing past or future tense sentences would not automatically activate spatial representations. In other words, changing the task to avoid explicit time reference would not yield the results of the first experiment. In fact, no space-time congruency effect was found in the second experiment. In contrast to the findings of Sell and Kaschak (2011), hand motion forward was not faster when judging the sensibility of future sentences (nor backward for past sentences). The authors take this result as evidence that processing sentences about temporal relationships does not automatically activate a spatial representation; rather, spatial representations are only activated when participants are explicitly

asked to attend to the temporal dimensions of the sentences. Two important observations must be made here. First, in contrast to Sell & Kaschak (2011), the authors *do* find a space-time congruency effect for proximal future events (e.g., ‘yesterday’ or ‘tomorrow’) when participants are attending to a sentence’s relationship to time. Second, this effect disappears when participants are not specifically attending to time.

Walker et al. (2014) attempted to disambiguate these conflicting space-time mapping studies by offering an alternative experimental approach. The authors describe two critical problems with some of the studies described above (Walker et al., 2014, p. 318). First, several of these experiments require participants to perform manual motion, and thus motion and space are conflated, effectively not allowing the researchers to determine whether space or motion are critical components of participants’ temporal representations. Second, and perhaps most importantly, these experiments involve a keyboard that is physically located in front of the participant (Sell & Kaschak, 2011; Ulrich et al., 2012). Therefore, a backward hand motion on the keyboard is not a gesture behind the participant—it is a backward gesture towards the body. In other words, these manual motion paradigms do not reflect how natural gestures occur, and thus they do not fully reflect conceptualizations of the past behind the ego and the future in front of the ego.

In Walker et al.’s (2014) experiments, participants were presented stimuli auditorily, through speakers on the left, right, in front of, or behind them. Participants were asked about events in their own lives relating to either Deictic or Sequential time, responding vocally ‘past’ or ‘future’ to events about their own lives (e.g., *your birth*, *your prom*) or ‘earlier’ and ‘later’ to event pairs in someone else’s life (e.g., *her wedding*, *her retirement*). In this case, past events presented auditorily behind the participant are congruent, where past events presented in front of

the participant are incongruent. The experiments support prior work finding a space-time mapping along a left-right axis, but they present new evidence with regard to the front-back axis. In the study, no congruency effects were found for internal Deictic time along the front-back axis (where the ego is co-located with the present), but they were found for Sequential time (when time events are placed in sequence with relation to one another (e.g., *May follows April*). In other words, participants seem to recruit a front-back spatial representation for Sequential time, but not for Deictic time. The authors conjecture that Deictic time may strongly involve a motion representation, not just a spatial representation, thus causing the null effect in this experiment that involved verbal responses to auditory stimuli rather than motions.

Therefore, in addition to offering further (if conflicting) evidence in support of the space-time topography hypothesis, the above studies also encourage another research question:

RQ3. Do space-time construals involve static *spatial* representations or *motion* representations?

In addition to examining fine-grained space-time topography, psycholinguistic studies have involved multiple paradigms, and these paradigms have helped researchers to address another question in the literature: the notion of metaphor asymmetry.

2.5.1 Space-time Mapping Asymmetry

Examining the specificity of space-time mapping effects also allows for the opportunity to examine metaphorical structure and processing. Lakoff and Johnson (1980) argue that space-time mapping is a fundamentally metaphorical process. Time, an abstract concept, is structured by the more concrete domains of space and motion, which are grounded in sensorimotor experience. While other cognitive models provide alternatives to the conceptual metaphor (see Barsalou, 1999; Fauconnier & Turner, 2008), conceptual metaphor theory is supported by a large range of experimental data and will serve as the primary focus of this dissertation.

Conceptual metaphor theory makes strong predictions about space-time mapping. Specifically, it maintains that metaphorical representations, such as space-time metaphors, are asymmetrical. That is, the target domain (Time) is structured by the source domains (space and motion), but space and motion are not structured by Time. The argument that space-time mapping is asymmetrical is important given the array of experimental data in the field. Broadly speaking, space-time mapping effects are of two types: (1) concrete-to-abstract and (2) abstract-to-concrete (Lee & Schwarz, 2012). Whereas concrete-to-abstract effects are predicted by a strong conceptual metaphor model, abstract-to-concrete effects are not predicted. For example, thinking about space and/or motion should influence perception of Time, but thinking about Time should not influence perceptions of space and motion.

2.5.1.1 Concrete-to-abstract Effects

Conceptual metaphor theory is most strongly supported through concrete-to-abstract effects. These effects are robust in the experimental literature, showing, for example, that holding a hot cup of coffee (concrete domain) influences people's judgments of an individual's personality (target domain) (Williams & Bargh, 2008), or that smelling a fish smell (source domain) makes people more suspicious when playing an investment game (target domain) (Lee & Schwarz, 2012). Concrete-to-abstract effects, however, are perhaps most pervasive in the space-time mapping experimental literature.

In the space-time mapping literature, concrete-to-abstract effects manifest themselves in one of three ways:

- Nonlinguistic space/motion prime (source) produces Time judgment effect (target)
- Nonlinguistic space/motion prime (source) produces sentence processing reaction time effect (source/target)
- Linguistic metaphor comprehension (source/target) produces sentence processing reaction time effect (source/target)

There is ample evidence that confirms the psychological reality of English speakers' two conceptualizations of Time: (1) the ego-moving perspective and (2) the time-moving perspective. Priming these two different perspectives—through physical and motion primes—has yielded consistent space-time mapping effects. In most of these studies, participants are asked the following question: *Next Wednesday's meeting has been moved forward two days. What day is the meeting on?* Given both time construal perspectives, the motion 'forward' is ambiguous. That is, if one adopts the ego-moving perspective, then one would answer 'Friday.' If, on the other hand, one adopts a time-moving perspective, then one would answer 'Monday.' Variations of this study have used a variety of different primes. Participants have viewed pictures of different spatial scenarios (Boroditsky, 2000), rows of blocks onscreen (Núñez, Motz, and Teuscher, 2006), airplanes landing (Boroditsky & Ramscar, 2002; Gentner, Imai, & Boroditsky, 2002), or even imagined traversing a number line (Matlock, Holmes, Srinivasan & Ramscar, 2011). These studies have repeatedly demonstrated that space and motion primes influence people's temporal judgments, where people who are primed with the ego-moving prime reliably choose Friday over Monday, and those who are primed with a time-moving prime reliably choose Monday instead of Friday.

In a series of six psychophysical experiments, Casasanto and Boroditsky (2008) demonstrate the asymmetrical relationship between Time and space. In the experiments, participants are asked to either (1) estimate a physical line's duration on a computer screen or (2) estimate a physical line's length. In all experiments, participants consistently use the physical line's length to estimate duration, but they fail to use the line's duration on the screen to estimate length. In other words, the lines' space is used to structure estimates of Time, but Time is not used to estimate space. The authors argue that this is consistent with patterns in language, where

people more often talk about Time in terms of physical space than about physical space in terms of time. Importantly, however, the authors observe that asymmetry is not the same as unidirectionality. For example, one can still refer to space with reference to time. The sentence *We're only a few minutes from the subway* does exactly that (Casasanto & Boroditsky, 2008, p. 590). So, whereas it's possible for Time to influence judgments of space, the phenomenon is far less frequent than the reverse (Bottini & Casasanto, 2010; Casasanto & Bottini, 2010).

Other experiments use space/motion primes predicting an effect on the reaction time of sentence processing, particularly across languages. In a comparison of English and Mandarin speakers, Boroditsky (2001) shows that nonlinguistic horizontal and vertical spatial primes influence the reaction times at which people respond to questions about the Sequential time of events (e.g., *March comes before April, True or False?*). This is because, unlike English, Mandarin speakers also refer to events along a vertical timeline. Though this seminal study has been questioned (Chen, 2007), it has since been replicated (Boroditsky, Fuhrman, & McCormick, 2011). In addition, such crosslinguistic studies have also shown that speakers conceptualize time from left to right, or right to left, depending on the writing direction of the language (e.g., English, Arabic, or Hebrew) (Flumini & Santiago 2013; Santiago et al. 2007; Weger & Pratt, 2008).

Rather than use nonlinguistic space/motion primes, Gentner and Boronat (1991) utilize a paradigm in which participants read a small text with a consistent metaphorical construal (i.e., ego-moving perspective vs. time-moving perspective). When participants encounter a final sentence that is incongruent with the text (e.g., an ego-moving text concluded with a time-moving target sentence), participants are slower to process these incongruent sentences than congruent counterparts. The authors thus conclude that there is a “cost” to switching between the

two conceptualizations, thus verifying the psychological validity of ego-moving and time-moving conceptual mappings (Gentner, 2001; Gentner & Imai, 1992; McGlone, & Harding, 1998).

2.5.1.2 Abstract-to-concrete Effects

Researchers have also been able to demonstrate abstract-to-concrete effects in the domain of metaphor. In these experiments, participants process the target domain of a metaphor, and this results in an effect in a (oftentimes sensorimotor) source domain. Importantly, these effects are not necessarily predicted by conceptual metaphor theory. Abstract-to-concrete effects have been shown in multiple domains (Landau et al., 2010): assessments of power can influence judgments of height (Schubert, 2005), feelings of guilt can increase hand-washing times (Zhong & Liljenquist, 2006), descriptions of importance influence weight judgments (Jostmann, Lakens, & Schubert, 2009), and suspicious behavior can enhance one's ability to identify a fishy smell (Lee & Schwarz, 2012).

Abstract-to-concrete effects in the space-time literature are much more sparse. In the space-time mapping literature, abstract-to-concrete effects manifest themselves in one of two ways:

Time judgments (target) affect spatial judgments (source)
Sentence processing (source/target) influences sensorimotor performance/perception (source)

Early psychology studies demonstrate the Kappa and Tau effects, or interactions between modulating spatial length and duration of an event (Bill & Teft, 1969; Cohen, 1967; Cohen et al., 1954). These studies avoid linguistic prompts altogether, instead focusing on the ways in which space influences time judgments and vice versa. For example, the Kappa effect shows that physically separating blinking lights increases participants' temporal judgment of the sequence's duration. So, the further that experimenters separate blinking lights, even if the sequence is over

the same temporal duration, the longer participants judge the sequence to take. The Tau effect essentially reverses the Kappa effect, where extending the duration of a blinking light sequence will lead participants to judge the lights to be further apart.

More recently, Miles, Nind, and Macrae (2010) show that just thinking about a temporal event elicits a physical response. In their experiment, participants, when asked simply to imagine events four years in the past or four years in the future, progressively lean further backward and forward over the course of fifteen seconds. That is, participants lean backward when conjuring mental images of the past and lean forward when projecting the future. Processing an event, in other words, produces a physical response either backward or forward, depending on the event being in the past or future.

Teuscher, McQuire, Collins and Coulson (2008) show that processing conventional time metaphors, either ego-moving or time-moving, can influence participants' perceptions of space and motion of onscreen cartoons. With ERPs as the dependent variable, participants processed temporal events and then viewed a small cartoon clip featuring a smiley face in motion. In one condition, the motion was congruent with the time sentence (e.g., the face moves toward the participant), and in the second condition, the video was incongruent (the face moves away from the participant). Results show incongruity effects—or negativity in the ERP waveform, evidence of greater semantic processing compared to the congruent condition—depending on the depicted motion in the cartoons, indicating a qualitatively different neural response to space and motion following the processing of a time sentence. In essence, a sensorimotor response was prompted through sentence processing.

To address metaphor asymmetry, Slepian and Ambady (2014) show an abstract-to-concrete effect by teaching participants “novel” metaphors in a lab setting. While this study does

not involve *space*-time mapping, it does address participants' metaphorical understanding of Time. With a between-subjects design, half of the participants read a text describing the past as heavy, and half read a text describing the present as heavy. Participants were then given a book and asked to estimate its weight. In one condition, the book was disguised to appear old, and in the second condition, the book appeared new. As predicted, participants in the past-heavy condition estimated the old-appearing book to weigh more than the new-appearing book, and participants in the present-heavy condition estimated the new-appearing book to weigh more than the old-appearing book. In other words, processing time metaphors influences sensorimotor perception.

Given the array of concrete-to-abstract as well as abstract-to-concrete effects, it is clear that space-time mapping can contribute to our understanding of metaphor and its underlying mechanisms. Moreover, since perceptual judgments can be fine-grained, space-time topography offers the ideal lens with which to examine abstract-to-concrete effects. In other words, this dissertation is also able to ask the following research question:

RQ4. Do English speakers recruit fine-grained spatial representations of Time for an abstract-to-concrete methodology?

2.5.2 Psycholinguistic Studies of Space-time Mapping Summary

Space-time mapping effects have been demonstrated through a myriad of different psycholinguistic experiments. Some of these methods have shown that English speakers do, indeed, distinguish between proximal and distal temporal events. Bar-Anan et al.'s (2007) work on psychological distance serves as strong evidence that English speakers process proximal and distal Time differently, specifically with words 'tomorrow' and 'year' and with space in front of the participant. However, Sell and Kaschak (2011) and Ulrich et al. (2012) find conflicting

evidence with regard to proximal and distal temporal event processing when full sentences are used.

Improving upon these previous methodologies, Walker et al. (2014) suggest that new methodologies need to disentangle external and internal Deictic time. Studies of internal Deictic time, for example, should include space behind and in front of the ego. Otherwise, they are not truly testing speakers' supposed conceptualizations. Second, the authors do not find evidence of space recruitment on the front-back axis when processing internal Deictic time events. The authors conclude that this is due to the methodology, which does not have a motion component.

Lastly, space-time mapping studies produce effects of two varieties: concrete-to-abstract or abstract-to-concrete. Traditionally, scholars argue that conceptual metaphor theory, given metaphor asymmetry, predicts concrete-to-abstract effects, but it does not predict abstract-to-concrete effects (Lee & Schwarz, 2012). Despite these predictions, I have outlined several studies that have produced abstract-to-concrete effects. Most recently, Slepian and Ambady (2014) demonstrate that novel time metaphors influence sensorimotor perception. The space-time topography hypothesis, by examining fine-grained spatial distinctions, offers an opportunity to examine an abstract-to-concrete effect in the space-time mapping literature, effectively contributing to the metaphor asymmetry issue.

2.6 Chapter Summary

The above analysis of Time Types, Crosslinguistic Variation, Temporal Expressions in English, and Psycholinguistic Studies of Space-Time Mapping have helped to outline the following research questions in the space-time mapping literature (as well as metaphor studies in general). I have combined the questions below, as each will be addressed in chapters 3-6.

External Deictic Time

RQ1. Under what conditions do English speakers construe temporal events with an external deictic center (as opposed to an internal one)?

RQ1a. Do English speakers construe external Deictic time using an image with front-back physical space (as opposed to left-right physical space)?

RQ1b. Do English speakers adopt a deictic center that is incongruent with their own internal Deictic time?

RQ1c. Does the adoption of an external deictic center require explicit reference to Time in terms of physical space, or the explicit activation of a mental timeline?

Fine-grained Space-time Mapping

RQ2. Do English speakers construe coarse-grained (categorical front/back) or fine-grained (landscape) spatial representations when space-time mapping?

RQ2a. Does this vary based on speakers' construal of external Deictic time versus internal Deictic time?

RQ2b. Do lexical adverbials encode fine-grained spatial representations?

RQ2c. Do grammaticalized past and future constructions encode fine-grained spatial representations?

RQ2d. Do epistemic modal verbs *may* and *might* encode fine-grained spatial representations?

RQ3. Do space-time construals involve static *spatial* representations or *motion* representations?

RQ4. Do English speakers recruit fine-grained spatial representations of Time for an abstract-to-concrete methodology?

This dissertation addresses each of these research questions through the use of two novel experimental paradigms, one which specifically addresses external Deictic time and a second that specifically addresses internal Deictic time. Table 2.2 below outlines the research questions that are addressed in each experiment.

	Experiment									
	1a	1b	2a	2b	3	4a	4b	5	6	7
External Deictic Time										
RQ1. Adoption of an external deictic center with:										
a. front-back physical space	•	•	•	•		•	•			
b. congruent/incongruent locus	•	•	•	•		•	•			
c. explicit activation of a mental timeline	•		•			•				
non-explicit activation of a mental timeline		•		•	•		•	•		
Fine-grained Space-time Topography										
RQ2. Fine-grained space-time mapping for:										
a. external Deictic time	•	•	•	•		•	•			
internal Deictic time					•			•	•	•
b. adverbials	•	•							•	•
c. grammaticalized constructions			•	•	•					
d. modal verbs						•	•			
RQ3. Space-time mapping with:										
static spatial representations	•	•	•	•		•	•			
motion representations									•	•
RQ4. Abstract-to-concrete methodology									•	•

Table 2.2. Study outline. An outline of the experiments in Chapters 3-6 that address the research questions of interest in this dissertation.

Table 2.2 thus provides an overview of the experiments in the chapters that follow and the research questions that they address. In other words, I hope to demonstrate that, despite Time being a fruit fly, there is still plenty to discover.

Chapter III:

External Deictic Time and Adverbials

3.1 Introduction

Languages frequently make use of terms about physical space and motion to refer to temporal events. This has led some researchers to claim that our understanding of Time, an abstract concept, is structured by the concrete domains of space and motion (Clark, 1973; Lakoff, 2008, 1993, 1987; Lakoff & Johnson, 1980; Lehrer, 1990; Radden, 2004; Traugott, 1978). For English speakers, assuming the present is co-located with the speaker, space behind the speaker is mapped to past events, and space in front of the speaker is mapped to future events (Núñez & Cooperrider, 2013). However, recent evidence suggests that—in terms of human cognition—the picture is much more complicated. Núñez, Cooperrider, Doan, & Wassmann (2012) provide insight into the Yupno people, a small tribe indigenous to Papua New Guinea. The Yupno construe past events with the physical, downhill landscape leading to the river basin from their village Gua and future events with the upward landscape leading to the nearby mountaintop (Núñez et al., 2012). In other words, the topography of Gua and its surroundings serve as the source domain for the Yupno people's time metaphors.

In the literature, researchers have implicitly assumed that English speakers conceptualize Time in a categorical (or coarse-grained) manner, with the past behind and the future in front of the ego (Núñez & Cooperrider, 2013, p. 225). In contrast, the Yupno people demonstrate space-

time topography, or the construal of fine-grained physical space to refer to events in time (Núñez et al., 2012). The Yupno language thus motivates a re-analysis of English, one that examines the specificity of the physical space English speakers recruit when talking about events in the past or future. Specifically, do English speakers construe proximal temporal events (e.g., ‘yesterday’ and ‘tomorrow’) as physically closer than distal temporal events (e.g., ‘last year’ and ‘next year’)? If so, this would suggest that English speakers process time events by recruiting fine-grained spatial representations, not just categorical front-back space. Understanding the space-time topography of English speakers gives us a much better sense of the depth and breadth of space-time metaphors and thus how the human mind processes abstract domains.

In addition, exploring space-time topography affords the opportunity to address other unanswered questions in the space-time mapping domain. Núñez and Cooperrider (2013) observe that Time need not only be conceptualized with the present co-located with the speaker, but rather, English speakers are able to conceptualize external Deictic time, where the present is co-located with an external locus. However, research isolated to external deictic Time is relatively rare, and the research that does exist is isolated to the left-right axis, not the front-back axis (Casasanto & Jasmin, 2012; Chan & Bergen, 2005; Flumini & Santiago, 2013; Santiago, Lupiáñez, Pérez, & Funes, 2007). Moreover, Brown (2012) as well as Torralbo, Santiago, & Lupiáñez (2006) show that speakers who have multiple possible space-time construals available flexibly alternate in the construal they use, depending on the task required. Torralbo et al. (2006), however, compare two natural space-time mappings: front-back space with reference to an on-screen silhouette and left-right space with reference to the participant’s body. The present study adds to the literature by addressing the conditions under which English speakers adopt an external Deictic center. It uses a unique paradigm, one that allows participants to construe

temporal events using physical space both behind and in front of an external deictic center on an image with front-back space (as opposed to the conventional left-right axis). Second, these front-back images feature external loci that are incongruent with participants' internal Deictic time representations (that is, a character that faces towards the participant).

Ulrich et al. (2012) offer an additional factor, contending that space-time mapping effects—external or internal—must be explicitly activated. In other words, though sentences like *The meeting was moved back* utilize words of physical space and motion, spatial and motion representations may not be recruited during sentence processing. That is, space-time effects only occur when participants are explicitly attending to the temporal dimensions of a sentence, specifically thinking about Time in terms of space and motion (or, as Ulrich et al. (2012) phrase it, the researchers activate a “mental timeline” in the minds of the participants). For example, if the experimental task requires them to respond a certain way based on whether the sentence takes place in the past or future, it explicitly activates a mental timeline. Given their findings, manipulating the extent to which a space-time mapping is explicitly activated may modulate speakers' recruitment of physical space and motion as well as their adoption of an external or internal deictic center.

The experiments reported in this chapter use temporal adverbials (e.g., ‘tomorrow’ and ‘next year’) to elicit fine-grained mapping effects. As lexical items, adverbials are the most likely candidates to produce an effect, as they are non-grammaticalized temporal expressions (compared to e.g., the *Be Going to* Future and the *Will* Future). As such, they may have a greater link to English speakers' spatial and motion representations when construing temporal events (see Chapter 2 for a more detailed discussion). In addition, Walker, Bergen, and Núñez (2014) argue that most contemporary space-time mapping studies conflate English speakers' spatial and

motion representations when they process temporal events. That is, the physical tasks that participants perform, such as moving their hands backward or forward in response to sentences, involves both space and motion (Sell & Kaschak, 2011; Ulrich et al., 2012). But it is possible that space-time construals involve static space alone, with no motion. For example, Walker et al. (2014) provide experimental evidence that internal Deictic time, for example, may necessarily include a motion component, and is not strictly spatial. Therefore, disentangling space and motion representations is also critical to any study in this domain.

In short, the research questions addressed in this chapter (as numbered from Chapter 2) are as follows:

External Deictic Time

RQ1. Under what conditions do English speakers construe temporal events with an external deictic center (as opposed to an internal one)?

RQ1a. Do English speakers construe external Deictic time using an image with front-back physical space (as opposed to left-right physical space)?

RQ1b. Do English speakers adopt a deictic center that is incongruent with their own internal Deictic time?

RQ1c. Does the adoption of an external deictic center require explicit reference to Time in terms of physical space, or the explicit activation of a mental timeline?

Fine-grained Space-time Mapping

RQ2. Do English speakers construe coarse-grained (categorical front/back) or fine-grained (landscape) spatial representations when space-time mapping?

RQ2a. Does this vary based on speakers' construal of external Deictic time versus internal Deictic time?

RQ2b. Do lexical adverbials encode fine-grained spatial representations?

RQ3. Do space-time construals involve static *spatial* representations or *motion* representations?

Through the use of a novel experimental paradigm, the present study examines English speakers' adoption of an external deictic center and the granularity of their space-time construals. Motivated by previous psycholinguistic studies demonstrating that English speakers likely have a

fine-grained conceptualization of Time (Bar-Anan et al., 2007; Bar-Anan, Liberman, & Trope, 2006; Liberman & Trope, 2008; Sell & Kaschak, 2011; Ulrich et al., 2012), this chapter will address a subset of the issues presented in Chapter 2. Further experiments in Chapters 4-6 will address the remaining research questions.

In the experiments reported below, participants are provided an image with front-back depth of a character on a road—explicitly activating a mental timeline by using the Life is a Journey metaphor (Lakoff & Johnson, 1980)—with which they can co-locate the present in a given sentence. Across conditions, the character switches directions, meaning that he either faces away from the participant or towards the participant. When facing away from the participant, the character is congruent with the participant’s own internal Deictic time, where the present is co-located with the ego. When facing toward the participant, the character is incongruent with the participant’s internal Deictic time. This manipulation tests whether English speakers co-locate the present with an external deictic center even when the locus is incongruent with their own internal conceptualization of deictic Time. Secondly, these sentences are coupled with different pictures across experiments. The second picture also features front-back depth, but it does not explicitly activate the Life is a Journey metaphor, instead depicting a chair (with a canonical front and back) on a beach. This manipulation examines whether or not participants must be explicitly attending to the temporal dimension of sentences in order to elicit space-time mapping effects. Lastly, participants are asked to choose a physical location on these images corresponding with particular past and future sentences. These sentences include adverbials that encode fine-grained time distinctions (e.g., ‘tomorrow’ and ‘next year’). These past and sentences with adverbials demonstrate the extent to which English speakers exhibit fine-grained space-time topography, or whether they physically separate proximal and distal events.

3.2 Experiment 1a – Adverbials on the Street

English has a robust system for encoding space-time topography—through the use of adverbial phrases that specifically reference a time scale. For example, English speakers can say ‘five seconds from now’ or ‘tomorrow’ for events that will happen more immediately, or phrases like ‘next year’ and ‘five years from now’ for events in the more distal future. Unlike tense or aspectual markers, such adverbials are not grammaticalized in English (Comrie, 1985). This means that adverbials are not required by English grammar when referring to past or future events; instead, they allow the speaker to lexically indicate fine-grained time distinctions. Adverbials thus provide an ideal starting point for the present study, as they (1) represent an overt expression of the potential space-time topography of English speakers and (2) are a non-grammaticalized means of reflecting proximal or distal temporal events.

The present study specifically examines external Deictic time, or English speakers’ ability to co-locate the present (or now) with an external locus. Unlike studies that have demonstrated external Deictic time along a left-right axis, this study examines external Deictic time with an image composed with front-back depth. Participants view images with a potential deictic center that is either congruent or incongruent with an ego co-located deictic center (internal Deictic time). In Experiment 1a, this is a picture of a man on a street. The man faces two directions: one that is congruent with the speaker (facing away from the speaker and walking towards the horizon), and one is incongruent (facing towards the speaker and walking towards the speaker). Lastly, Experiment 1a features a novel experimental paradigm that is strictly spatial. That is, the experiment does not conflate space and motion (Walker et al., 2014)

3.2.1 Method

3.2.1.1 Participants

For Experiment 1a, 75 participants were recruited on Amazon's Mechanical Turk. The task took an average of 15 minutes, and participants were paid \$2.00 each for their participation. Only participants with a 90% approval rating or higher who had performed at least 500 previous tasks were employed.

After completing the task, participants took a post-survey asking questions about the experiment. Questions from this post-survey can be found in Appendix C. Based on results of this post-survey, three participants were dropped due to lack of attention (unable to remember the color of the man's shirt on the image), and 13 were dropped due to them guessing the intention of the study, leaving a total of 59 participants for the final analysis.

I conducted four analyses investigating the effects of Temporal Distance (Proximal vs. Distal), Tense (Past vs. Future), and Character Direction (Away vs. Towards) on participants' choice of spatial location for sentence placement.

3.2.1.2 Stimuli

The stimuli were 16 target sentences in four Temporal Distance conditions mixed with 32 filler sentences. A complete list of the target and filler stimuli can be found in Appendix B. The four conditions are as follows:

Proximal Past	<i>Yesterday, he began a letter.</i>
Distal Past	<i>Last year, he stopped a fight.</i>
Proximal Future	<i>Tomorrow, he will win a bike.</i>
Distal Future	<i>Next year, he will discover a planet.</i>

To avoid any confounds, sentences include only achievement verbs, the Aktionsart class of verbs that describe instantaneous events as categorized by Vendler (1957) (e.g., *discover*, *find*, etc.).

This helps mitigate event duration from influencing conceptualization (*reading a book* takes

longer than *lighting a match*). All clauses were cross-balanced across groups, such that each clause was seen in each condition. That is, where one participant read *Next year, he will discover a planet*, another participant read *Tomorrow, he will discover a planet*, and so on. All sentences use the third person to avoid the ambiguity of the first person (where participants could interpret an external deictic center or an internal deictic center and be correct in either case). Lastly, participants viewed all sentences in randomized order.

The target sentences were paired with one of two images. In the first image, a man walks on a street facing away from the participant towards the horizon. In the second image, the man walks towards the participant. Figure 3.1 demonstrates.



Figure 3.1. Man on the street images. Left: A man on a street faces away from the participant, or is congruent with the participant’s internal Deictic time. Right: A man on the street faces towards the participant, or is incongruent with the participant’s internal Deictic time. The images have front-back depth.

The pictures are identical in almost every way; they only differ in the direction the man on the street faces. Each image is 700 pixels by 438 pixels.

The study was designed using Qualtrics survey software.

3.2.1.3 Procedure

Participants were told that the researchers were making a series of posters and that they should place the sentences on the street where they would be the most “visually appealing.” They were also told that they should vary their sentence placement, or choose more than one location

across posters, and that they should not worry about font size, as that would be changed. These instructions were intended to increase the variety of responses and avoid sentence placement based strictly on font size. Participants were allowed to place the sentences on one of 18 segments along the street. Each segment stretches the width of the street on the image and 24 pixels in height. Figure 3.2 is a screenshot of the task.

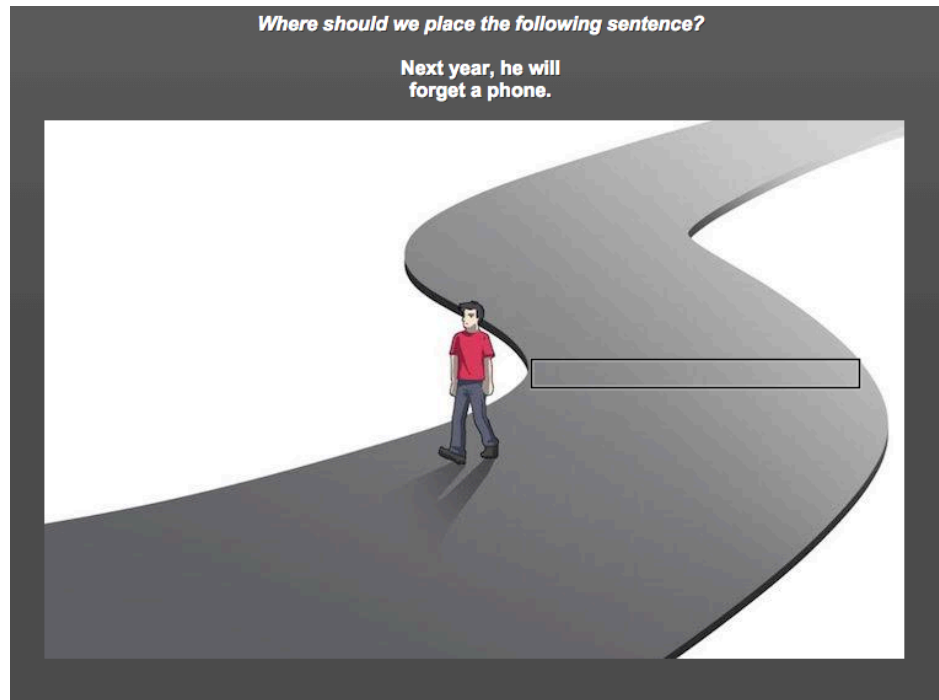


Figure 3.2. Segments on the street. Participants chose one of 18 segments along the street to place the sentence. The sentence did not physically appear on the street. Rather, the segment was highlighted as the mouse hovered over it.

The sentence did not physically appear on the street. Rather, a rectangular segment of the street was highlighted as the mouse hovered over it. Participants could click on one (and only one) of 18 segments in order to advance to the next stimulus.

3.2.2 Results

Responses whose locations were more than two standard deviations from the mean for each Temporal Distance x Tense x Character Direction condition were removed, resulting in the

loss of 36 observations and leaving a total of 908 observations. I used R (R Core Team, 2012) and lme4 (Bates, Maechler, & Bolker, 2012) to perform mixed effects analyses of the data.² P-values were obtained with likelihood ratio tests of a model with the effect under examination compared to a model without the effect.

The first statistical analysis examines whether or not participants adopted the character on the street as the deictic center (or co-located the present with the character), placing past-related sentences behind him and future-related sentences in front of him. To answer this question, sentence placement location was coded as a categorical variable. Since the character was specifically drawn directly in the middle of the image, the exact middle of the image was used as the center point for the dependent variable. So, for example, when the character is facing away, a sentence placement location on the lower half of the image was coded as ‘behind’ the character and a sentence placement location on the upper half of the image was coded as ‘in front’ of the character (this coding was reversed for conditions in which the character faces toward the participant).

A mixed effects logistic regression analysis was conducted using treatment coding for fixed effects with Location (‘behind’ versus ‘in front’) as the outcome variable. The model included fixed effects of Tense (Past vs. Future) and Character Direction (Away vs. Towards) and random effects of Participant and Item. I tested for a main effect of Tense by conducting a likelihood ratio test comparing a mixed-effects model that included Tense and Character Direction fixed effects with a model that included only Character Direction as the fixed effect. The likelihood ratio test revealed a main effect of Tense ($\chi^2(1)=105.71$, $p < .001$). The beta

² All models are maximally specified (i.e., with random slopes) unless the model or a likelihood ratio test was unable to converge. When a model did not converge, models without random slopes (but still with random effects for Participant and Item) were used.

coefficients, standard errors, and p-values for the fixed effects are reported in Table A Appendix A. Comparison between a model containing Tense and Character Direction and a model with only Tense showed that Character Direction also contributes significantly to the model ($\chi^2(1)=58.972, p < .001$). This effect is not of interest to this particular study, however, as it indicates a difference in Location when comparing the character facing away versus towards the participant. A further comparison between a model containing the fixed effects of Tense and Character Direction with a model including an interaction between Tense and Character Direction revealed no significant effect of the interaction term ($\chi^2(1)=0.9249, p=.336$).

In other words, for both character directions, participants place past sentences behind the character and future sentences in front of the character. As predicted, participants attend to the character on the street, shifting the placement of sentences on the street depending on the direction he is facing.

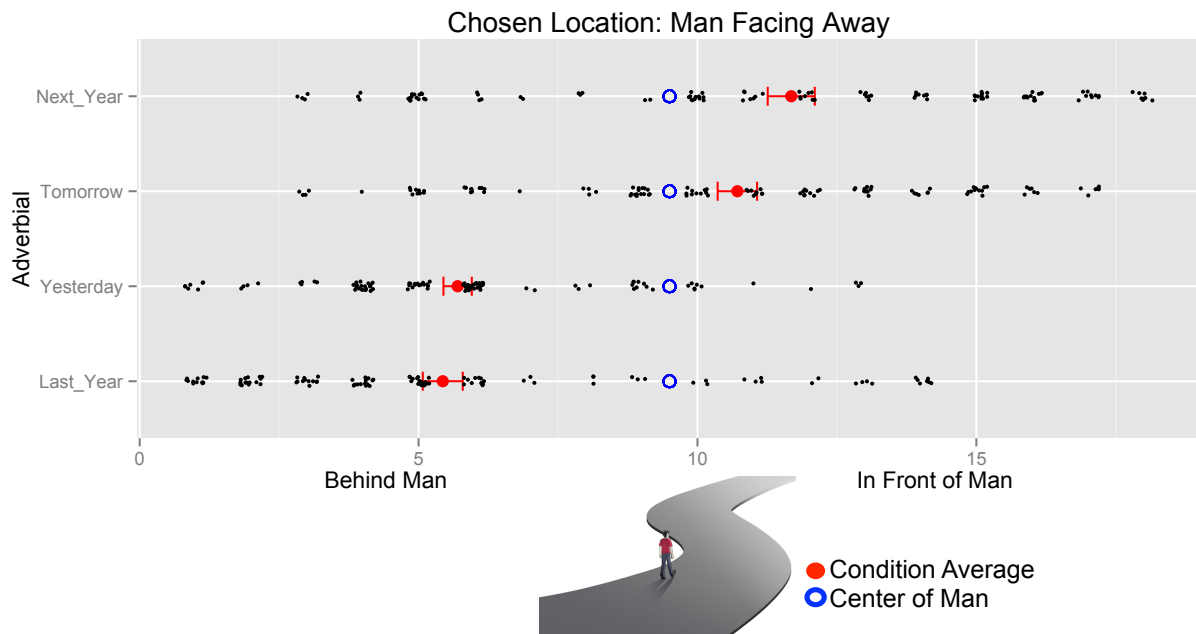


Figure 3.3. Experiment 1a results when the character faces away from the participant, or is congruent with his/her internal Deictic time. Red dots indicate condition means, or the average sentence placement location for each adverbial condition. Blue dots indicate the center of the character/image, and black dots represent all individual observations.

While the first analysis demonstrates a categorical distinction between past and future sentences, the second analysis demonstrates the extent to which participants spatially separated past and future sentences. In other words, do participants place past and future sentences a significant distance from one another, and does this distance shift depending on the character's direction? Answering this question required re-coding of the dependent variable to reflect relative sentence placement location regardless of the direction of the character. Therefore, the Relative Location dependent variable (1-18 physical segments on the image) changes depending on the image: for the character facing away, 1 is the location furthest behind the character (bottom of screen) and 18 is the furthest in front of the character (top of screen), and for the character facing toward the participant, 1 is also furthest behind the character (but at the top of the screen) and 18 is furthest in front of the character (but at the bottom of the screen).

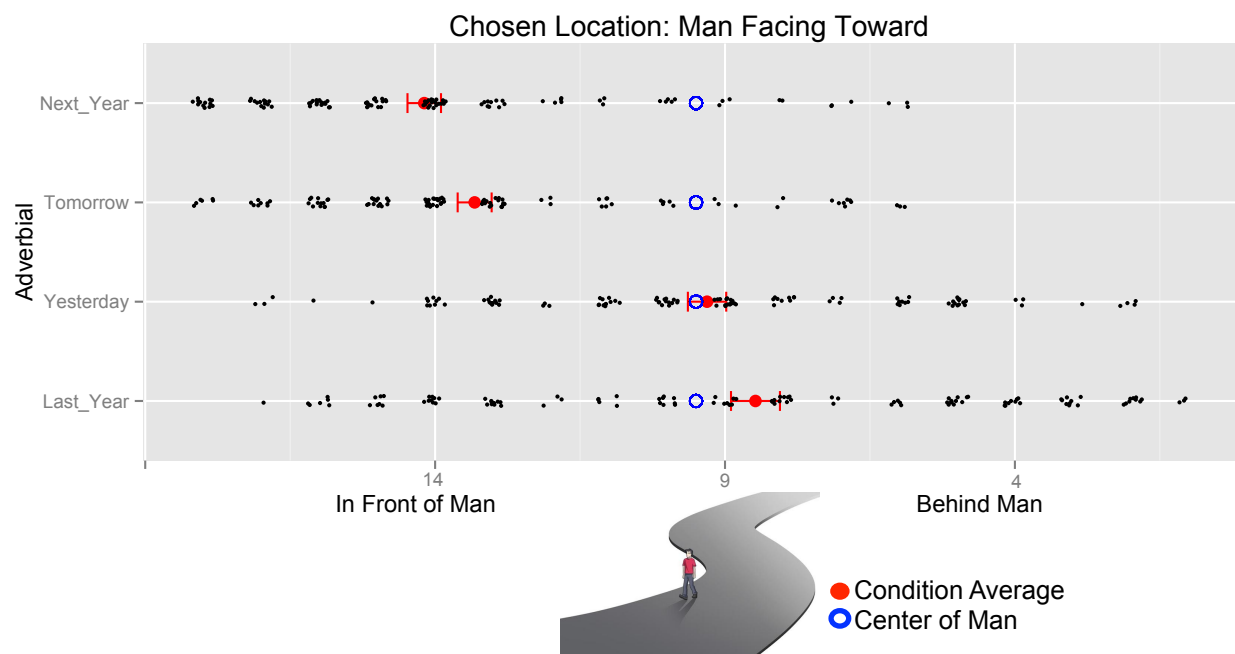


Figure 3.4. Experiment 1a results when the character faces towards the participant, or is incongruent with his/her internal Deictic time. Note that the x axis in this figure is reversed to reflect the Relative Location dependent variable.

In other words, lower numbers indicate locations further behind the character and higher numbers indicate locations further in front of the character for both images, whether the character is facing away or towards the participant.

A mixed effects linear regression analysis was conducted with Relative Location (1 furthest behind the character, 18 furthest in front of the character) as the dependent variable. The model again included Tense (Past vs. Future) and Character Direction (Away vs. Towards) as fixed effects and Participant and Item as random effects. I again tested for a main effect of Tense by conducting a likelihood ratio test comparing a mixed-effects model that included Tense and Character Direction as fixed effects with a model that included only Character Direction as the fixed effect. The likelihood ratio test revealed a main effect of Tense ($\chi^2(1)=129.91$, $p < .001$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table A in Appendix A. Again, a comparison between a model containing Tense and Character Direction and a model with only Tense showed that Character Direction also contributes significantly to the model ($\chi^2(1)=73.789$, $p < .001$). As with the first analysis, this effect is not of interest. Lastly, the comparison between a model containing the fixed effects of Tense and Character Direction with a model including an interaction between Tense and Character Direction revealed no significant effect of the interaction term ($\chi^2(1)=2.262$, $p=.132$). Table 3.1 provides the mean distances at which participants placed past and future sentences in the congruent (away) and incongruent conditions.

	Relative Location for Tense					
Character Direction	Past			Future		
	Mean	SD	SE	Mean	SD	SE
Away	5.56	3.29	0.22	11.2	4.21	0.28
Towards	8.88	4.11	0.27	13.76	3.09	0.21

Table 3.1. Experiment 1a Relative Location for tense. Means table using the Relative Location dependent variable (1 for furthest behind character, 18 for furthest in front of character) for tense.

The linear regression analysis confirms the findings of the logistic regression analysis, demonstrating that participants placed past and future sentences a significant physical distance from each other. Second, it shows that temporal distinctions are not categorical relative to the deictic anchor (as shown by the first analysis), but they are also mapped onto spatial locations that are physically distant from each other. Third, the lack of interaction confirms that participants do so both when the character is facing away and towards them. The estimated distance between past and future sentences is significant at $5.64 \pm .36$ segments (of 18) when the character is facing away from the participant and $4.86 \pm .36$ segments (of 18) when the character is facing towards the participant.

The third analysis examines fine-grained space-time topography, or whether or not participants differentiate between proximal and distal temporal events using fine-grained physical space. In other words, do participants place proximal temporal events closer to the deictic center than distal temporal events for both past and future sentences? To answer this question, the Relative Location dependent variable was again used. Analyzing Temporal Distance requires an analysis separate from the previous analyses (which include Tense) due to the Relative Location dependent variable. Specifically, when Tense is included in the model, if participants place the distal expressions at locations that are significantly distant from the proximal expressions, the difference will *not* be reflected in the quantitative values owing to the coding scheme. That is, the distal sentences will be coded with a higher value than proximal

sentences if they are located further to the front of the character, but only for future tense sentences. Distal sentences will receive a *lower* value than proximal sentences if they are located further away from the back of the character for sentences that are in the past tense. Hence, when including Tense in the model, the relative difference between proximal and distal sentences wash out because of the coding scheme, even though there might be a real difference in the distance between the locations of the distal and the proximal sentences. Consequently, I ran two separate analyses: one for past tense sentences and one for future tense sentences.

A mixed effects linear regression analysis was conducted only on past tense sentences with Relative Location (1 furthest behind the character, 18 furthest in front of the character) as the dependent variable. The model included Temporal Distance (Proximal vs. Distal) and Character Direction (Away vs. Towards) as fixed effects and Participant and Item as random effects. This time, I tested for a main effect of Temporal Distance by conducting a likelihood ratio test comparing a mixed-effects model that included Temporal Distance and Character Direction as fixed effects with a model that included only Character Direction as the fixed effect. The likelihood ratio test revealed no main effect of Temporal Distance for past sentences ($\chi^2(1)=2.3471$, $p=.3093$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table A in Appendix A. A comparison between a model containing Temporal Distance and Character Direction and a model with only Temporal Distance showed that Character Direction contributes significantly to the model ($\chi^2(1)=41.748$, $p<.001$). As in the other models, this effect is not of interest. Lastly, the comparison between a model containing the fixed effects of Temporal Distance and Character Direction with a model including an interaction between Temporal Distance and Character Direction revealed no significant effect of the interaction term ($\chi^2(1)=0.3529$, $p=.55$).

	Relative Location for Past Sentences					
Character Direction	Proximal			Distal		
	Mean	SD	SE	Mean	SD	SE
Away	5.7	2.66	0.25	5.43	3.81	0.36
Towards	9.31	3.52	0.33	8.47	4.58	0.42

Table 3.2. Experiment 1a Relative Location for past sentences. Means table using the Relative Location dependent variable (1 for furthest behind character, 18 for furthest in front of character) for past sentences. Note: The prediction of this study is that means for the proximal sentences ('yesterday') will be *higher* than the means for distal sentences ('last year').

The analysis of past sentences demonstrates no difference between proximal and distal sentences (i.e., 'yesterday' vs. 'last year'). The interaction is also not significant, so participants did not separate proximal and distal past sentences when the character was facing either direction. This can be seen in Table 3.2. Note that this study predicts that relative location means for the proximal sentences ('yesterday') will be higher than means for distal sentences ('last year'). These results run counter to the predictions of the study, where participants only separate proximal and distal past sentences by $.31 \pm .51$ segments (of 18) when the character is facing away and $.74 \pm .5$ segments (of 18) when the character is facing toward the participant.

Lastly, a mixed effects linear regression analysis was run only on future sentences with Relative Location (1 furthest behind the character, 18 furthest in front of the character) as the dependent variable. This model included Temporal Distance (Proximal vs. Distal) and Character Direction (Away vs. Towards) as fixed effects and Participant and Item as random effects. A main effect of Temporal Distance was examined by conducting a likelihood ratio test comparing a mixed-effects model that included Temporal Distance and Character Direction as fixed effects with a model that included only Character Direction as the fixed effect. The likelihood ratio test revealed a main effect of Temporal Distance for future sentences ($\chi^2(1)=8.1253$, $p=.015$). The beta coefficients, standard errors, and p-values for the random and fixed effects are reported in Table A in Appendix A. A comparison between a model containing Temporal Distance and

Character Direction and a model with only Temporal Distance showed that Character Direction also contributes significantly to the model ($\chi^2(1)=38.007$, $p < .001$). Again, this effect is not of interest. Lastly, the comparison between a model containing the fixed effects of Temporal Distance and Character Direction with a model including an interaction between Temporal Distance and Character Direction revealed no significant effect of the interaction term ($\chi^2(1)=0.0107$, $p=.918$).

	Relative Location for Future Sentences					
Character Direction	Proximal			Distal		
	Mean	SD	SE	Mean	SD	SE
Away	10.72	3.81	0.35	11.68	4.54	0.42
Towards	13.32	3.07	0.29	14.19	3.06	0.29

Table 3.3. Experiment 1a Relative Location for future sentences. Means table using the Relative Location dependent variable (1 for furthest behind character, 18 for furthest in front of character) for future sentences. Note: The prediction of this study is that means for the proximal sentences ('tomorrow') will be *lower* than the means for distal sentences ('next year').

The final analysis of future sentences shows a significant difference in sentence placement between proximal and distal sentences (i.e., 'tomorrow' vs. 'next year') in the predicted direction. Given that the midpoint of the image (i.e., the deictic center) is at segment location 9.5, we can infer that proximal sentences were placed closer to the deictic center than distal sentences. Moreover, the lack of a significant interaction indicates that participants attend to the character's direction (much like with Tense) when placing proximal and distal sentences. Mean differences can be seen in Table 3.3. Note that prediction of the study is that relative location means for proximal future events ('tomorrow') will be lower than means for distal future events ('next year'). In this case, participants place proximal and distal sentences a significant $.99 \pm .44$ segments (of 18) apart when the character is facing away and $.92 \pm .45$ segments (of 18) apart when the character is facing towards them. This is strong evidence of

English speakers' fine-grained space-time topography for future sentences using external Deictic time.

3.2.3 Discussion

Experiment 1a very clearly demonstrates that participants readily adopt the character on the street as a deictic center, and they strongly attend to the direction the character is facing. Whether the character is facing away from or towards the participant, the participant places past sentences behind the character and future sentences in front of the character. In this way, participants demonstrate a very flexible space-time construal, such that they adopt a deictic center on an image with front-back space (an unconventional axis for external Deictic time) that is incongruent with their own internal Deictic time. Importantly, they do so under the impression that the sentences are more 'visually pleasing' in these physical locations. In addition, the images in this experiment, unlike similar past experiments, have front-back depth, thus suggesting that external Deictic time conceptualization is not limited to a left-right axis. The images are also static, indicating that this effect is strictly one of space—not of motion.

Experiment 1a also offers the first evidence for English speakers' fine-grained space-time topography. This is an exciting confirmation of the space-time topography hypothesis, effectively demonstrating that English speakers' construals of temporal events are not categorical. Interestingly, this effect is limited to future sentences. Participants place proximal future sentences ('tomorrow') closer to the deictic center than distal future sentences ('next year'). They do not do this, however, for past sentences. This finding is important for two reasons. First, it suggests that English speakers do, indeed, think about Time in terms of fine-grained physical space and not categorically. Secondly, it also indicates that English speakers construe the past and future in fundamentally different ways. In this case, fine-grained physical

space is apparently utilized for the future, but not for the past. Possible reasons for this will be discussed in Chapter 7.

Importantly, the robust Tense effect of Experiment 1a—or participants’ adoption of the man on the street as a deictic center—could largely be the consequence of its explicit activation a mental timeline via the Life is a Journey conceptual metaphor (Lakoff & Johnson, 1980), which encourages participants to think about Time in terms of space. The images feature an animate character walking along a street, and this may very explicitly encourage participants to think of Time using the provided road with the character as the deictic center. Experiment 1b below follows up on this possibility.

3.3 Experiment 1b – Adverbials on the Beach

Experiment 1a gives initial insight into the space-time topography of English speakers, but it does so through the explicit activation of the conceptual metaphor Life is a Journey, which hypothetically encourages participants to think about time in terms of physical space with the character as the deictic center. Participants are given time-related sentences and simultaneously view a picture of a man on a road (or on a journey), and are thus invited to think about the street as the physical manifestation of a timeline. Moreover, they also attend to the direction the man is facing when placing temporal sentences, and the man could very easily be the subject of the stimuli (sentences all use the third person ‘he’). Experiment 1b attempts to replicate the effect of Experiment 1a with a less explicit reference to Life is a Journey by replacing the image of a man on street with an image of a chair on a beach. This provides an ideal comparison with Experiment 1a in two ways. First, it involves a picture consisting of depth but without an obvious journey. Second, the focal point of the picture is inanimate, but it still has a canonical back and

front. Therefore, the chair is a viable locus for external Deictic time representations both congruent and incongruent with the participants' internal Deictic time.

Consequently, Experiment 1b further explores whether participants co-locate the present with an external locus and exhibit fine-grained space-time mapping effects—as in Experiment 1a—without the explicit activation of a mental timeline.

3.3.1 Method

3.3.1.1 Participants

For Experiment 1b, 40 participants were recruited using Amazon's Mechanical Turk. The task took participants an average of 18 minutes to complete, and participants were paid \$2.00 each for their participation. Only participants with a 90% approval rating or higher who had performed at least 500 previous tasks were employed.

A post-survey revealed that six participants were not paying attention to the task (could not remember the color of the chair), and they were thus dropped from the study, leaving a total of 34 participants for the final analysis. The post-survey can be found in Appendix C.

I conducted four analyses investigating the effects of Temporal Distance (Proximal vs. Distal), Tense (Past vs. Future), and Character Direction (Away vs. Towards) on participants' choice of spatial location for sentence placement.

3.3.1.2 Stimuli

The same stimuli sentences from Experiment 1a were used in Experiment 1b. The critical difference between Experiment 1b and Experiment 1a is that two different images were paired with the stimuli. In Experiment 1b, participants viewed images with front-back depth with a chair on a beach. Figure 3.5 shows these stimuli. Each image is 700 pixels by 438 pixels.



Figure 3.5. Chair on the beach images. Left: An image of a chair on a beach facing away from the participant, or congruent with his/her internal Deictic time. Right: An image of a chair on a beach facing towards the participant, or incongruent with his/her internal Deictic time. The images have front-back depth.

Importantly, participants were able to select the exact same physical locations on the beach image as the street image (1-18 physical segments). Each segment stretches the width of the street on the image from Experiment 1a and 24 pixels in height.

As in Experiment 1a, the study was designed using Qualtrics survey software.

3.3.1.3 Procedure

As in Experiment 1a, participants were asked to place the stimuli on the images as if they were posters. Figure 3.6 provides a screenshot of the task.

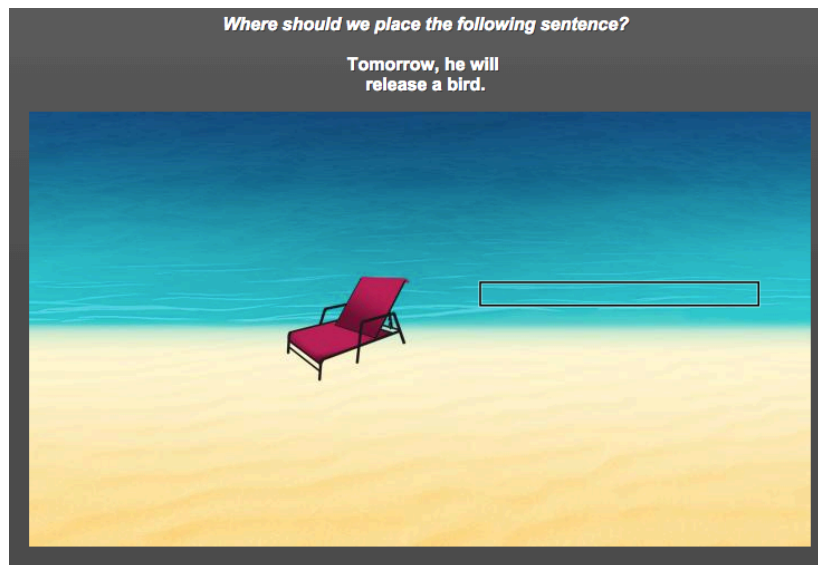


Figure 3.6. Segments on the beach. Participants chose one of 18 segments on the beach image to place the sentence. The sentence did not physically appear on the street. Rather, the segment was highlighted as the mouse hovered over it. Segments were in identical locations as those in Experiment 1a (with the man on the street).

3.3.2 Results

Responses whose locations were more than two standard deviations from the mean for each Temporal Distance x Tense x Character Direction condition were removed, resulting in the loss of 15 observations and leaving a total of 531 observations for the final analysis.

For Experiment 1b, the first statistical analysis addresses whether or not participants adopted the chair as a deictic center (or co-located the present with the chair) and placed past-related sentences behind it and future-related sentences in front of it. To answer this question, sentence placement location was again coded as a categorical variable where the center of the images (and chair) marks the distinction between ‘behind’ and ‘in front.’

A mixed effects logistic regression analysis was run using Location (‘behind’ vs. ‘in front’) as the dependent variable. The model included Tense (Past vs. Future) and Character Direction (Away vs. Towards) as fixed effects and Participant and Item as random effects. I tested for a main effect of Tense by conducting a likelihood ratio test comparing a mixed-effects model that included Tense and Character Direction as fixed effects with a model that included only Character Direction as the fixed effect. The likelihood ratio test reveals no significant main effect of Tense ($\chi^2(1)=1.5891$, $p=.452$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table B in Appendix A. A comparison between a model containing Tense and Character Direction and a model with only Tense showed a main effect of Character Direction ($\chi^2(1)=79.076$, $p<.001$). As with previous models, this effect is not of interest. A further comparison between a model containing the fixed effects of Tense and Character Direction with a model including an interaction between Tense and Character Direction revealed no significant effect of the interaction term ($\chi^2(1)=0.2951$, $p=.587$).

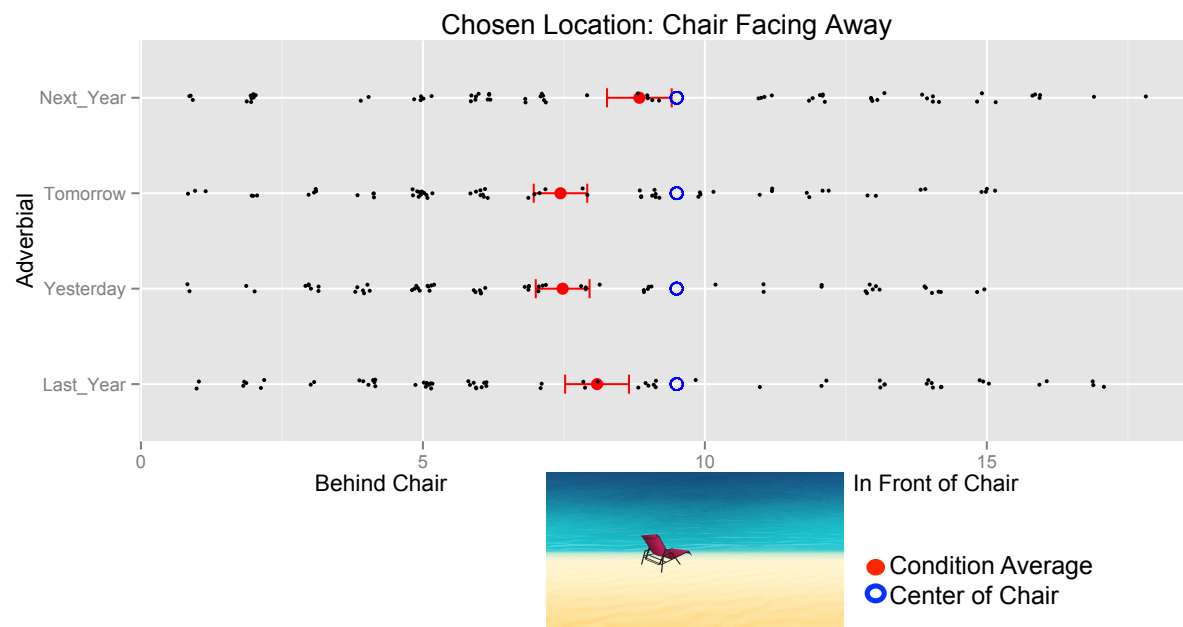


Figure 3.7. Experiment 1b results when the chair faces away from the participant, or is congruent with his/her internal Deictic time.

In Experiment 1b, participants do not attend to the direction of the chair by placing past sentences behind it and future sentences in front of it. This is a sharp contrast with Experiment 1a, which demonstrated a strong effect of Tense. This is clear from Figures 3.7 and 3.8, which show that participants tend to place sentences in the lower segments on screen with little attendance to the chair.

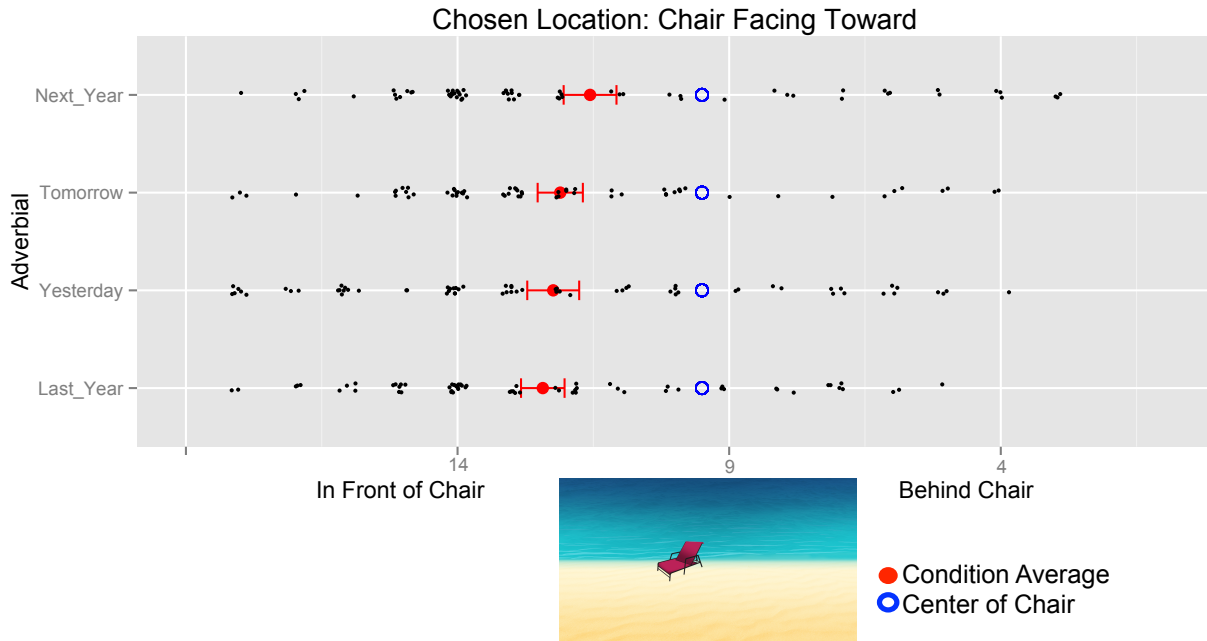


Figure 3.8 Experiment 1b results when the chair faces toward the participant, or is incongruent with his/her internal Deictic time. Note that the x axis in this figure is reversed to reflect the Relative Location dependent variable.

To examine the extent to which participants used distance to separate past and future sentences, the second analysis utilizes the Relative Location dependent variable (1 furthest behind chair; 18 furthest in front of chair). A mixed effects linear regression analysis was run to address this question. It included Tense (Past vs. Future) and Character Direction (Away vs. Towards) as fixed effects and Participant and Item as random effects. The main effect of Tense was examined by conducting a likelihood ratio test comparing a mixed-effects model that included Tense and Character Direction as fixed effects with a model that included only Character Direction as the fixed effect. The likelihood ratio test revealed no main effect of Tense ($\chi^2(1)=2.081$, $p=.353$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table B in Appendix A. Again, a comparison between a model containing Tense and Character Direction and a model with only Tense showed that Character Direction contributes significantly to the model ($\chi^2(1)=88.349$, $p<.001$). As with earlier models, this effect

is not of interest. Lastly, the comparison between a model containing the fixed effects of Tense and Character Direction with a model including an interaction between Tense and Character Direction revealed no significant effect of the interaction ($\chi^2(1)=2.031$, $p=.154$).

	Relative Location for Tense					
Character Direction	Past			Future		
	Mean	SD	SE	Mean	SD	SE
Away	7.79	4.3	0.37	8.15	4.36	0.38
Towards	12.33	3.58	0.31	11.83	3.65	0.32

Table 3.4 Experiment 1b Relative Location for tense. Means table using the Relative Location dependent variable (1 for furthest behind character, 18 for furthest in front of character) for tense.

This analysis mirrors results from the first logistic regression of Experiment 1b, effectively demonstrating that participants do not attend to the chair when placing past and future sentences. The lack of a significant interaction shows that no effect is present for either chair direction. Specifically, participants place past and future sentences $.39 \pm .47$ segments (of 18) apart when the character is facing away and $.55 \pm .47$ segments (of 18) apart when the character is facing towards them.

Again, two additional analyses are required to examine fine-grained space time-topography, or whether or not participants differentiate between proximal and distal temporal events using fine-grained physical space. To answer this question, the Relative Location dependent variable was again used for past sentences and for future sentences.

A mixed effects linear regression model of only past sentences with Relative Location (1 furthest behind the character, 18 furthest in front of the character) as the dependent variable was run. The model included Temporal Distance (Proximal vs. Distal) and Character Direction (Away vs. Towards) as fixed effects and Participant and Item as random effects. I tested for a main effect of Temporal Distance by conducting a likelihood ratio test comparing a mixed-

effects model that included Temporal Distance and Character Direction as fixed effects with a model that included only Character Direction as the fixed effect. The likelihood ratio test revealed no main effect of Temporal Distance for past sentences ($\chi^2(1)=1.0363$, $p=.596$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table B in Appendix A. A comparison between a model containing Temporal Distance and Character Direction and a model with only Temporal Distance showed that Character Direction contributes significantly to the model ($\chi^2(1)=41.748$, $p < .001$). This effect is not of interest. Lastly, the comparison between a model containing the fixed effects of Temporal Distance and Character Direction with a model including an interaction between Temporal Distance and Character Direction revealed no significant effect of the interaction term ($\chi^2(1)=0.1544$, $p=.694$).

	Relative Location for Past Sentences					
Character Direction	Proximal			Distal		
	Mean	SD	SE	Mean	SD	SE
Away	7.48	3.9	0.48	8.09	4.67	0.57
Towards	12.24	3.9	0.48	12.43	3.23	0.4

Table 3.5. Experiment 1b Relative Location for past sentences. Means table using the Relative Location dependent variable (1 for furthest behind character, 18 for furthest in front of character) for past sentences. Note: The prediction of this study is that means for the proximal sentences ('yesterday') will be *higher* than the means for distal sentences ('last year').

The analysis of past sentences reveals no difference between proximal and distal sentences ('yesterday' vs. 'last year'). The interaction is also not significant, so participants did not separate proximal and distal past sentences when the chair was facing either direction. This can be seen in Table 3.5. Note that this study predicts that relative location means for the proximal sentences ('yesterday') will be higher than means for distal sentences ('last year'). Participants place proximal and distal past sentences $.6 \pm .63$ segments (of 18) apart when the character is facing away and $.24 \pm .64$ segments (of 18) apart when the character is facing towards

them. These results converge with those of Experiment 1a, which also found no effect for past sentences.

Lastly, a mixed effects linear regression model was run on future sentences with Relative Location (1 furthest behind the chair, 18 furthest in front of the chair) as the dependent variable. The model included Temporal Distance (Proximal vs. Distal) and Character Direction (Away vs. Towards) as fixed effects and Participant and Item as random effects. I tested for a main effect of Temporal Distance by conducting a likelihood ratio test comparing a mixed-effects model that included Temporal Distance and Character Direction as fixed effects with a model that included only Character Direction as the fixed effect. The likelihood ratio test revealed no main effect of Temporal Distance for future sentences, though it does approach significance ($\chi^2(1)=5.1226$, $p=.077$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table B in Appendix A. A comparison between a model containing Temporal Distance and Character Direction and a model with only Temporal Distance showed that Character Direction contributes significantly to the model ($\chi^2(1)=38.37$, $p < .001$). Lastly, the comparison between a model containing the fixed effects of Temporal Distance and Character Direction with a model including an interaction between Temporal Distance and Character Direction shows a significant effect of the interaction term ($\chi^2(1)=4.3481$, $p=.037$).

	Relative Location for Future Sentences					
Character Direction	Proximal			Distal		
	Mean	SD	SE	Mean	SD	SE
Away	7.44	3.86	0.47	8.84	4.72	0.57
Towards	12.11	3.33	0.42	11.56	3.95	0.49

Table 3.6. Experiment 1b Relative Location for future sentences. Means table using the Relative Location dependent variable (1 for furthest behind character, 18 for furthest in front of character) for future sentences. Note: The prediction of this study is that means for the proximal sentences ('tomorrow') will be *lower* than the means for distal sentences ('next year').

Though the analysis of future sentences shows no main effect of Temporal Distance, the significant interaction shows that participants did place proximal and distal future sentences at significantly distinct locations from one another when the chair was facing away from them compared to when it was facing towards them. This can be seen in Figures 3.7 and 3.8 as well as Table 3.6. Note that the prediction of the study is that Relative Location means for proximal future events ('tomorrow') will be lower than means for distal future events ('next year'). The first statistical models of Experiment 1b, which demonstrate no effect of Tense, effectively show that participants do not attend to chair direction. Therefore, this significant interaction suggests that participants co-locate the present with the ego, placing proximal future sentences ('tomorrow') closer to themselves than distal future sentences ('next year') when the chair is facing away from them. This difference in proximal and distal future sentences was also found in Experiment 1a (though with the man on the street as the deictic center). In other words, when participants do not adopt the external locus as a deictic center, they default to internal Deictic time but still recruit the front-back depth of the image (if the image is congruent with their internal Deictic time). So, they place proximal future sentences closer to the ego and distal future sentences further away from the ego. Specifically, participants place proximal and distal sentences $1.38 \pm .64$ segments (of 18) apart when the character is facing away and $.57 \pm .65$ segments (of 18) apart when the character is facing towards them. As observable in Figure 3.8, though not significant, sentence location means when the chair faces towards the participant also reflect an internal Deictic time perspective. That is, participants trend towards co-locating the present with the ego, with proximal sentences closer to the ego and distal sentences further away. This result contrasts with Experiment 1a, where participants co-locate the present with the character on the image.

3.3.3 Discussion

Unlike Experiment 1a, participants in Experiment 1b do not adopt the external locus (or co-locate the present with the chair) when placing past and future sentences. This is strong evidence that the explicit activation of the Life is a Journey metaphor in Experiment 1a is largely responsible for participants adopting an external deictic center. In other words, without an animate character on a street, participants do not exhibit external Deictic time effects.

Instead, participants do seem to recruit the front-back physical space of the images, but they do so by co-locating the present with the ego. They thus exhibit internal Deictic time when the Life is a Journey metaphor is not activated. The interaction between Temporal Distance and Character Direction is the evidence of this effect, where participants place proximal future sentences ('tomorrow') closer to the ego than distal future sentences ('next year') when the chair is facing away compared to when it is facing towards them. In other words, even though participants do not adopt the chair as an external Deictic center, they do adopt the front-back depth of the image when the chair is congruent with their own internal Deictic time. Experiment 1b thus provides further evidence of fine-grained space-time topography, or the recruitment of fine-grained physical space for temporal events. However, in contrast to Experiment 1a, this recruitment occurs in an experiment in which participants do not co-locate the present with an external locus and the Life is a Journey metaphor is not explicitly activated.

Experiment 1b thus verifies the presence of English speakers' fine-grained space-time topography, but it suggests that external Deictic time requires explicit activation of the Life is a Journey metaphor. When this explicit activation is not present, as in Experiment 1b, participants default to co-locating the present with the ego. Importantly, this effect is only present for future sentences when the external locus is congruent with their internal Deictic time, but not for past

sentences. Like Experiment 1a, this is further evidence that English speakers are more prone to recruiting fine-grained physical space when processing future sentences than past sentences.

3.4 General Discussion

Experiments 1a and 1b begin to map the landscape of English speakers' space-time topography, specifically with regard to external Deictic time. To begin, Experiment 1a shows that English speakers readily co-locate the present with an external locus on an image with front-back depth—an unconventional spatial orientation for external Deictic time—as they place past sentences behind a man on a street and future sentences in front of the man regardless of the direction he is facing. They do so under the impression that the sentences are more 'visually appealing' in these locations, thus suggesting that they are unconsciously construing the time events in association with the physical space that is available. When the image of the man is facing away from the participants, it is congruent with their internal Deictic time conceptualization. However, when the man is facing towards them, the image is incongruent with their internal Deictic time conceptualization. Incredibly, participants still co-locate the present with the man on the street in the incongruent condition, meaning that their external space-time construal runs directly counter to their internal space-time construal. This mapping speaks to a highly flexible space-time mapping ability. Supporting the work of researchers such as Brown (2012) and Torralbo et al. (2006), Experiment 1a is evidence that English speakers have multiple space-time construals available in a given context and can shift their construal based on a particular deictic center.

In Experiment 1b, participants do not co-locate the present with a front-back image of a chair on beach, suggesting that the adoption of the man on the street as a deictic center in Experiment 1a is because the first experiment explicitly activates the Life is a Journey metaphor

(or a mental timeline). This suggests that, for external Deictic time, English speakers must be explicitly prompted to think of temporal events in terms of space. This is consistent with the findings of Ulrich et al. (2012), who find that space-time mapping effects disappear when the experiment does not explicitly activate a mental timeline.

In addition, unlike past studies that conflate space and motion—as argued by Walker et al. (2014)—the task presented in Experiments 1a and 1b is strictly spatial. Participants do not engage in any consistent physical motion related to the task (except for moving their computer mouse or finger on a trackpad, but this motion is consistent across conditions). Of course, one could argue that the man on the street mimics motion, as if he is walking away from or towards the participants. While this is true, he is a static figure. So, though motion is implied, the actual character is stationary. This suggests that space-time mapping of external Deictic time is a spatial phenomenon, and it does not necessarily involve a representation of motion.

Experiment 1a also demonstrates English speakers' fine-grained space-time topography for external Deictic time. As predicted, participants reliably place proximal future sentences ('tomorrow') closer to the deictic center than distal future sentences ('next year'). Importantly, this effect is not present for proximal past sentences ('yesterday') and distal past sentences ('last year'). This space-time topography effect is highly consistent with the experimental literature (Bar-Anan et al., 2007; Bar-Anan, Liberman, & Trope, 2006; Liberman & Trope, 2008; Sell & Kaschak, 2011), but the present study improves upon past work by demonstrating an effect (1) specific to external Deictic time, (2) with images congruent/incongruent with internal Deictic time, and (3) with front-back space relative to the deictic center. In contrast to previous studies, these results also suggest that English speakers' construals of past and future events somehow

differ, in that future events yield fine-grained effects but past events do not. This issue will be more thoroughly addressed in Chapter 7.

Lastly, Experiment 1b also yields a space-time topography effect, but ostensibly not for external Deictic time. When participants do not adopt an external locus as a deictic center, as revealed by the null effect of the logistic regression analysis, they still place proximal and distal future sentences a significant distance apart from one another. They do so only when the chair is ‘facing away’ from them. These results suggest that English speakers are still construing a fine-grained space-time representation in the absence of an external deictic center, but they ‘default’ to co-locating the present with the ego. In other words, they place proximal future sentences closer to themselves and distal future sentences further away from themselves. In addition, they separate proximal and distal sentences without the explicit activation of the Life is a Journey metaphor. In contrast with the claims of Ulrich et al. (2012), space-time mapping effects do not necessarily require the explicit activation of a mental timeline. Or, more accurately, space-time mapping effects of external Deictic time require the explicit activation of a mental timeline (Experiment 1a), but space-time mapping effects of internal Deictic time do not (Experiment 1b).

Chapter IV:

External Deictic Time and Constructions

4.1 Introduction

Experiments 1a and 1b demonstrate the space-time topography of English speakers through the use of stimuli sentences that include adverbials. Adverbials make very specific, overt reference to proximal versus distal temporal events (e.g., ‘tomorrow’ vs. ‘next year’). However, English is clearly able to express temporal distinctions without the use of lexical adverbials, as time distinctions such as past, present, and future are encoded through grammaticalized tense constructions. Comrie (1985, p. 1-6) observes that tense is the “grammaticalisation of location in time,” or the placement of an event with reference to a deictic center as encoded by grammatical markers such as the past tense *-ed* or the future tense marker *will*. Experiments 1a and 1b yielded an effect of space-time topography by coupling these tense markers with adverbials (e.g., *Last year, he discovered a planet* and *Next year, he will discover a planet*). But sentences with adverbials and tense forms are not the only possible means whereby English speakers process fine-grained topography. Rather, fine-grained proximal-distal spatial distinctions may actually be encoded in grammaticalized constructions alone. If this is the case, then I hypothesize that English speakers make fine-grained space-time construals every time they hear or speak of past or future events using different grammatical constructions. Experiments 2a and 2b explore this possibility by employing the same sentence placement paradigm of Experiments 1a and 1b.

To begin, there is strong reason to believe that proximal-distal distinctions are encoded in grammaticalized linguistic constructions. For past events, Comrie (1985) argues that the Simple Past form (i.e., VERB-ed) encodes an event that occurred prior to speech time. In contrast, the Present Perfect (i.e., has VERB-ed) references the “current relevance” of a past situation at speech time (Comrie, 1985, p. 24-25). Therefore, though the construal of this current relevance may vary (see Michaelis (1994) for a discussion of the ambiguity of the Present Perfect construction), the Present Perfect encodes a proximal temporal event (or a stronger tie to the present) compared to the Simple Past, which encodes a more distal temporal event (see Chapter 2 for a lengthier discussion of this claim). This distinction can be observed in the following examples, taken from Comrie (1985, p. 24):

Present Perfect (Proximal)	<i>John has broken his leg.</i>
Simple Past (Distal)	<i>John broke his leg.</i>

With future constructions, Langacker (2008) and Brisard (2001) observe a distinction between the future tense forms *will* and *be going to*. Brisard (2001, p. 269) argues that the *Will* Future encodes a “projected reality,” or a future event that the hearer cannot directly perceive or verify. The *Be Going to* Future construction, on the other hand, encodes an “evoked reality,” or a future event that is grounded in evidence that the hearer can perceive from the present. In other words, the *Be Going to* Future may encode a proximal temporal event (or a strong tie to the perceivable present), whereas the *Will* Future may encode a more distal future event (again, see Chapter 2 for a longer discussion). The difference between these two forms can be seen in the following examples, as taken from Brisard (2001, p. 269):

<i>Be Going to</i> Future (Proximal)	<i>It's going to rain.</i>
<i>Will</i> Future (Distal)	<i>It will rain.</i>

Finding that speakers make fine-grained distinctions in physical space corresponding to proximal and distal temporal distinctions when processing these grammaticalized past and future

constructions would provide evidence that English speakers recruit fine-grained representations of physical space with nearly every past and future sentence that they encounter.

To explore the role of grammaticalized constructions in space-time topography, Experiments 2a and 2b use the sentence placement paradigm of Experiments 1a and 1b. Since the same paradigm is being used, Experiments 2a and 2b also offer the opportunity to ask the same research questions regarding deictic centers and fine-grained topography—albeit without the use of adverbials—to replicate and expand the findings of Experiments 1a and 1b. To this end, the following research questions (numbered from Chapter 2) are addressed in this chapter:

External Deictic Time

RQ1. Under what conditions do English speakers construe temporal events with an external deictic center (as opposed to an internal one)?

RQ1a. Do English speakers construe external Deictic time using an image with front-back physical space (as opposed to left-right physical space)?

RQ1b. Do English speakers adopt a deictic center that is incongruent with their own internal Deictic time?

RQ1c. Does the adoption of an external deictic center require explicit reference to Time in terms of physical space, or the explicit activation of a mental timeline?

Fine-grained Space-time Mapping

RQ2. Do English speakers construe coarse-grained (categorical front/back) or fine-grained (landscape) spatial representations when space-time mapping?

RQ2a. Does this vary based on speakers' construal of external Deictic time versus internal Deictic time?

RQ2c. Do grammaticalized past and future constructions encode fine-grained spatial representations?

RQ3. Do space-time construals involve static *spatial* representations or *motion* representations?

Experiment 2a begins to address these questions through the use of the image of the man on the street.

4.2 Experiment 2a – Constructions on the Street

To provide empirical support for the hypothesis that grammaticalized English constructions encode fine-grained physical space, Experiment 2a uses the same sentence location paradigm of Experiment 1a. However, instead of sentences with adverbials, participants are asked to place sentences with grammaticalized constructions for the past (Present Perfect vs. Simple Past) and future (*Be Going to* Future vs. *Will* Future).

4.2.1 Method

4.2.1.1 Participants

For Experiment 2a, 85 participants were recruited on Amazon's Mechanical Turk. The task took an average of 13 minutes, and participants were paid \$2.00 each for their participation. Only participants with a 90% approval rating or higher who had performed at least 500 previous tasks were employed.

Following a post-survey, which can be found in Appendix C, 12 participants were dropped due to lack of attention (not remembering the color of the character's shirt), and 8 were dropped due to them guessing the intention of the study, leaving a total of 65 participants.

I conducted four analyses investigating the effects of Temporal Distance (Proximal vs. Distal), Tense (Past vs. Future), and Character Direction (Away vs. Towards) on participants' choice of spatial location for sentence placement.

4.2.1.2 Stimuli

The only difference between Experiment 2a and Experiment 1a is the stimuli sentences. For Experiment 2a, 16 target sentences (mixed with 32 filler sentences) feature proximal forms for the past and future (Present Perfect and *Be Going to* Future) and distal forms for the past and future (Simple Past and *Will* Future). The stimuli are as follows:

Present Perfect (Proximal Past)	<i>He has begun a letter.</i>
Simple Past (Distal Past)	<i>He stopped a fight.</i>
<i>Be Going to</i> Future (Proximal Future)	<i>He's gonna win a bike.</i>
<i>Will</i> Future (Distal Future)	<i>He will discover a planet.</i>

Note that, in order to mitigate a motion reading of the verb *go*, the *Be Going to* Future was reduced to '*s gonna*.

Target sentences included the same achievement verbs as the stimuli from Experiment 1a, and all clauses were again cross-balanced across groups. Sentences were presented in randomized order.

The study was designed using Qualtrics survey software.

4.2.1.3 Procedure

The procedure was identical to that in Experiment 1a, in that participants were asked to place sentences on 'posters' of a man on a street based on 'visual appeal.'

4.2.2 Results

Responses whose locations were more than two standard deviations from the mean for each Temporal Distance x Tense x Character Direction condition were removed, resulting in the loss of 20 observations and leaving a total of 1020 observations for the final analysis.

The first statistical analysis addresses whether or not participants adopted the character as the deictic center (or co-located the present with the character) and placed past-related sentences behind the character and future-related sentences in front of him. As with the previous experiments, to answer this question, sentence placement location was again coded as a categorical variable where the center of the images (and character) mark the distinction between 'behind' and 'in front of.'

A mixed effects logistic regression analysis was run using Location ('behind' vs. 'in

front') as the dependent variable. The model included fixed effects of Tense (Past vs. Future) and Character Direction (Away vs. Towards) and random effects of Participant and Item. A main effect of Tense was examined by conducting a likelihood ratio test comparing a mixed-effects model that included Tense (Past vs. Future) and Character Direction (Away vs. Towards) fixed effects with a model that included only Character Direction as the fixed effect. The likelihood ratio test revealed a main effect of Tense ($\chi^2(1)=27.716$, $p < .001$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table C in Appendix A. A comparison between a model containing Tense and Character Direction and a model with only Tense showed a main effect of Character Direction ($\chi^2(1)=28.578$, $p < .001$). As with previous experiments, this effect is not of interest, as it compares the collapsed sentence placement locations when the character is facing away versus when the character is facing towards the participant. A further comparison between a model containing the fixed effects of Tense and Character Direction with a model including an interaction between Tense and Character Direction revealed a significant effect of the interaction term ($\chi^2(1)=6.7165$, $p=.009$).

In Experiment 2a, participants attend to the direction of the character; they place past sentences behind him and future sentences in front of him. However, the significant interaction indicates that this effect is different across images. That is, participants place past sentences behind the character and future sentences in front of him when the character is facing away, but they do not do so when the character faces towards them (see Figures 4.1 and 4.2 below). Specifically, when the character faces towards the participants, participants do not place the past sentences behind the character. These results suggest that English speakers only adopt the man on the street as an external deictic center when the man is congruent with their internal Deictic time conceptualization.

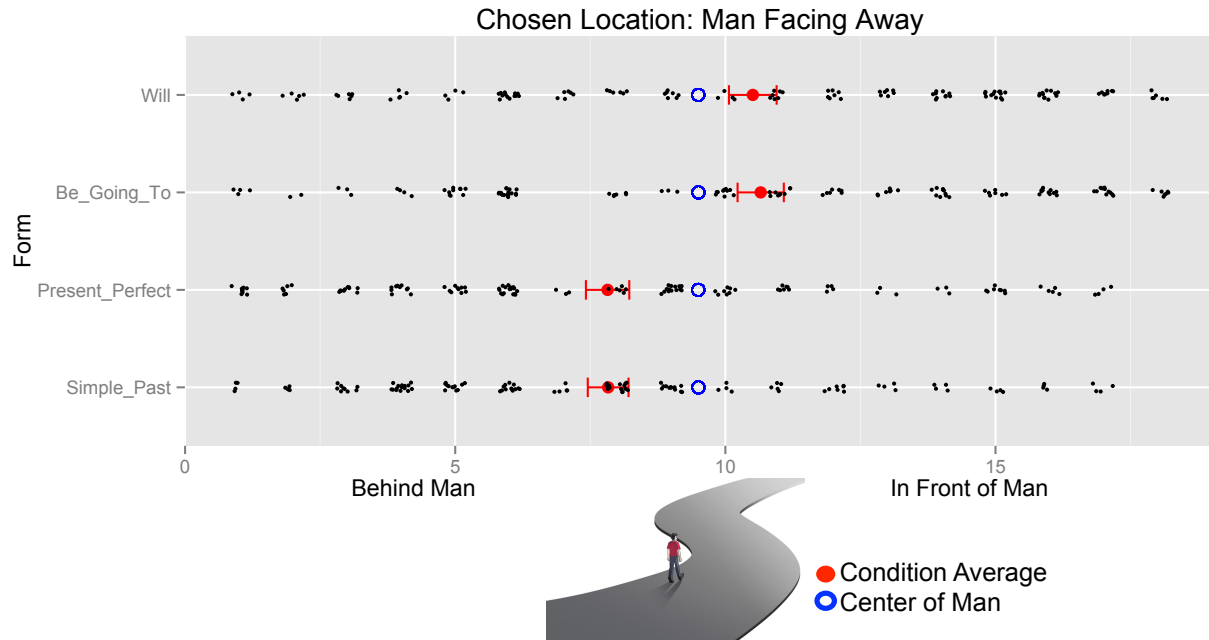


Figure 4.1. Experiment 2a results when the character is facing away from the participant, or congruent with his/her internal Deictic time. Red dots indicate condition means, or the average sentence placement location for each construction condition. Blue dots indicate the center of the character/image, and black dots represent all individual observations.

The second analysis addresses the extent to which participants separated past and future sentences in the sentence placement task. A mixed effects linear regression analysis was run to address this question. As with the previous experiments, the second analysis utilizes the Relative Location dependent variable (1 furthest behind character, 18 furthest in front of the character). The model again included Tense (Past vs. Future) and Character Direction (Away vs. Towards) as fixed effects and Participant and Item as random effects. I examined a main effect of Tense by conducting a likelihood ratio test comparing a mixed-effects model that included Tense (Past vs. Future) and Character Direction (Away vs. Towards) as fixed effects with a model that included only Character Direction as the fixed effect. The likelihood ratio test revealed a main effect of Tense ($\chi^2(1)=27.275$, $p < .001$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table C in Appendix A. A comparison between a model containing Tense and Character Direction and a model with only Tense showed that Character Direction also

contributes significantly to the model ($\chi^2(1)=29.273$, $p < .001$). Lastly, the comparison between a model containing the fixed effects of Tense and Character Direction with a model including an interaction between Tense and Character Direction revealed a significant effect of the interaction term ($\chi^2(1)=4.8557$, $p=.028$).

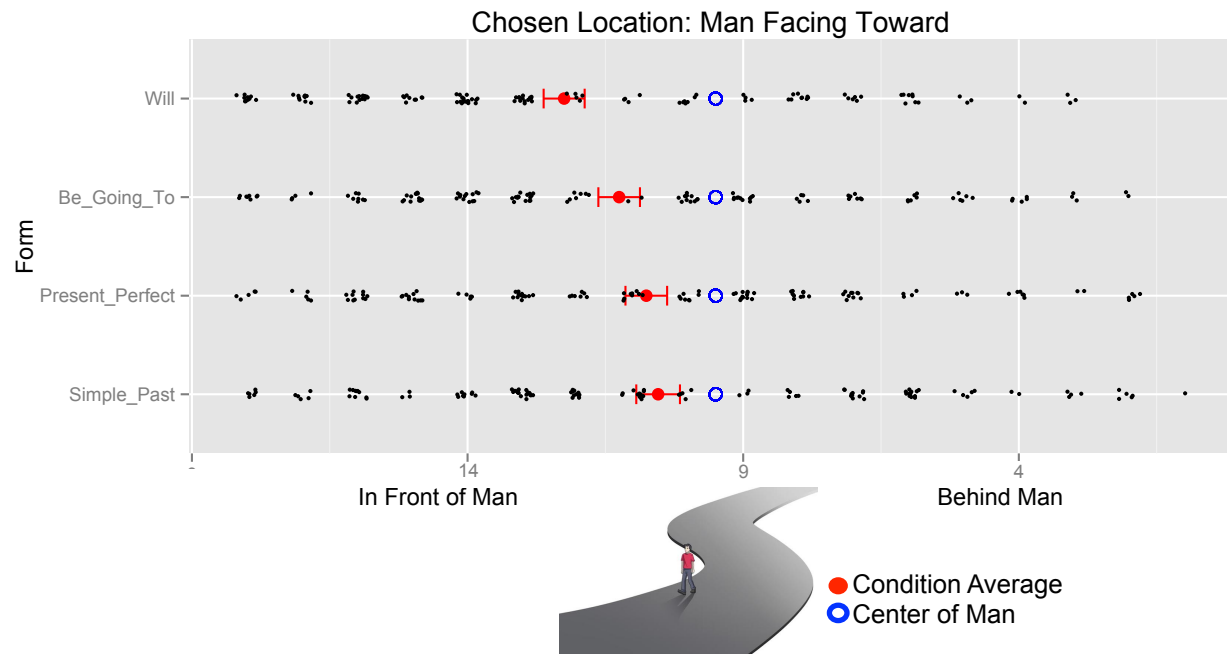


Figure 4.2. Experiment 2a results when the character is facing towards the participant, or incongruent with his/her internal Deictic time. Note that the x axis in this figure is reversed to reflect the Relative Location dependent variable.

This linear mixed effects analysis mirrors the first logistic regression of Experiment 2a, again showing that participants attend to the character, but they do so primarily when the character is facing away from them (as evident from the significant interaction between Tense and Character Direction). Participants place past and future sentences a significant distance from one another when the character is facing away from them compared to when the character is facing towards them. Specifically, participants place sentences $2.7 \pm .49$ segments (of 18) apart when the character is facing away from them and $1.12 \pm .49$ segments (of 18) apart when the character is facing towards them.

	Relative Location for Tense					
Character Direction	Past			Future		
	Mean	SD	SE	Mean	SD	SE
Away	7.83	4.37	0.28	10.58	4.95	0.31
Towards	10.65	4.36	0.27	11.74	4.24	0.27

Table 4.1. Experiment 2a Relative Location for tense. Means table using the Relative Location dependent variable (1 for furthest behind character, 18 for furthest in front of character) for tense.

The third analysis examines the possibility that English speakers demonstrate fine-grained space-time topography for past events when placing sentences with grammaticalized constructions. To examine past forms, a mixed effects linear regression model of only past sentences with Relative Location (1 furthest behind the character, 18 furthest in front of the character) as the dependent variable was run. The model included Temporal Distance (Proximal vs. Distal) and Character Direction (Away vs. Towards) as fixed effects and Participant and Item as random effects. I tested for a main effect of Temporal Distance by conducting a likelihood ratio test comparing a mixed-effects model that included Temporal Distance (Proximal vs. Distal) and Character Direction (Away vs. Towards) as fixed effects with a model that included only Character Direction as the fixed effect. The likelihood ratio test revealed no main effect of Temporal Distance for past sentences ($\chi^2(1)=0.0344$, $p=.983$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table C in Appendix A. A comparison between a model containing Temporal Distance and Character Direction and a model with only Temporal Distance showed that Character Direction contributes significantly to the model ($\chi^2(1)=16.849$, $p < .001$). Lastly, the comparison between a model containing the fixed effects of Temporal Distance and Character Direction with a model including an interaction between Temporal Distance and Character Direction revealed no significant effect of the interaction term ($\chi^2(1)=0.0227$, $p=.88$).

	Relative Location for Past Sentences					
Character Direction	Proximal			Distal		
	Mean	SD	SE	Mean	SD	SE
Away	7.82	4.54	0.4	7.83	4.2	0.38
Towards	10.76	4.28	0.38	10.54	4.46	0.4

Table 4.2. Experiment 2a Relative Location for past sentences. Means table using the Relative Location dependent variable (1 for furthest behind character, 18 for furthest in front of character) for past sentences. Note: The prediction of this study is that means for the proximal sentences (Present Perfect) will be *higher* than the means for distal sentences (Simple Past).

Experiment 2a shows no main effect of Temporal Distance for past sentences, meaning that participants do not place proximal past sentences (Present Perfect) closer to the deictic center than distal past sentences (Simple Past) for either character direction. Participants place proximal and distal past sentences $.02 \pm .82$ segments (of 18) apart when the character faces away from them and $.15 \pm .82$ segments (of 18) apart when the character faces towards them.

Lastly, to examine fine-grained space-time topography of future sentences, a mixed effects linear regression analysis was run only on future sentences with Relative Location (1 furthest behind the character, 18 furthest in front of the character) as the dependent variable. This model included Temporal Distance (Proximal vs. Distal) and Character Direction (Away vs. Towards) as fixed effects and Participant and Item as random effects. A main effect of Temporal Distance was examined by conducting a likelihood ratio test comparing a mixed-effects model that included Temporal Distance (Proximal vs. Distal) and Character Direction (Away vs. Towards) as fixed effects with a model that included only Character Direction as the fixed effect. The likelihood ratio test revealed no main effect of Temporal Distance for future sentences ($\chi^2(1)=3.2162, p=.2003$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table C in Appendix A. A comparison between a model containing Temporal Distance and Character Direction and a model with only Temporal Distance showed that Character Direction contributes significantly to the model ($\chi^2(1)=10.411, p=.005$). Lastly,

the comparison between a model containing the fixed effects of Temporal Distance and Character Direction with a model including an interaction between Temporal Distance and Character Direction shows no significant effect of the interaction term ($\chi^2(1)=2.2589$, $p=.1328$).

	Relative Location for Future Sentences					
Character Direction	Proximal			Distal		
	Mean	SD	SE	Mean	SD	SE
Away	10.65	4.88	0.43	10.51	5.03	0.44
Towards	11.25	4.27	0.38	12.25	4.16	0.37

Table 4.3. Experiment 2a Relative Location for future sentences. Means table using the Relative Location dependent variable (1 for furthest behind character, 18 for furthest in front of character) for future sentences. Note: The prediction of this study is that means for the proximal sentences (*Be Going to Future*) will be lower than the means for distal sentences (*Will Future*).

Contrary to predictions, participants do not place proximal future sentences (*Be Going to Future*) closer to a deictic center and distal future sentences (*Will Future*) further from the deictic center, regardless of the direction the character is facing. In other words, Experiment 2a offers no experimental support for the claim that participants make fine-grained spatial distinctions corresponding to *be going to* (which arguably encodes proximal future events) and *will* (which arguably encodes distal future events). Participants place proximal and distal sentences .17±.55 segments (of 18) apart when the character is facing away from them and 1.0±.55 segments (of 18) apart when the character is facing towards them.

4.2.3 Discussion

Similar to Experiment 1a, Experiment 2a shows that participants co-locate the present with the man on the street when placing past and future sentences. However, in contrast to Experiment 1a, participants in Experiment 2a place a greater distance between past and future sentences when the character faces away from them than when the character faces towards them. As evident from the logistic regression model and Figures 4.1 and 4.2, participants are less

inclined to place past sentences behind the character when he is facing towards them. This is likely because the image with the character facing away is congruent with their own internal Deictic time conceptualization, where the present is co-located with the ego, and the image with the character facing towards them is incongruent. So, English speakers are less flexible with their space-time construals of external Deictic time when the time-related sentences do not overtly reference the temporal event with a lexical adverbial. That is, they do not readily co-locate the present with an incongruent external deictic center when the sentence does not include an adverbial. These results suggest that internal Deictic time is a more basic conceptualization of Time than external Deictic time, as the less overt a sentence is in making reference to the time of an event, the less likely English speakers are to adopt an external deictic center that is incongruent with their conceptualization of internal Deictic time.

Second, with regard to fine-grained space-time topography, Experiment 2a shows no evidence that English speakers make proximal-distal spatial distinctions corresponding to Present Perfect vs. Simple Past forms nor *Be Going to* Future or *Will* Future constructions for external Deictic time. As evident from Experiment 1a, when English speakers read explicit reference to a fine-grained time scale through time-related adverbials, they make fine-grained spatial distinctions for external Deictic time. However, Experiment 2a shows that they do not make these same proximal-distal distinctions with grammaticalized constructions for either past or future forms. In other words, this study finds no evidence that English speakers construe fine-grained space-time topography with grammaticalized constructions for external Deictic time.

4.3 Experiment 2b – Constructions on the Beach

Experiment 2a shows that English speakers co-locate the present with a character on a street when he is facing away and the sentences include only grammaticalized past and future

constructions. However, like Experiment 1a, Experiment 2a explicitly activates a mental timeline via the Life is a Journey metaphor. Experiment 2b thus serves as a follow-up to Experiment 2a, examining whether or not participants' adoption of the external deictic center in Experiment 2a is the consequence of its use of an image with a character on a road. It does so by re-using the grammaticalized constructions from Experiment 2a but instead pairing them with the beach image with front-back depth and the inanimate chair (from Experiment 1b) as the potential deictic center.

4.3.1 Method

4.3.1.1 Participants

For Experiment 2b, 40 participants were recruited on Amazon's Mechanical Turk. The task took an average of 18 minutes, and participants were paid \$2.00 each for their participation. Only participants with a 90% approval rating or higher who had performed at least 500 previous tasks were employed.

Based on the results of a post-survey (which can be found in Appendix C), 6 participants were dropped due to lack of attention (unable to remember the color of the chair) and no participants guessed the intention of the study, leaving the data from a total of 34 participants for analysis.

I conducted four analyses investigating the effects of Temporal Distance (Proximal vs. Distal), Tense (Past vs. Future), and Character Direction (Away vs. Towards) on participants' choice of spatial location for sentence placement.

4.3.1.2 Stimuli

The same target sentences from Experiment 2a were used. The critical difference between Experiment 2a and 2b is the pairing of the sentences with an image of a beach scene with a chair (from Experiment 1b) instead of the image of a man on a street.

The study was designed using Qualtrics survey software.

4.3.1.3 Procedure

The task is identical to Experiment 2a, where participants choose a location on the image to place sentences.

4.3.2 Results

Observations outside of two standard deviations from the mean for each Temporal Distance x Tense x Character Direction condition were removed, resulting in the loss of 29 observations and a total of 515 observations for the final analysis.

The first statistical analysis addresses whether or not participants adopted the chair as the deictic center (or co-located the present with the chair) and by placing past-related sentences behind the chair and future-related sentences in front of it. To answer this question, sentence placement location was again coded as a categorical variable where the center of the images (and chair) mark the distinction between ‘behind’ and ‘in front of.’

A mixed effects logistic regression analysis was run using Location (‘behind’ vs. ‘front’) as the dependent variable. The model included Tense (Past vs. Future) and Character Direction (Away vs. Towards) as fixed effects and Participant and Item as random effects. I tested for a main effect of Tense by conducting a likelihood ratio test comparing a mixed-effects model that included Tense (Past vs. Future) and Character Direction (Away vs. Towards) fixed effects with

a model that included only Character Direction as the fixed effect. The likelihood ratio test revealed a significant main effect of Tense ($\chi^2(1)=11.803$, $p=.003$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table D in Appendix A. A comparison between a model containing Tense and Character Direction and a model with only Tense showed a main effect of Character Direction ($\chi^2(1)=92.87$, $p < .001$). As with previous models, this effect is not of interest. A further comparison between a model containing the fixed effects of Tense and Character Direction with a model including an interaction between Tense and Character Direction revealed no significant effect of the interaction term ($\chi^2(1)=1.9165$, $p=.166$).

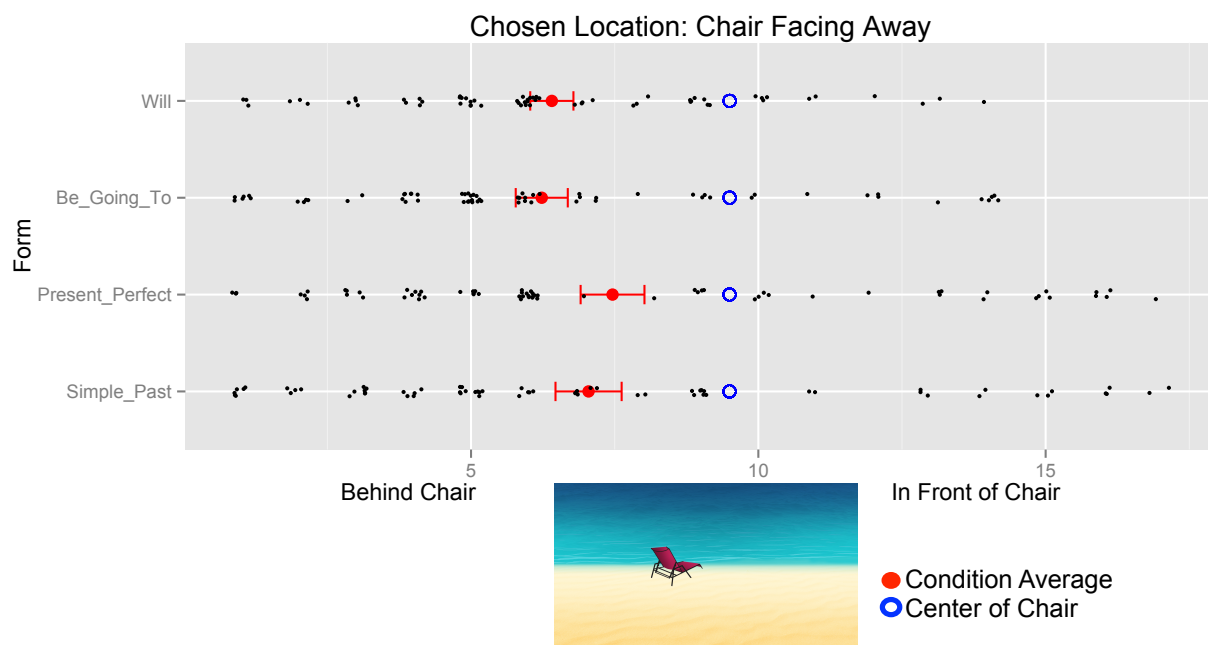


Figure 4.3. Experiment 2b results where the chair is facing away from the participant, or congruent with his/her internal Deictic time.

These are surprising results because, unlike earlier experiments, the effect is in the opposite direction as predicted. Past sentences are reliably placed ‘in front of’ the chair and future sentences are reliably placed ‘behind’ the chair when the chair is facing away from the

participant. Moreover, the lack of an interaction indicates that participants are attending to the direction of the chair, also placing past sentences ‘in front of’ the chair and future sentences ‘behind’ the chair when the chair faces towards the participant. The reasons for the direction of this effect are unclear. These results may simply challenge my assumptions about the canonical front and back of the chair. If we reverse assumptions about the chair, the results are in perfect alignment with predictions.

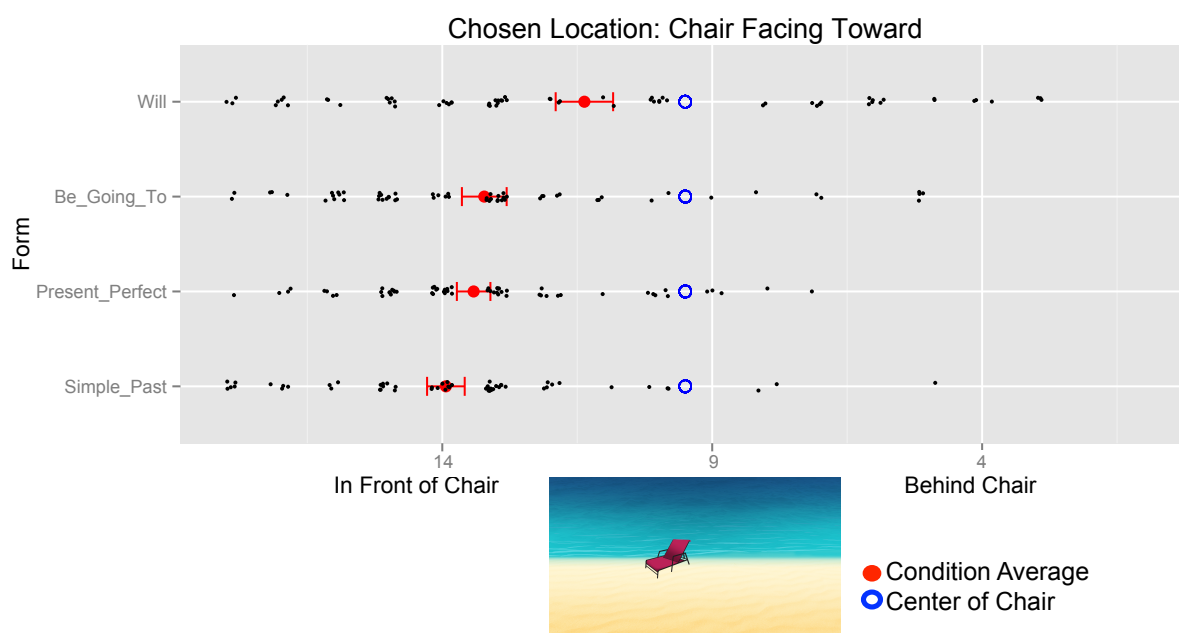


Figure 4.4. Experiment 2b results when the chair is facing toward the participant, or incongruent with his/her internal Deictic time. Note that the x axis in this figure is reversed to reflect the Relative Location dependent variable.

To examine the extent to which participants separated past and future sentences using distance, the second analysis utilizes the Relative Location dependent variable (1 furthest behind chair, 18 furthest in front of chair). A mixed effects linear regression model was run to address this question. The model included Tense (Past vs. Future) and Character Direction (Away vs. Towards) as fixed effects and Participant and Item as random effects. I examined a main effect of Tense by conducting a likelihood ratio test comparing a mixed-effects model that included

Tense (Past vs. Future) and Character Direction (Away vs. Towards) as fixed effects with a model that included only Character Direction as the fixed effect. The likelihood ratio test revealed a main effect of Tense ($\chi^2(1)=8.1319$, $p=.017$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table D in Appendix A. A comparison between a model containing Tense and Character Direction and a model with only Tense showed that Character Direction also contributes significantly to the model ($\chi^2(1)=100.84$, $p<.001$). Lastly, the comparison between a model containing the fixed effects of Tense and Character Direction with a model including an interaction between Tense and Character Direction revealed no significant effect of the interaction term ($\chi^2(1)=0.3405$, $p=.56$).

	Relative Location for Tense					
Character Direction	Past			Future		
	Mean	SD	SE	Mean	SD	SE
Away	7.26	4.6	0.4	6.32	3.33	0.29
Towards	13.67	2.58	0.23	12.26	3.99	0.35

Table 4.4. Experiment 2b Relative Location for tense. Means table using the Relative Location dependent variable (1 for furthest ‘behind’ the chair, 18 for furthest ‘in front of’ the chair) for tense.

The findings from the linear mixed effects analysis converges with the first logistic regression analysis of Experiment 2b, effectively demonstrating that participants do attend to the direction of the chair when placing past and future sentences, albeit in the opposite direction predicted by the study. Participants place past sentences a significant distance from future sentences both when the character is facing away from them and towards them. Specifically, participants separate past and future sentences by $.93 \pm .57$ segments (of 18) when the character is facing away and $1.4 \pm .57$ segments (of 18) when the character is facing towards them.

The third model addresses fine-grained space-time topography, or the extent to which participants made a proximal-distal distinction between past-related sentences. To that end, a

mixed effects linear regression model of only past sentences was run with Relative Location (1 furthest behind the character, 18 furthest in front of the character) as the dependent variable. The model included Temporal Distance (Proximal vs. Distal) and Character Direction (Away vs. Towards) as fixed effects and Participant and Item as random effects. I tested for a main effect of Temporal Distance by conducting a likelihood ratio test comparing a mixed-effects model that included Temporal Distance (Proximal vs. Distal) and Character Direction (Away vs. Towards) as fixed effects with a model that included only Character Direction as the fixed effect. The likelihood ratio test revealed no main effect of Temporal Distance for past sentences ($\chi^2(1)=0.7007$, $p=.705$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table D in Appendix A. A comparison between a model containing Temporal Distance and Character Direction and a model with only Temporal Distance showed that Character Direction contributes significantly to the model ($\chi^2(1)=52.931$, $p<.001$). Lastly, the comparison between a model containing the fixed effects of Temporal Distance and Character Direction with a model including an interaction between Temporal Distance and Character Direction revealed no significant effect of the interaction term ($\chi^2(1)=0.6889$, $p=.407$).

	Relative Location for Past Sentences					
Character Direction	Proximal			Distal		
	Mean	SD	SE	Mean	SD	SE
Away	7.46	4.55	0.56	7.05	4.68	0.58
Towards	13.42	2.45	0.31	13.93	2.7	0.35

Table 4.5. Experiment 2b Relative Location for past sentences. Means table using the Relative Location dependent variable (1 for furthest ‘behind’ the chair, 18 for furthest ‘in front of’ the chair) for past sentences. Note: The prediction of this study is that means for the proximal sentences (Present Perfect) will be *higher* than the means for distal sentences (Simple Past).

The results demonstrate no significant spatial difference between proximal temporal events (Present Perfect) and distal temporal events (Simple Past) for either chair direction.

Participants separate proximal and distal sentences by $.39 \pm .78$ segments (of 18) when the character is facing away and $.53 \pm .8$ segments (of 18) apart when the character is facing towards them.

Lastly, a mixed effects linear regression analysis was run only on future sentences with Relative Location (1 furthest behind the chair, 18 furthest in front of the chair) as the dependent variable. The model included Temporal Distance (Proximal vs. Distal) and Character Direction (Away vs. Towards) as fixed effects and Participant and Item as random effects. I tested for a main effect of Temporal Distance by conducting a likelihood ratio test comparing a mixed-effects model that included Temporal Distance (Proximal vs. Distal) and Character Direction (Away vs. Towards) as fixed effects with a model that included only Character Direction as the fixed effect. The likelihood ratio test revealed no main effect of Temporal Distance for future sentences, though it is approaching significance ($\chi^2(1)=5.6906$, $p=.058$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table D in Appendix A. A comparison between a model containing Temporal Distance and Character Direction and a model with only Temporal Distance showed that Character Direction contributes significantly to the model ($\chi^2(1)=54.44$, $p < .001$). Lastly, the comparison between a model containing the fixed effects of Temporal Distance and Character Direction with a model including an interaction between Temporal Distance and Character Direction shows no significant effect of the interaction term, though it also nears significance ($\chi^2(1)=3.4721$, $p=.062$).

	Relative Location for Future Sentences					
Character Direction	Proximal			Distal		
	Mean	SD	SE	Mean	SD	SE
Away	6.23	3.65	0.45	6.4	3.0	0.38
Towards	13.22	3.29	0.41	11.37	4.39	0.53

Table 4.6. Experiment 2b Relative Location for future sentences. Means table using the Relative Location dependent variable (1 for furthest ‘behind’ the chair, 18 for furthest ‘in front of’ the chair) for future sentences. Note: The prediction of this study is that means for the proximal sentences (*Be Going to Future*) will be lower than the means for distal sentences (*Will Future*).

There is no effect of Temporal Distance nor a significant interaction of Temporal Distance and Character Direction, thus indicating that sentences with the *Be Going to Future* are not placed a significant distance from sentences with the *Will Future*. Specifically, participants separate proximal and distal future sentences by $.16 \pm .73$ segments (of 18) when the chair is facing away and $1.8 \pm .72$ segments (of 18) when the character is facing towards them.

4.3.3 Discussion

Unlike Experiment 1b, participants in Experiment 2b do, indeed, adopt the chair as an external deictic center to some degree. However, they place past sentences ‘in front of’ the chair and future sentences ‘behind’ the chair for both chair directions. This is exactly contrary to predictions, assuming I am correct about the canonical front and back of the chair. However, if we reverse my assumption about the chair’s back and front, the results directly follow predictions.



Figure 4.5. Experiment 2b assumptions versus participant responses. Left and Right: My assumptions about ‘behind’ and ‘in front’ of the chair compared to participant responses in Experiment 2b.

Despite my assumptions, it is clear that participants co-locate the present with the chair to some extent, thus suggesting that explicit activation of the Life is a Journey metaphor is not necessary for participants to adopt an external deictic center when placing sentences with grammaticalized constructions. This is important, as it is evidence that sentences need not be overt about the specific time of the event (as with adverbials), nor does the image need to explicitly activate a mental timeline in order to yield space-time mapping effects of external Deictic time.

With regard to fine-grained space-time topography, results are unclear. The near-effect between the *Be Going to* Future and *Will* Future when the chair is facing toward the participant is intriguing, as it suggests that participants may actually spatially separate these two constructions, but this particular paradigm does not capture this distinction. Assuming that the spatial paradigm of Experiments 1b and 2b was not adequate to capture the proximal-distal distinction between grammaticalized constructions, I developed a post-hoc experiment that uses temporal judgments as opposed to spatial ones.

4.4 Experiment 3 - Non-spatial Time Estimation with Constructions

Though they demonstrate that participants adopt both the man on the street and the chair on the beach as deictic centers, Experiments 2a and 2b do not provide convincing evidence of a

proximal-distal distinction between past constructions (Present Perfect vs. Simple Past) or future constructions (*Be Going to* Future vs. *Will* Future). There are three possible explanations for these results. First, there is simply no proximal-distal distinction between these constructions. Second, English speakers make fine-grained spatial distinctions for these constructions when processing internal Deictic time, but not external Deictic time. Third, English speakers make fine-grained distinctions between these forms, but these distinctions will not manifest themselves in a task that involves physical space. That is, for example, the *Be Going to* Future encodes more proximal events than the *Will* Future, but this distinction is purely temporal and in no way spatial. Experiment 3, a post-hoc experiment motivated by the near-significant results of Experiment 2b, addresses this third possibility with a task that involves a temporal judgment.

This third explanation speaks to the role of grammaticalization in the processing of temporal events. Grammaticalization describes a morpheme's integration into the grammatical system of a language, such that morphemes often become abstracted away from their original meanings through conventional usage. Take the *Be Going to* Future. Diachronically, it began as an expression of motion (the verb *go*), then became an expression of volition, and now is a marker of future tense (Bybee, 2006, p. 720). Bowdle and Gentner (2005) argue that metaphors undergo a similar process of abstraction through conventionalization. For example, the expression *gold mine*'s original meaning was a hole in the ground with valuable ore inside. Over its "career," it has come to mean any "source of good things." So, one can now say: *That website is a gold mine of information*. In other words, similar to grammaticalized morphemes, some metaphors undergo a career, from original literal meaning to metaphorical meaning (Bowdle & Gentner, 2005, p. 199).

In the case of the *Be Going to Future*, grammaticalization and the career of metaphor work hand in hand, where the construction had a literal meaning but, through conventional usage, became more abstract to incorporate metaphorical meaning (in this case, referencing an event in time). Presumably, this process of abstraction ‘moves’ a morpheme away from its literal meaning. In other words, the more conventional a particular metaphor is, the less that it will activate the metaphor’s spatial/motion origins in the mind of a speaker. Figure 4.6 below provides a visualization of my hypothesized relationship between grammaticalized constructions and increasingly abstract linguistic realizations of the Time is Space/Motion conceptual metaphor.

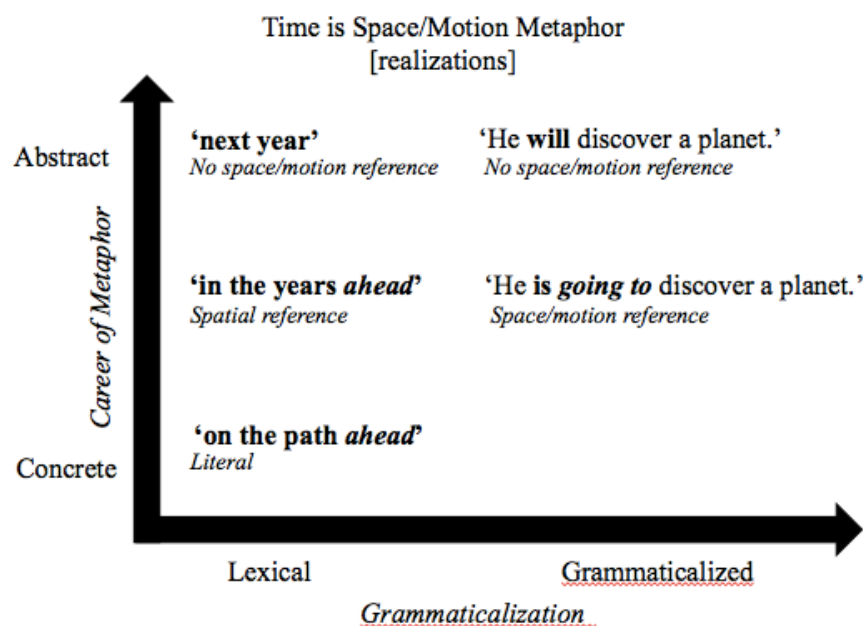


Figure 4.6. Realizations of the Time is Space/Motion conceptual metaphor. Presumably, constructions abstract away from concrete space/motion representations both in terms of grammaticalization *and* Bowdle and Gentner’s (2005) career of metaphor.

This observation produces strong predictions. Namely, it suggests that processing conventional metaphors (especially grammaticalized ones, which are presumably as conventional as metaphors can be) will not activate the metaphor’s source domain (see also Desai et al., 2011).

In the case of Time expressions, this suggests that using grammaticalized past and future constructions—specifically compared to lexical forms—will not necessarily activate representations of physical space and motion in the minds of speakers.

In short, I am arguing that past and future constructions are grammaticalized metaphorical constructions, and it is possible that grammaticalized metaphorical constructions will not activate spatial and motion representations to the same extent as lexical items (i.e., adverbials). If this is the case, then English speakers may, indeed, make fine-grained distinctions between past constructions and future constructions. However, these distinctions will only manifest themselves in a non-spatial task. That is, when English speakers process grammaticalized past and future constructions, they make proximal and distal temporal distinctions, but they do not necessarily recruit representations of physical space and motion to do so.

Therefore, motivated by Experiments 2a and 2b, Experiment 3 is a post-hoc experiment designed to test these predictions. Participants are provided a temporal event and are then given a non-spatial task: to estimate how long it has been since a past event occurred or how long it will take until a future event will occur. In other words, Experiment 3 is a follow-up to Experiments 2a and 2b. It tests whether English speakers do, indeed, make a proximal-distal distinction between past and future constructions.

4.4.1 Method

4.4.1.1 Participants

174 participants were recruited on Amazon's Mechanical Turk. The task took an average of 4 minutes, and participants were paid \$.50 each for their participation. This task was performed as a filler to a separate study involving metaphor and disease conceptualizations.

Based on a post-survey, which can be found in Appendix C, 25 participants were dropped due to lack of attention to the task (unable to remember the described event), leading to an analysis of 149 participants.

The experiment uses 2x2 between subjects design with Temporal Distance (Proximal vs. Distal) and Tense (Past vs. Future) as independent variables.

4.4.1.2 Stimuli

As subset of target sentences from Experiments 2a and 2b were used again, repeated here:

Present Perfect (Proximal Past)	<i>He has discovered a planet.</i>
Simple Past (Distal Past)	<i>He discovered a planet.</i>
Be Going to Future (Proximal Future)	<i>He's gonna discover a planet.</i>
Will Future (Distal Future)	<i>He will discover a planet.</i>

However, unlike Experiments 1a, 1b, 2a, and 2b, Experiment 3 uses only one clause with only the verb *discover*. The full clause was:

discover a planet

The study was designed using Qualtrics software.

4.4.1.3 Procedure

Participants read *only one* of the target sentences above and then were asked one of the following questions:

If you had to guess, how long ago did this event occur? for past sentences.
If you had to guess, how long until this event occurs? for future sentences.

Participants were given a Likert scale with seven options: (1) seconds, (2) minutes, (3) hours, (4) days, (5) weeks, (6) months, or (7) years.

4.4.2 Results

A Two-way Analysis of Variance with independent variables Temporal Distance (Proximal vs. Distal) and Tense (Past vs. Future) was run using R (R Core Team, 2012). The dependent variable was Time Estimate, or participants' estimate of time since an event or until an event on a 1-7 Likert scale (1 for seconds, 7 for years). The model revealed a main effect of Temporal Distance ($F(1, 148)=23.116, p < .001$). It also showed a main effect of Tense ($F(1, 148)=22.797, p < .001$). Lastly, the interaction between Temporal Distance and Tense was also significant ($F(1, 148)=6.404, p=.01$).

The significant effect of Temporal Distance means that participants estimated proximal past and future constructions (Present Perfect and *Be Going to* Future) as having occurred sooner or occurring sooner than distal past and future constructions (Simple Past and *Will* Future). This was exactly the prediction of the study, as based on previous literature (Comrie, 1985; Langacker, 2008).

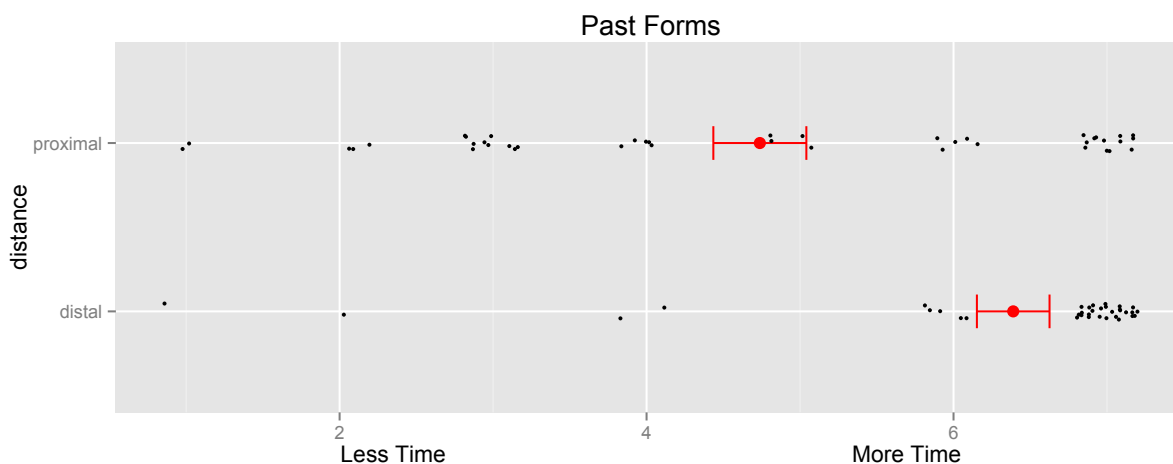


Figure 4.7. Experiment 3 results for past forms Present Perfect (proximal) versus Simple Past (distal). Participants answered *How long ago did this event occur?* on a Likert scale (1 seconds, 7 years).

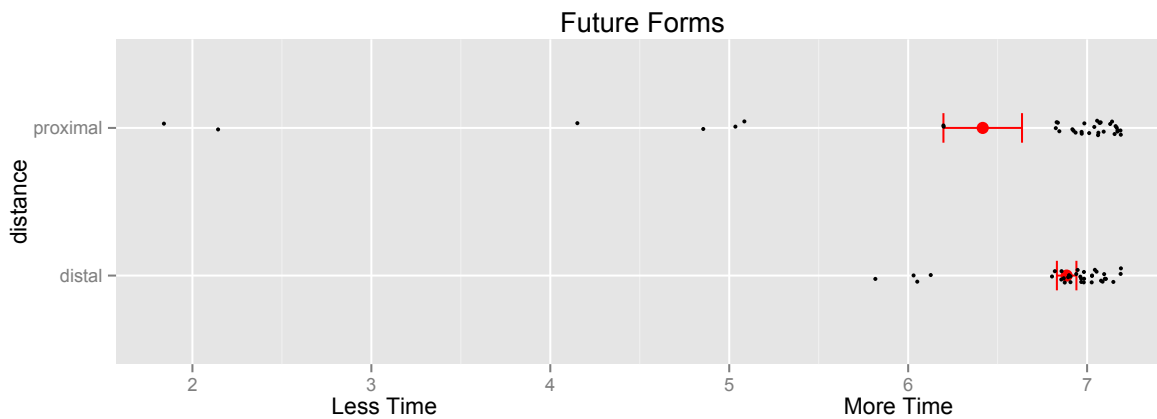


Figure 4.8. Experiment 3 results for future forms *Be Going to* Future (proximal) versus *Will* Future (distal). Participants answered *How long until this event occurs?* on a Likert scale (1 seconds, 7 years).

The main effect of Tense, though not necessarily predicted, is highly relevant to space-time topography. It means that, on average, participants estimate the exact same event (regardless of construction) as occurring more proximally to the present when in the past compared to the future. In other words, past events are more temporally proximal than future events, where past events are estimated to be weeks to months from the present and future events are estimated to be months to years from the present.

	Time Estimates by Tense			
	N	Mean	SD	SE
Past	78	5.5	1.91	0.22
Future	71	6.65	0.99	0.12

Table 4.7. Experiment 3 Time Estimates by tense. Means table of estimates on a Likert scale (1 seconds, 7 years)

The significant interaction between Temporal Distance and Tense indicates that the proximal-distal time estimate difference between past events (Present Perfect vs. Simple Past) is greater than the proximal-distal difference between future events. This is particularly clear from Figures 4.7, 4.8, and Table 4.7.

	Time Estimates by Temporal Distance							
Tense	Proximal				Distal			
	N	Mean	SD	SE	N	Mean	SD	SE
Past	42	4.74	1.96	0.3	36	6.39	1.42	0.24
Future	36	6.42	1.32	0.22	35	6.89	0.32	0.05

Table 4.8. Experiment 3 Time Estimates by temporal distance. Means table for time estimates on a Likert scale (1 seconds, 7 years).

This significant interaction warrants a post-hoc analysis to determine whether the difference between proximal-distal time estimates for past constructions are primarily responsible for the main effect of Temporal Distance, or if the proximal-distal distinction between future constructions is also significant. To this end, two simple t-tests were used to compare the data from the two past groups and the two future groups.

A Welch two sample t-test comparing past sentences (Present Perfect vs. Simple Past) reveals a significant difference between the two conditions ($t(1, 78)=4.2937, p < .001$). In other words, the proximal sentence *He has discovered a planet* is judged as occurring more recently than the distal sentence *He discovered a planet*. For the future sentences (*Be Going to Future* vs. *Will Future*), a Welch two sample t-test reveals a significant difference between *be going to* and *will* ($t(1, 70)=2.0731, p=.045$), where participants judge *He's gonna discover a planet* as happening sooner than *He will discover a planet*. In other words, the proximal-distal distinction is more robust between past constructions than future constructions, but the difference between future constructions is, indeed, significant. The reason for the smaller effect for future constructions is unclear, but it may be a dialectal difference, where some English speakers judge the *Be Going to Future* as more temporally proximal than others. Future research would be required to address such dialectal differences.

4.4.3 Discussion

As a post-hoc follow-up to Experiments 2a and 2b, Experiment 3 demonstrates a proximal-distal distinction between both past constructions (Present Perfect vs. Simple Past) and future constructions (*Be Going to* Future vs. *Will* Future). This experiment thus provides empirical support for assumptions about the space-time topography encoded in grammaticalized constructions, constructions that do not explicitly make reference to proximal or distal time (Comrie, 1985; Langacker, 2008). Specifically, English speakers judge the discovery of a planet as occurring more recently when described with the Present Perfect (*He has discovered a planet*) compared to the Simple Past (*He discovered a planet*). They also judge the event as more temporally proximal when described with the *Be Going to* Future (*He's gonna discover a planet*) compared to the *Will* Future (*He will discover a planet*).

Though the results should be taken with caution due to the use of only one verb (*discover*), Experiment 3 helps to round out the story of space-time mapping with grammaticalized constructions. When given a non-spatial task, participants make proximal-distal temporal distinctions between past and future constructions. This is evidence that speakers do not necessarily recruit physical space when construing temporal events based on past and future constructions. Perhaps these grammaticalized metaphors have been abstracted away from their spatial and motion origins enough that English speakers do not process space and motion to estimate the time at which they occurred.

There is one important observation to be made here, however. Experiment 3 does not distinguish between external Deictic time and internal Deictic time. Therefore, it is entirely possible that English speakers are, indeed, recruiting representations of space and motion to perform the time estimation task for Experiment 3. Unlike Experiments 2a and 2b, however, they

are recruiting internal Deictic time representations, co-locating the present with the ego.

Unfortunately, Experiment 3's paradigm does not provide conclusive evidence as to whether or not the effect is due to (1) abstraction from space/motion representations or (2) internal Deictic time representations, or both. Further research will be required to disentangle these possibilities.

Lastly, Experiment 3 shows that English speakers estimate the same event to be more proximal if in the past (weeks to months from the present) than in the future (months to years from the present). This adds to the converging evidence in this dissertation that the past is conceptualized differently than the future. This will be more thoroughly addressed in Chapter 7.

4.5 General Discussion

Experiment 2a adds to the story of Experiments 1a and 1b, showing the limits of participants' adoption of an external locus as the deictic center. When the man on the street is facing away from the participant or, in other words, congruent with their own internal Deictic time, participants place past sentences behind the character and future sentences in front of the character. However, when the character is facing toward the participant, this effect is less dramatic: participants are less inclined to co-locate the present with the man. This interaction of Tense and Character Direction speaks to the conditions required for participants to adopt an external locus as a deictic center. In Experiment 1a, which uses time adverbials, participants reliably adopt the character as a deictic center when facing both directions. When adverbials are not present, participants only adopt the character when his direction is congruent with their own internal Deictic time. In other words, as linguistic cues become less specified (from adverbials to grammaticalized constructions), participants become less likely to adopt an external deictic center when the deictic center is incongruent with their own internal Deictic time conceptualization. This result thus speaks to the primacy of internal Deictic time, but it also

shows the necessary conditions for participants to transfer from internal Deictic time to external Deictic time.

Unlike Experiment 1b, Experiment 2b suggests that English speakers do construe temporal events using the front-back depth of an image without explicit use of the Life is a Journey metaphor. Though the results from this experiment do leave some lingering questions—such as why participants adopted the chair in the opposite of the predicted direction—it is clear that participants do co-locate the present with the chair to some degree. This starkly contrasts with the findings of researchers like Ulrich et al. (2012), who claim that space-time mapping effects are the result of researchers explicitly activating a mental timeline in the minds of speakers. Moreover, this effect is for a strictly spatial task, thus indicating that external Deictic time involves only representations of static space (and not necessarily of motion).

In terms of fine-grained space-time topography, Experiments 2a and 2b show that English speakers do not recruit fine-grained spatial distinctions between grammaticalized constructions, even for future sentences. However, Experiments 2a and 2b involve strictly spatial tasks of external Deictic time. To address this null result, Experiment 3 involves a non-spatial task, and it shows that English speakers do, indeed, make fine-grained time distinctions between both past and future grammaticalized constructions. In other words, participants judge the same event as more proximal when described with the *Be Going to* Future and as more distal in the future when described with the *Will* Future. The same applies to past events: participants judge events described in the Present Perfect as occurring more recently in the past than events described with the Simple Past. Importantly, these results are very much in line with predictions made in the linguistics literature (Brisard, 2001; Comrie, 1985; Langacker, 2008). Moreover, the proximal-distal effect in Experiment 3 compared to Experiments 2a and 2b is strong evidence in

favor of Bowdle and Gentner's (2005) of metaphor theory. Whereas lexical items that make reference to fine-grained temporal distinctions yield spatial results (Experiment 1a), grammaticalized constructions may not require the construal of actual physical space. That is, frequent forms that have become grammaticalized slowly abstract away from spatial representations, such that English speakers are able to make fine-grained temporal distinctions in a non-spatial task. This is akin to the results of Desai et al. (2011), who show that embodied metaphors (e.g., *grasp*) involve the recruitment of motor cortex, but more abstract forms of the same metaphor (e.g., *understand*) do not.

Lastly, Experiment 3 contributes an unexpected element to the map of English speakers' space-time topography. When provided an identical event, the *discovery of a planet*, English speakers judge the event to have occurred weeks to months in the past but months to years in the future, regardless of the construction used. In other words, speakers conceptualize past events as temporally closer than future events. This is further evidence of a fundamental difference between the past and future, an issue that will be addressed further in Chapter 7.

Chapter V:

External Deictic Time and Modal Verbs

5.1 Introduction

Experiments 1-3 offer evidence of space-time topography for external Deictic time, demonstrating that English speakers adopt a character on an image with front-back depth as a deictic center, placing past sentences behind the character and future sentences in front of the character. These experiments also show that, when the sentences include time adverbials, participants place proximal future events closer to the deictic center than distal future events. Participants do not, however, demonstrate a proximal-distal distinction in the sentence placement task when placing sentences with grammaticalized constructions for the past (Present Perfect vs. Simple Past) or future (*Be Going to* Future vs. *Will* Future). These past and future constructions, however, encode the realis mood, or statements that the speaker presumably believes are true (Palmer, 2001). But speakers are not limited to realis sentences: they may also talk of the past and future with varying degrees of certainty. In English, epistemic modal verbs provide an efficient means for expressing the speaker's attitude towards or certainty of an event, or the irrealis mood (Palmer, 2001).

In fact, certainty of an event—as encoded in English epistemic modal verbs—could influence speakers' conceptualizations of an event's temporal proximity. In other words, modal verbs may play a role in English speakers' space-time topography. For example, Langacker

(2008) argues that “immediate” modal forms encode greater certainty than “nonimmediate” modal forms. Immediate verbs include *may*, *can*, *will*, *shall*, and *must*, whereas nonimmediate verbs include *might*, *could*, *would*, and *should*. According to Langacker (2008, p. 308), immediate forms encode “potential acceptance” about a future event based on evidence available in the speaker’s “immediate circumstances.” A nonimmediate form, on the other hand, “implies that the assessment conveyed is not sanctioned by...[the speaker’s] own immediate circumstances.” In other words, “using *might* rather than *may* serves to distance the speaker from the circumstances that justify the latter” (Langacker, 2008, p. 308). If this analysis is correct, then I hypothesize that immediate forms could encode more proximal (or present evidence-related) future than nonimmediate forms. Take the following two sentences, provided by Langacker (2008, p. 308):

They may finish the job next week.
They might finish the job next week.

By Langacker’s (2008) analysis, the immediate form *may* encodes a more certain and possibly more proximal future than the nonimmediate form *might*. These forms, of course, may also be used to reference past events. As Langacker (2008, p. 307) observes:

When modals are used in reference to past occurrences, English resorts to the perfect construction, where the grounded verb is *have*: *She may have already mailed it*. The modal assessment thus pertains to a present situation—that of a prior event being found in the current sphere of relevance.

That is, modal verbs *may* and *might* are used with the perfect construction in English, as in the following examples:

The may have finished the job last week.
They might have finished the job last week.

Even when referring to past events, I argue that the use of immediate and nonimmediate forms may modulate hearers’ construal of the event in proximal or distal time. In other words, based on Langacker’s (2008) model, one can make strong predictions about the correlation of Time and

space, such that immediate forms have a stronger association with the present (or encode more proximal events) and nonimmediate forms have less of an association with the present (or encode more distal events) for both past and future events.

Langacker's (2008) model is preliminarily supported in the experimental literature. Kaup et al. (2007), for example, show that English speakers process irrealis sentences, or unrealized events, just as we process realis sentences, or realized events—through mental simulations. In their experiments, participants read an irrealis sentence, such as *There is no eagle in the sky*, and then viewed a congruent image (a bird in flight) or an incongruent image (a bird with folded wings). When asked if the image had been described in the sentence, participants were faster to respond to the congruent image than the incongruent image. This shows that English speakers process events that do not happen in a similar way that we process events that do happen.

Fernández de Lara (2012) extends these findings to the space-time mapping domain, showing that Spanish speakers process irrealis temporal sentences similar to realis ones. In a paradigm with which participants respond 'past' or 'future' with their left or right hands, he shows that participants are faster to process irrealis sentences when they are congruent in physical space with a temporal event, with the past on the left and future on the right of a computer screen. That is, participants also map spatial representations to temporal representations, even when the sentences are in the irrealis mood.

These studies show that speakers process the irrealis mood similar to the realis mood, even when construing temporal events. They thus provide initial empirical support for Langacker's (2008) model of English modal verbs and the possibility that they encode proximal-distal temporal events. But several important questions still remain. With regard to external Deictic time, it is unclear whether or not English speakers co-locate the present with an external

locus when construing events in the irrealis mood. If they do, it would mean that speakers also construe potential temporal events—and not just actual events—with physical space. Second, it has yet to be empirically demonstrated that modal verbs like *may* and *might* do, in fact, encode a proximal-distal spatial distinction. If this is the case, then certainty modulates how English speakers construe temporal events. These are critical issues to space-time topography, and they help extend the space-time mapping literature to include a much more robust picture of the means by which English speakers think about all past and future events.

The sentence placement paradigm established in the previous chapters, which examines proximal-distal distinctions in external Deictic time, is ideal to address the role of modal verbs in space-time topography. Therefore, the research questions, as numbered from Chapter 2, for the following experiments are as follows:

External Deictic Time

RQ1. Under what conditions do English speakers construe temporal events with an external deictic center (as opposed to an internal one)?

RQ1a. Do English speakers construe external Deictic time using an image with front-back physical space (as opposed to left-right physical space)?

RQ1b. Do English speakers adopt a deictic center that is incongruent with their own internal Deictic time?

RQ1c. Does the adoption of an external deictic center require explicit reference to Time in terms of physical space, or the explicit activation of a mental timeline?

Fine-grained Space-time Mapping

RQ2. Do English speakers construe coarse-grained (categorical front/back) or fine-grained (landscape) spatial representations when space-time mapping?

RQ2a. Does this vary based on speakers' construal of external Deictic time versus internal Deictic time?

RQ2d. Do epistemic modal verbs *may* and *might* encode fine-grained spatial representations?

RQ3. Do space-time construals involve static *spatial* representations or *motion* representations?

Experiments 4a and 4b below address these questions using the sentence placement paradigm.

5.2 Experiment 4a – Modals on the Street

Using the sentence placement methodology established in Experiments 1-2, Experiment 4a asks participants to place sentences with the forms *may* and *might* on an image with a man on a street. The prediction for Experiment 4a is that participants will place sentences that express greater certainty about a past or future event based on perceptually available evidence (*may*) physically closer to a deictic center than sentences that express less certainty about a past or future event (*might*).

5.2.1 Method

5.2.1.1 Participants

For Experiment 4a, 32 participants were recruited on Amazon's Mechanical Turk. The task took an average of 14 minutes, and participants were paid \$2.00 each for their participation. Only participants with a 90% approval rating or higher who had performed at least 500 previous tasks were employed.

Based on results of a post-survey, which can be found in Appendix C, three participants were dropped due to lack of attention (unable to remember the color of the character's shirt), and one was dropped due to guessing the intention of the study, leaving a total of 28 participants for the final analysis.

I conducted four analyses investigating the effects of Form (May vs. Might), Tense (Past vs. Future), and Character Direction (Away vs. Towards) on participants' choice of spatial location for sentence placement.

5.2.1.2 Stimuli

Participants read 16 target stimuli sentences in four conditions mixed with 32 filler sentences. The four conditions are as follows:

Past May (Proximal)	<i>He may have begun a letter.</i>
Past Might (Distal)	<i>He might have stopped a fight.</i>
Future May (Proximal)	<i>He may win a bike.</i>
Future Might (Distal)	<i>He might discover a planet.</i>

As in Experiments 1-2, all stimuli were cross-balanced across four different groups and presented in random order. All sentences used the same clauses as stimuli from Experiments 1-2.

The study was designed using Qualtrics survey software.

5.2.1.3 Procedure

The task was identical to Experiments 1a and 2a, where participants placed sentences on an image of a man on a street based on ‘visual appeal.’

5.2.2 Results

Responses whose locations were more than two standard deviations from the mean for each Form x Tense x Character Direction condition were removed, resulting in the loss of 11 observations and a total of 437 observations for the final analysis.

The first statistical analysis addresses whether or not participants adopted the character as the deictic center (or co-located the present with the character) and placed past-related sentences behind him and future-related sentences in front of him. As with the previous experiments, to answer this question, sentence placement location was again coded as a categorical variable where the center of the images (and character) mark the distinction between ‘behind’ and ‘in front of.’

A mixed effects logistic regression analysis was run using Location (‘front’ versus ‘behind’) as the dependent variable. The model included fixed effects of Tense (Past vs. Future) and Character Direction (Away vs. Towards) and random effects of Participant and Item. I tested for a main effect of Tense by conducting a likelihood ratio test comparing a mixed-effects model

that included Tense and Character Direction as fixed effects with a model that included only Character Direction as the fixed effect. The likelihood ratio test revealed a main effect of Tense ($\chi^2(1)=6.9326$, $p=.031$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table E in Appendix A. A comparison between a model containing Tense and Character Direction and a model with only Tense showed a main effect of Character Direction ($\chi^2(1)=8.38.18$, $p=.015$). A further comparison between a model containing the fixed effects of Tense and Character Direction with a model including an interaction between Tense and Character Direction revealed no significant effect of the interaction term ($\chi^2(1)=1.3332$, $p=.248$).

In Experiment 4a, participants co-locate the present with the man on the street, even with sentences in the irrealis mood. They place past sentences behind him and future sentences in front of him. There is no significant interaction, and that indicates that participants place past sentences behind the character and future sentences in front of the character both when the character is facing away and facing towards them. This indicates that, as in Experiment 1a, English speakers shift their external deictic perspective flexibly based on the orientation of the character on the street.

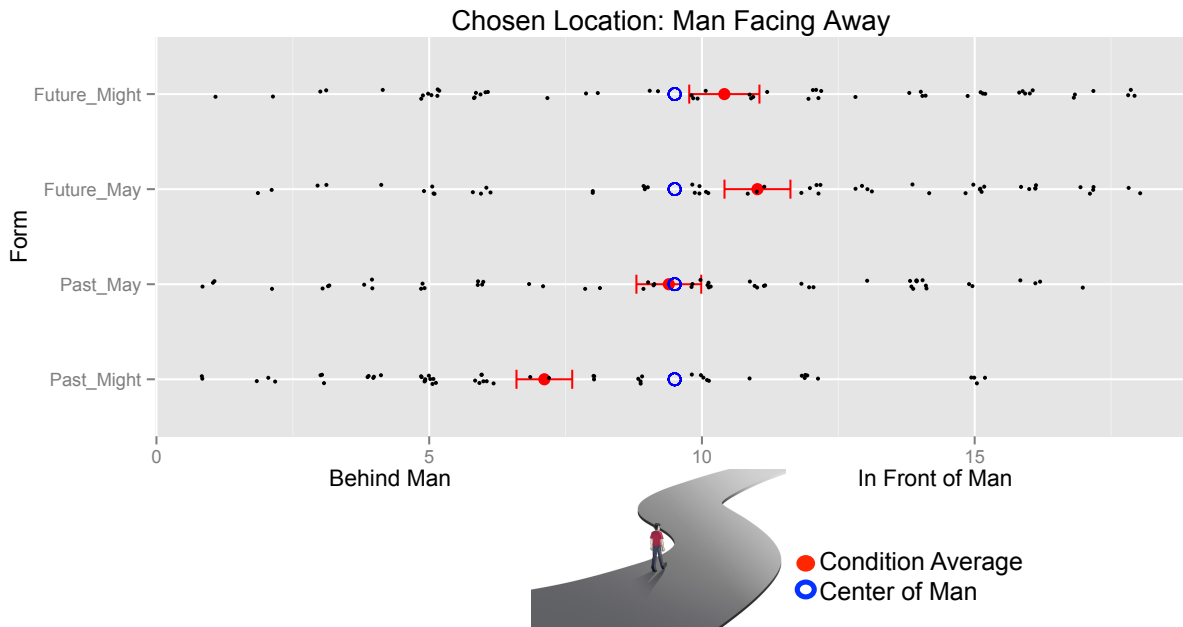


Figure 5.1. Experiment 4a results when the character is facing away from the participant, or congruent with his/her internal Deictic time. Red dots indicate condition means, or the average sentence placement location for each modal verb condition. Blue dots indicate the center of the character/image, and black dots represent all individual observations.

The second analysis examines the extent to which participants utilized physical distance when placing past sentences. A mixed effects linear regression model was run to address this question. As with the previous experiments, the second model uses the Relative Location dependent variable (1 furthest behind character, 18 furthest in front of the character). The model again included Tense (Past vs. Future) and Character Direction (Away vs. Towards) as fixed effects and Participant and Item as random effects. I examined a main effect of Tense by conducting a likelihood ratio test comparing a mixed-effects model that included Tense and Character Direction as fixed effects with a model that included only Character Direction as the fixed effect. The likelihood ratio test revealed a main effect of Tense ($\chi^2(1)=12.057$, $p = .002$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table E in Appendix A. Again, a comparison between a model containing Tense and Character Direction and a model with only Tense showed that Character Direction also contributes significantly to

the model ($\chi^2(1)=17.08, p < .001$). Lastly, the comparison between a model containing the fixed effects of Tense and Character Direction with a model including an interaction between Tense and Character Direction revealed a significant effect of the interaction term ($\chi^2(1)=4.23, p=.04$).

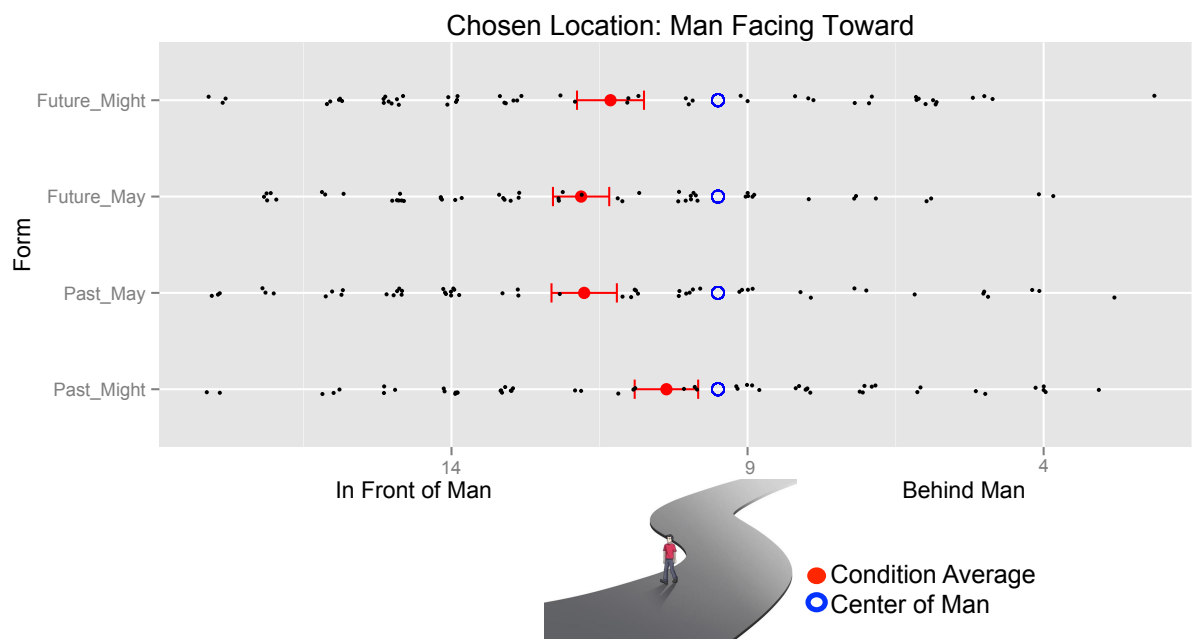


Figure 5.2. Experiment 4a results when the character is facing towards the participant, or incongruent with his/her internal Deictic time. Note that the x axis in this figure is reversed to reflect the Relative Location dependent variable.

This linear mixed effects analysis adds to the first logistic regression of Experiment 4a, showing that participants attend to the character when placing past and future sentences, but the nature of this attention is different for the two character orientations: participants place a greater distance between past and future sentences when the character is facing away than when facing towards them. This is consistent with the results of Experiment 2a (with grammaticalized constructions and the man on the street), where participants also place greater distance between past and future sentences when the character faces away from them. Specifically, participants separate past and future sentences by $2.36 \pm .65$ segments (of 18) when the character is facing away from the participant and $.43 \pm .65$ segments (of 18) when the character is facing towards the

participant. This is thus further evidence that English speakers are more inclined to separate sentences when the image is congruent with their own internal Deictic time.

	Relative Location for Tense					
Character Direction	Past			Future		
	Mean	SD	SE	Mean	SD	SE
Away	8.27	4.26	0.41	10.71	4.66	0.44
Towards	11.06	4.04	0.39	11.56	3.82	0.37

Table 5.1. Experiment 4a Relative Location for tense. Means table using the Relative Location dependent variable (1 for furthest behind character, 18 for furthest in front of character) for tense.

To examine the fine-grained space-time topography of past forms, a mixed effects linear regression analysis of only past sentences with Relative Location (1 furthest behind the character, 18 furthest in front of the character) as the dependent variable was run. The model included Form (May vs. Might) and Character Direction (Away vs. Towards) as fixed effects and Participant and Item as random effects. A main effect of Form was tested by conducting a likelihood ratio test comparing a mixed-effects model that included Form and Character Direction as fixed effects with a model that included only Character Direction as the fixed effect. The likelihood ratio test revealed a main effect of Form for past sentences ($\chi^2(1)=7.1327$, $p = .028$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table E in Appendix A. A comparison between a model containing Form and Character Direction and a model with only Form showed that Character Direction contributes significantly to the model ($\chi^2(1)=14.156$, $p < .001$). Lastly, the comparison between a model containing the fixed effects of Form and Character Direction with a model including an interaction between Form and Character Direction revealed no significant effect of the interaction term ($\chi^2(1)=0.659$, $p=.417$).

	Relative Location for Past Sentences					
Character Direction	<i>May</i> (Proximal)			<i>Might</i> (Distal)		
	Mean	SD	SE	Mean	SD	SE
Away	9.39	4.45	0.59	7.11	3.76	0.51
Towards	11.76	4.06	0.55	10.37	3.94	0.54

Table 5.2. Experiment 4a Relative Location for past sentences. Means table using the Relative Location dependent variable (1 for furthest behind character, 18 for furthest in front of character) for past sentences. Note: The prediction of this study is that means for the proximal sentences (*may*) will be *higher* than the means for distal sentences (*might*).

This analysis of past sentences shows a main effect of Form, meaning that participants reliably place *may* and *might* sentences a significant distance from one another. Moreover, the lack of interaction suggests that this occurs both when the character is facing away from and towards the participant. This result is particularly clear on Figure 5.1 with the image of the man facing away from the participant, where *may* is placed closer to the deictic center than *might* for past sentences. Participants separate *may* or *might* by $2.34 \pm .94$ segments (of 18) when the character faces away and $1.26 \pm .94$ segments (of 18) when the character faces towards them.

The final analysis examines *may* and *might* for future sentences. A mixed effects linear regression model was run only on future sentences with Relative Location (1 furthest behind the character, 18 furthest in front of the character) as the dependent variable. This model included Form (May vs. Might) and Character Direction (Away vs. Towards) as fixed effects and Participant and Item as random effects. I tested for a main effect of Form by conducting a likelihood ratio test comparing a mixed-effects model that included Form and Character Direction as fixed effects with a model that included only Character Direction as the fixed effect. The likelihood ratio test revealed no main effect of Form for future sentences ($\chi^2(1)=1.2928$, $p=.524$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table E in Appendix A. A comparison between a model containing Form and Character Direction and a model with only Form showed that Character Direction did not contribute

significantly to the model ($\chi^2(1)=2.4975$, $p = .287$). Lastly, the comparison between a model containing the fixed effects of Form and Character Direction with a model including an interaction between Form and Character Direction shows no significant effect of the interaction term ($\chi^2(1)=0.0009$, $p=.974$).

	Relative Location for Future Sentences					
Character Direction	May (Proximal)			Might (Distal)		
	Mean	SD	SE	Mean	SD	SE
Away	11.02	4.52	0.6	10.41	4.82	0.64
Towards	11.81	3.46	0.48	11.31	4.16	0.57

Table 5.3. Experiment 4a Relative Location for future sentences. Means table using the Relative Location dependent variable (1 for furthest behind character, 18 for furthest in front of character) for future sentences. Note: The prediction of this study is that means for the proximal sentences (*may*) will be *lower* than the means for distal sentences (*might*).

Experiment 4a reveals no significant effect of Form (proximal *may* vs. distal *might*) for future sentences. In other words, participants do not place *might* sentences further from the deictic center than *may* sentences. Participants separate *may* and *might* future sentences by $.61 \pm .72$ segments (of 18) when the character faces away and $.58 \pm .74$ segments (of 18) when the character faces towards them.

5.2.3 Discussion

Experiment 4a shows that, even with sentences in the irrealis mood with modal verbs *may* and *might*, participants co-locate the present with man on the street by placing past sentences behind him and future sentences in front of him for both images. This shows that English speakers make use of physical space for external Deictic time even when construing potential events, and they are dynamic in this construal. As with Experiment 2a, this effect is particularly strong when the man is facing away from the participant, or is congruent with the participants' internal Deictic time. Lastly, this effect is strictly spatial, as the task only involves

physical space. As with Experiments 1a, 2a, and 2b, this is further evidence that space-time mapping with external Deictic time is primarily a spatial phenomenon, with no apparent motion representation.

Experiment 4a also offers exciting results in terms of fine-grained space-time topography. Unlike previous experiments, there is no fine-grained distinction for future tense sentences. However, participants place past sentences with *may* and *might* a significant distance from one another both when the character is facing away from and towards them. Experiment 4a thus supports Langacker's (2008) predictions, but only for events that have already taken place. This suggests that using space to think about temporal events can be modulated by degree of certainty about an event, but space recruitment is only necessary/beneficial when thinking about past events when those events are in the irrealis mood. This may be because future events are equally difficult to predict, so they have a low likelihood regardless of the form being used. Regardless of the reason, this provides further evidence that English speakers construe past events differently from future events, a topic that will be addressed in Chapter 7.

5.3 Experiment 4b – Modals on the Beach

Experiment 4a shows both that participants co-locate the present with the man on the street for sentences in the irrealis mood and that they draw a proximal-distal distinction between *may* and *might* for past sentences. However, these effects may be the consequence of the explicit activation of the Life is a Journey metaphor. Therefore, to determine whether or not the space-time topography effect is prompted by explicit use of this metaphor, Experiment 4b asks participants to place sentences on an image featuring a chair on a beach.

5.3.1 Method

5.3.1.1 Participants

For Experiment 4b, 31 participants were recruited on Amazon's Mechanical Turk. The task took an average of 18 minutes, and participants were paid \$2.00 each for their participation. Only participants with a 90% approval rating or higher who had performed at least 500 previous tasks were employed.

Due to results from a post-survey, which can be found in Appendix C, seven participants were dropped due to lack of attention (unable to remember the color of the chair), and none were dropped due to guessing the intention of the study, leaving a total of 24 participants for analysis.

I again conducted four analyses investigating the effects of Form (May vs. Might), Tense (Past vs. Future), and Character Direction (Away vs. Towards) on participants' choice of spatial location for sentence placement.

5.3.1.2 Stimuli

The sentence stimuli were the same as Experiment 4a. Only the image was changed for Experiment 4b, where participants instead viewed images of a chair on a beach.

The study was designed using Qualtrics survey software.

5.3.1.3 Procedure

The task was the same as Experiment 4a, where participants choose locations to place a sentence on an image of a beach instead of an image of man on a street based on 'visual appeal.'

5.3.2 Results

Responses whose locations were more than two standard deviations from the mean for each Form x Tense x Character Direction condition were removed, resulting in the loss of 25 observations and 359 observations for the final analysis.

The first statistical analysis of Experiment 4b addresses whether or not participants adopted the chair as the deictic center (or co-located the present with the chair) and placed past-related sentences behind the chair and future-related sentences in front of it. To answer this question, sentence placement location was again coded as a categorical variable where the center of the images (and chair) mark the distinction between ‘behind’ and ‘in front of.’

A mixed effects logistic regression analysis was run using Location (‘behind’ versus ‘front’) as the dependent variable. The model included Tense (Past vs. Future) and Character Direction (Away vs. Towards) as fixed effects and Participant and Item as random effects. The main effect of Tense was tested by conducting a likelihood ratio test comparing a mixed-effects model that included Tense and Character Direction fixed effects with a model that included only Character Direction as the fixed effect. The likelihood ratio test revealed no significant main effect of Tense ($\chi^2(1)=3.8362$, $p=.147$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table F in Appendix A. A comparison between a model containing Tense and Character Direction and a model with only Tense showed a main effect of Character Direction ($\chi^2(1)=106.87$, $p<.001$). A further comparison between a model containing the fixed effects of Tense and Character Direction with a model including an interaction between Tense and Character Direction reveals an interaction term that nears significance ($\chi^2(1)=3.7939$, $p=.051$).

Experiment 4b shows no main effect of Tense, indicating that participants do not place past sentences behind the chair and future tenses in front of chair, regardless of chair direction. The interaction between Tense and Character Direction that approaches significance, however, suggests that participants may attend to the chair as a deictic center more when the chair is facing towards them as opposed to away (again challenging the canonical ‘front’ and ‘back’ of the chair

(as in Experiment 2b with grammaticalized constructions and the image of the chair on the beach).

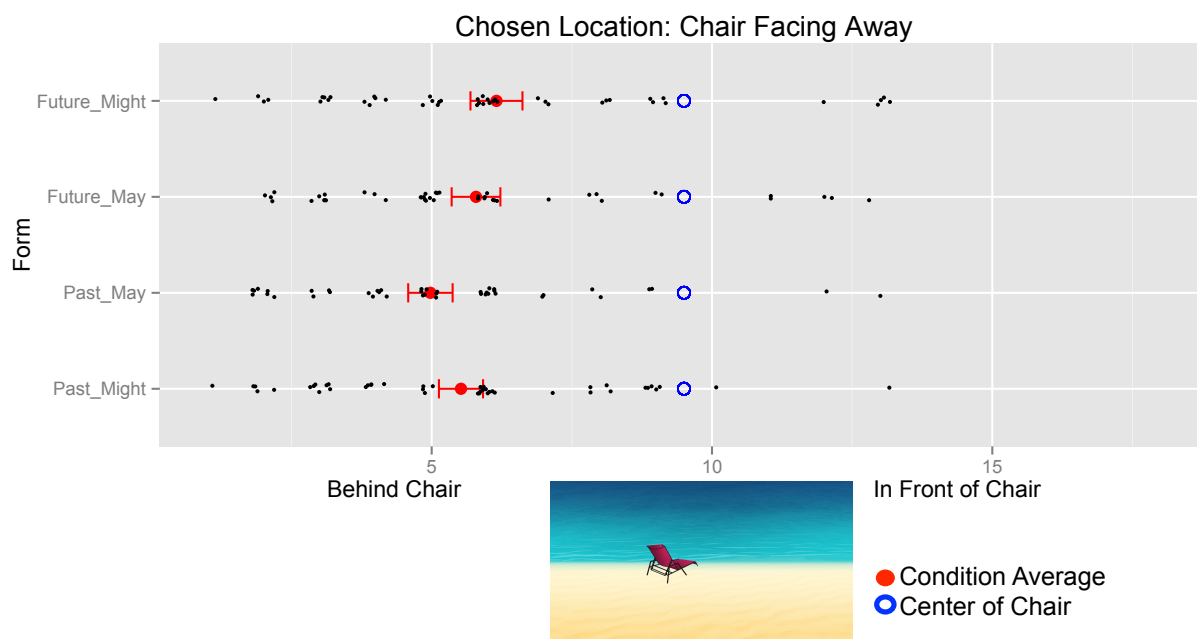


Figure 5.3. Experiment 4b results when the chair is facing away from the participant, or congruent with his/her internal Deictic time.

The second model utilizes the Relative Location dependent variable (1 furthest behind chair; 18 furthest in front of chair) to examine the extent to which participants separated sentences on the image. A mixed effects linear regression analysis was run to address this question, and it included Tense (Past vs. Future) and Character Direction (Away vs. Towards) as fixed effects and Participant and Item as random effects. I examined a main effect of Tense by conducting a likelihood ratio test comparing a mixed-effects model that included Tense (Past vs. Future) and Character Direction (Away vs. Towards) as fixed effects with a model that included only Character Direction as the fixed effect. The likelihood ratio test revealed a main effect of Tense that neared significance ($\chi^2(1)=5.3909$, $p=.068$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table F in Appendix A. Again, a comparison between a model containing Tense and Character Direction and a model with only Tense showed

that Character Direction also contributes significantly to the model ($\chi^2(1)=141.83$, $p < .001$). Lastly, the comparison between a model containing the fixed effects of Tense and Character Direction with a model including an interaction between Tense and Character Direction revealed a significant effect of the interaction term ($\chi^2(1)=5.365$, $p=.021$).

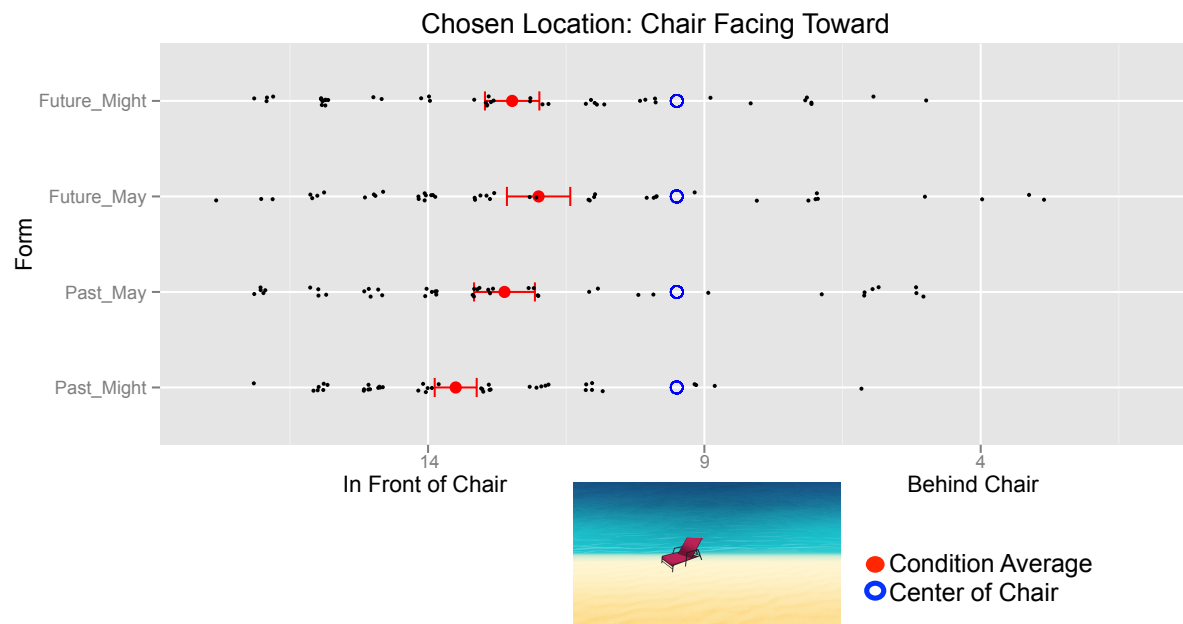


Figure 5.4. Experiment 4b results when the chair is facing towards the participant, or incongruent with his/her internal Deictic time. Note that the x axis in this figure is reversed to reflect the Relative Location dependent variable.

Again, this second analysis demonstrates no main effect of Tense, so participants did not place past sentences behind the chair and future sentences in front of the chair regardless of chair direction. However, the significant interaction term shows that participants did attend to the chair when it was facing towards them, as they separate past and future sentences for this image. Specifically, participants place past and future sentences $.73 \pm .47$ segments (of 18) apart when the chair faces away and $.8 \pm .46$ segments (of 18) apart when the chair faces towards them. As Table 5.4 below shows, where all sentence placement means are between the participant and the chair, this may again be a consequence of participants defaulting to internal Deictic time when the chair is congruent with their internal Deictic time (though it is technically incongruent based on

my assumptions of the canonical back and front of the chair), placing future sentences further away from the ego than past sentences. Again, regardless of why participants adopt the chair in this direction, it is still further evidence of English speakers utilizing the front-back depth of an image without explicit activation of the Life is a Journey metaphor.

	Relative Location for Tense					
Character Direction	Past			Future		
	Mean	SD	SE	Mean	SD	SE
Away	5.25	2.62	0.28	5.98	2.97	0.32
Towards	13.04	3.24	0.34	12.24	3.61	0.38

Table 5.4. Experiment 4b Relative Location for tense. Means table using the Relative Location dependent variable (1 for furthest behind character, 18 for furthest in front of character) for tense.

To examine fine-grained space-time topography of past sentences, a mixed effects linear regression analysis of only past sentences with Relative Location (1 furthest behind the character, 18 furthest in front of the character) as the dependent variable. The model included Form (May vs. Might) and Character Direction (Away vs. Towards) as fixed effects and Participant and Item as random effects. I tested for a main effect of Form by conducting a likelihood ratio test comparing a mixed-effects model that included Form and Character Direction as fixed effects with a model that included only Character Direction as the fixed effect. The likelihood ratio test revealed no main effect of Form for past sentences ($\chi^2(1)=2.8383$, $p=.705$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table F in Appendix A. A comparison between a model containing Form and Character Direction and a model with only Form showed that Character Direction contributes significantly to the model ($\chi^2(1)=83.821$, $p < .001$). Lastly, the comparison between a model containing the fixed effects of Form and Character Direction with a model including an interaction between

Form and Character Direction revealed no significant effect of the interaction term

($\chi^2(1)=0.1501$, $p=.6984$).

Character Direction	Relative Location for Past Sentences					
	<i>May</i> (Proximal)			<i>Might</i> (Distal)		
	Mean	SD	SE	Mean	SD	SE
Away	4.98	2.63	0.4	5.52	2.61	0.39
Towards	12.62	3.77	0.55	13.5	2.52	0.38

Table 5.5. Experiment 4b Relative Location for past sentences. Means table using the Relative Location dependent variable (1 for furthest behind character, 18 for furthest in front of character) for past sentences. Note: The prediction of this study is that means for the proximal sentences (*may*) will be *higher* than the means for distal sentences (*might*).

In short, the linear mixed effects analysis of past sentences demonstrates no difference between the placement of *may* sentences and *might* sentences. Participants place past *may* and *might* sentences $.54 \pm .62$ segments (of 18) apart when the character is facing away and $.88 \pm .61$ segments (of 18) apart when the character is facing towards them. When compared to the findings of Experiment 4a, this suggests that the physical separation of past *may* and *might* sentences is dependent on the explicit activation of the Life is a Journey metaphor.

Lastly, a mixed effects linear regression analysis was run only on future sentences with Relative Location (1 furthest behind the chair, 18 furthest in front of the chair) as the dependent variable. The model included Form (May vs. Might) and Character Direction (Away vs. Towards) as fixed effects and Participant and Item as random effects. I tested for a main effect of Form by conducting a likelihood ratio test comparing a mixed-effects model that included Form and Character Direction as fixed effects with a model that included only Character Direction as the fixed effect. The likelihood ratio test revealed no main effect of Form for future sentences ($\chi^2(1)=0.7548$, $p=.686$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table F in the Appendix A. A comparison between a model containing Form and

Character Direction and a model with only Form showed that Character Direction contributes significantly to the model ($\chi^2(1)=60.692$, $p < .001$). Lastly, the comparison between a model containing the fixed effects of Form and Character Direction with a model including an interaction between Form and Character Direction shows no significant effect of the interaction term ($\chi^2(1)=0.0134$, $p=.091$).

	Relative Location for Future Sentences					
Character Direction	<i>May</i> (Proximal)			<i>Might</i> (Distal)		
	Mean	SD	SE	Mean	SD	SE
Away	5.79	2.85	0.43	6.16	3.11	0.46
Towards	12	3.89	0.57	12.48	3.34	0.49

Table 5.6. Experiment 4b Relative Location for future sentences. Means table using the Relative Location dependent variable (1 for furthest behind character, 18 for furthest in front of character) for future sentences. Note: The prediction of this study is that means for the proximal sentences (*may*) will be *lower* than the means for distal sentences (*might*).

The linear mixed effects regression analysis of future sentences reveals no effect of Form and no interaction between Form and Character Direction. In other words, participants do not place *may* sentences and *might* sentences a significant distance from one another for either image. Specifically, participants place future *may* and *might* sentences $.36 \pm .7$ segments (of 18) apart when the character is facing away and $.48 \pm .69$ segments (of 18) apart when the character is facing towards them.

5.3.3 Discussion

Experiment 4b shows that participants do not place past and future sentences behind or in front of the chair regardless of direction. This suggests that the results of Experiment 4a are largely the result of explicit activation of the Life is a Journey metaphor. Experiment 4b does show an interaction of Tense and Character Direction, however, indicating that participants physically separate past and future sentences when the chair is facing towards them. This mirrors

the results of Experiment 2b, suggesting that there is something salient about the chair facing towards participants. Based on the data across experiments, the most likely explanation is that participants assume that the chair has a different canonical front and back than I do, and, thus, the chair facing towards the participant is congruent with their internal Deictic time. This could be because pictures of chairs facing away are infrequent, whereas chairs facing towards the participant are more frequent. Further research would be required to determine the reason. However, the reason for the salience of the chair direction is secondary to fact that, as in Experiment 2b, participants do seem to construe past and future events using the front-back physical space of an image. In other words, the Life is a Journey metaphor facilitates English speakers' construal of Time in terms of space for external Deictic time, but it is not necessary.

Lastly, the fine-grained proximal-distal effect found in Experiment 4a disappears for Experiment 4b. This suggests that the proximal *may* versus distal *might* distinction for past events found in Experiment 1a is the result of explicit activation of the Life is a Journey metaphor.

5.4 Experiment 5 – Non-spatial Time Estimation with Modals

Experiments 4a and 4b show that English speakers spatially separate *may* sentences from *might* sentences, but only for past events and only when the participant is prompted to think about time in terms of space with an image of a man on a street. In light of the results from Experiment 3, in which participants estimate the time to an event based on a proximal versus distal distinction in the past and future using grammaticalized constructions, Experiment 5 is a post-hoc experiment that uses the same paradigm as Experiment 3 to determine if English speakers also make a proximal-distal temporal distinction between *may* and *might* in a non-spatial task. That is, do participants estimate that *may* and *might* occur at proximal and distal

time points respectively relative to the present in a non-spatial task that explicitly asks participant to estimate time to an event?

Secondly, Experiments 4a and 4b make an important assumption about *may* or *might*. Based on observations from Langacker (2008), the assumption is that the immediate form *may* encodes greater certainty than the nonimmediate form *might*, where *may* entails that the speaker has perceptually available evidence for their claim. If certainty—or the likelihood of an event occurring—is the driving force behind the proximal-distal distinction of Experiment 4a, then English speakers should judge the same event described with *may* as more likely than the same event described with *might*. Experiment 5 addresses the extent to which English speakers associate certainty with modal verbs.

5.4.1 Method

5.4.1.1 Participants

171 participants were recruited on Amazon’s Mechanical Turk. The task took an average of 4 minutes, and participants were paid \$.50 each for their participation. This task was performed as a filler to a separate study involving metaphor and disease conceptualizations, but the participants in Experiment 5 did not perform the same task as those in Experiment 3.

Following a post-survey, which can be found in Appendix C, 23 participants were dropped due to lack of attention to the task (unable to remember the described event), leading to an analysis of 148 participants.

The study used a 2x2 between subjects design, with Form (May vs. Might) and Tense (Past vs. Future) as independent variables and Time Estimate and Likelihood Estimate as dependent variables.

5.4.1.2 Stimuli

This experiment uses a between subjects design with four conditions. These conditions consist of the sentences below:

Past May (Proximal)	<i>He may have discovered a planet.</i>
Past Might (Distal)	<i>He might have discovered planet.</i>
Future May (Proximal)	<i>He may discover a planet.</i>
Future Might (Distal)	<i>He might discover a planet.</i>

As with Experiment 3, participants read only one clause with a single verb:

discover a planet

The study was designed using Qualtrics software.

5.4.1.3 Procedure

Like Experiment 3, participants were asked to provide an estimate of the amount of time since/until the described event. Participants read *only one* of the target sentences and then were asked the following question:

If you had to guess, how long ago did this event occur? for past sentences.
If you had to guess, how long until this event occurs? for future sentences.

Participants were given seven options on a Likert scale: seconds (1), minutes (2), hours (3), days (4), weeks (5), months (6), or years (7).

Participants were also asked to provide an estimate of the probability that the event would take place on a 1 – 100% sliding scale, with 1% being the least likely and 100% being the most likely. The questions were phrased as follows:

If you had to guess, how likely is it that this event occurred? for past sentences.
If you had to guess, how likely is it that this event occurs? for future sentences.

5.4.2 Results

A Two-way Analysis of Variance with independent variables Form (May vs. Might) and Tense (Past vs. Future) was run using R (R Core Team, 2012). The dependent variable was Time

Estimate, or participants' estimate of time since an event or until an event on a 1-7 Likert scale (1 for seconds, 7 for years). The model revealed no main effect of Form ($F(1, 147) = .53, p = .47$). It did, however, show a main effect of Tense ($F(1, 147) = 48.09, p < .001$). Lastly, the interaction between Form and Tense was not significant ($F(1, 147) = 6.404, p = .21$).

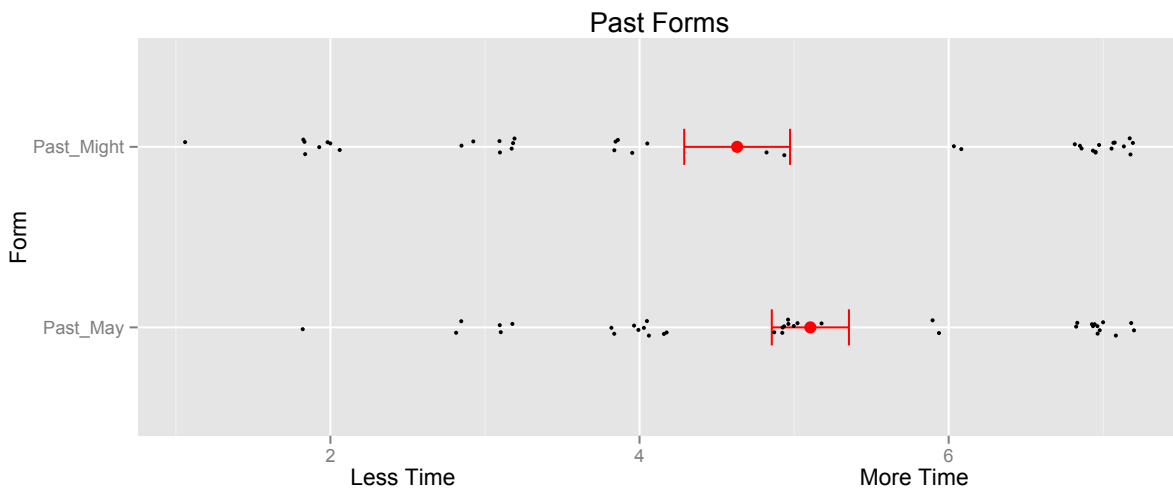


Figure 5.5. Experiment 5 results for past sentences with proximal modal *may* and distal modal *might*. Participants answered *How long ago did this event occur?* on a Likert scale (1 seconds, 7 years).

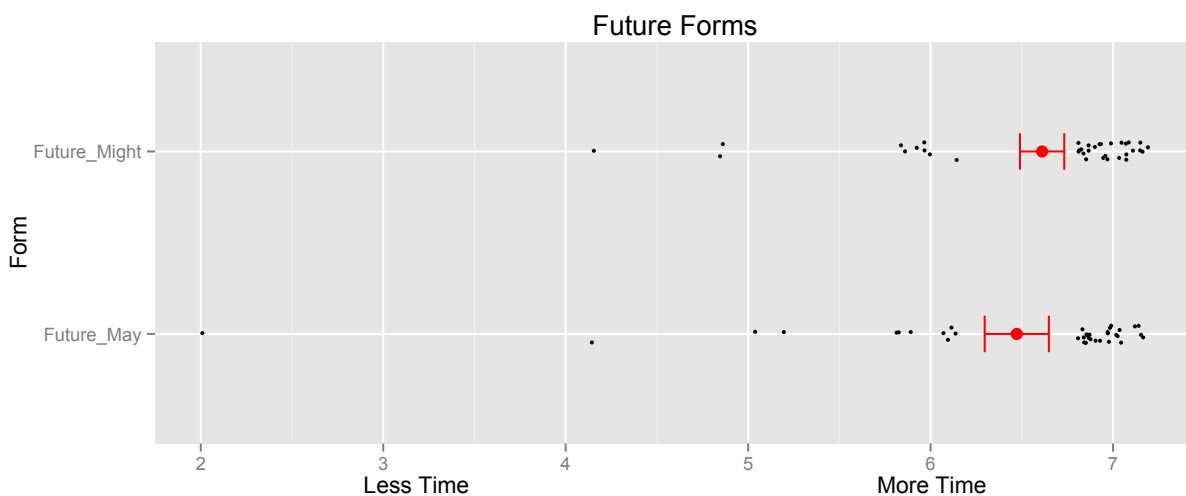


Figure 5.6. Experiment 5 results for future sentences with proximal modal *may* and distal modal *might*. Participants answered *How long until this event occurs?* on a Likert scale (1 seconds, 7 years).

In other words, participants in Experiment 5 do not make a proximal-distal temporal distinction between *may* or *might*. These results run counter to predictions of the study as well as

the results of Experiment 4a, which found a difference between sentence placement of both forms for past sentences.

	Time Estimates by Form							
Tense	<i>May</i> (Proximal)				<i>Might</i> (Distal)			
	N	Mean	SD	SE	N	Mean	SD	SE
Past	38	5.11	1.54	0.25	38	4.63	2.11	0.34
Future	36	6.47	1.06	0.18	36	6.61	0.73	0.12

Table 5.7. Experiment 5 Time Estimates by form. Means table for Time Estimate by forms *may* versus *might* on a Likert scale (1 seconds, 7 years).

The significant effect of Tense, however, directly mirrors results from Experiment 3, where participants estimated past events with grammaticalized constructions as more temporally proximal than future events. It also extends those results to include sentences using the irrealis mood.

	Time Estimates by Tense			
	N	Mean	SD	SE
Past	76	4.87	1.85	0.21
Future	72	6.54	0.9	0.1

Table 5.8. Experiment 5 Time Estimates by tense on a Likert scale (1 seconds, 7 years).

When participants are asked to think about a potential event—the discovery of a planet—in the past, they estimate that discovery happened days or weeks ago (on average). In contrast, participants estimate the exact same potential event will occur months to years in the future. In other words, at least for this one event, participants assume that past events are more proximal (in terms of the elapse of time) than future events. This result is further evidence that English speakers think about the past in a fundamentally different way than the future. As with Experiment 3, however, these results should be taken with caution: only one clause was used for this study.

In addition to estimating the amount of elapsed time since or until an event, participants were also asked to estimate the likelihood of the event on a scale of 1% to 100%. Using Likelihood Estimate as the dependent variable, a second two-way Analysis of Variance with independent variables Form (May vs. Might) and Tense (Past vs. Future) was run. The model again revealed no main effect of Form ($F(1, 147) = .06, p = .82$). The model did show a main effect of Tense ($F(1, 147) = 5.818, p = .02$). Lastly, the interaction between Form and Tense was not significant ($F(1, 147) = 2.96, p = .09$).

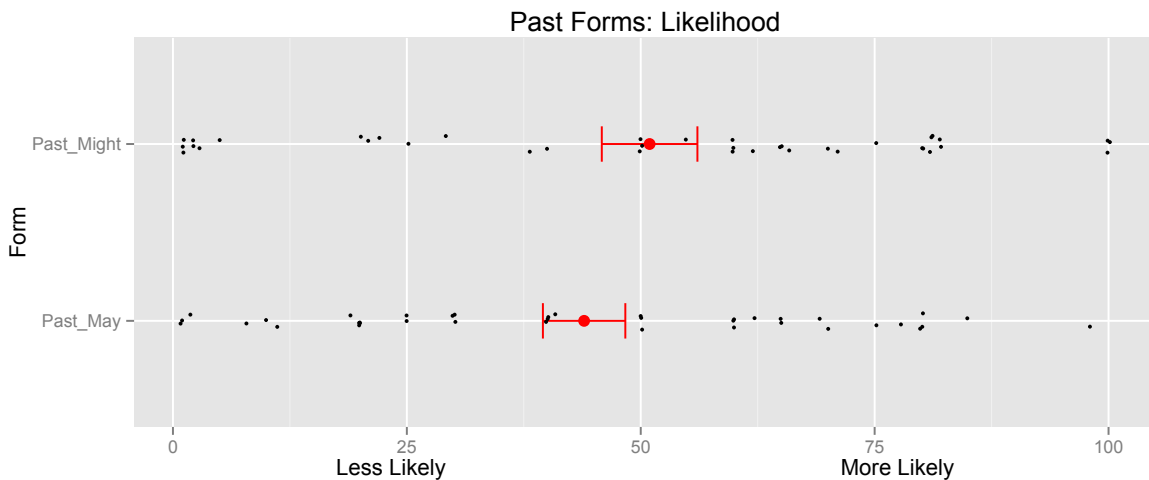


Figure 5.7. Experiment 5 likelihood results for past sentences with *may* and *might*. Participants answered *How likely is it that this event occurred?* on a scale (1% least likely, 100% most likely).

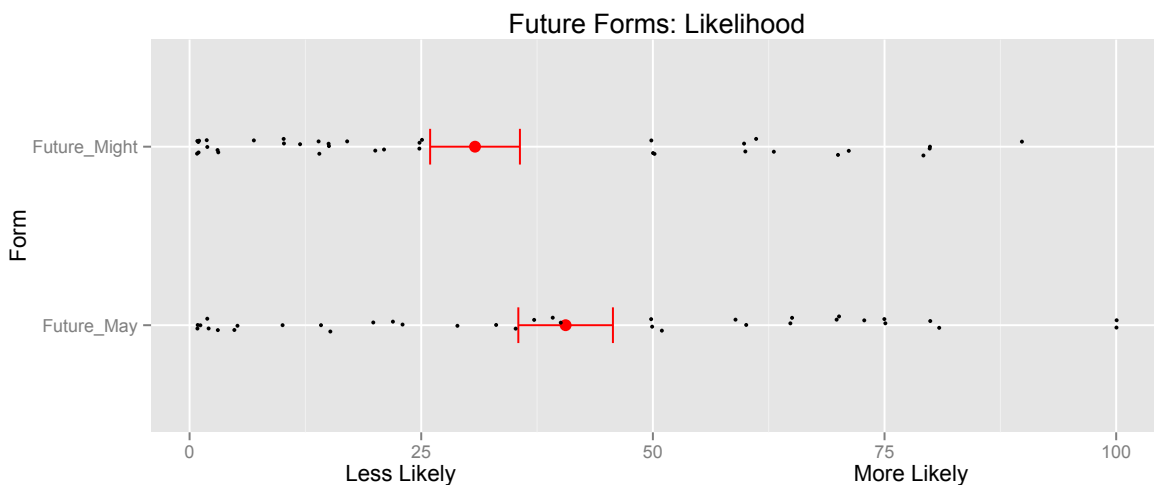


Figure 5.8. Experiment 5 likelihood results for future sentences with *may* and *might*. Participants answered *How likely is it that his event occurs?* on a scale (1% least likely, 100% most likely).

Again, contrary to predictions that *may* indicates greater certainty about an event than *might*, this difference is not found in the present analysis.

	Likelihood Estimates by Form							
Tense	<i>May</i> (Proximal)				<i>Might</i> (Distal)			
	N	Mean	SD	SE	N	Mean	SD	SE
Past	38	43.95	27.15	4.41	38	50.95	31.5	5.11
Future	36	40.58	30.63	5.1	36	30.81	29.07	4.85

Table 5.9. Experiment 5 Likelihood Estimates by form. Means table of likelihood estimates on 1-100% scale.

However, just as with the Time Estimate dependent variable, there is a significant effect of Tense. In this case, English speakers judge a potential event to be more likely if described as in the past than in the future.

	Likelihood Estimates by Tense			
	N	Mean	SD	SE
Past	76	47.45	29.42	3.38
Future	72	35.69	30.05	3.54

Table 5.10. Experiment 5 Likelihood Estimates by tense. Means table of likelihood estimates on 1-100% scale.

In other words, the exact same potential event is judged by English speakers to be more likely if it is a past event, not a future event.

Finally, as participants provided both Time Estimates of events and Likelihood Estimates of those same events, a post-hoc analysis was run to determine whether or not there was a correlation between participants' conceptualizations of temporal distance and likelihood. In other words, do English speakers also think of temporally proximal events as more likely than events that are temporally distal?

A Pearson correlation was run with Time Estimate and Likelihood. The model revealed a significant correlation between Time Estimate and Likelihood ($t(2, 146) = -2.59, p = .01$).

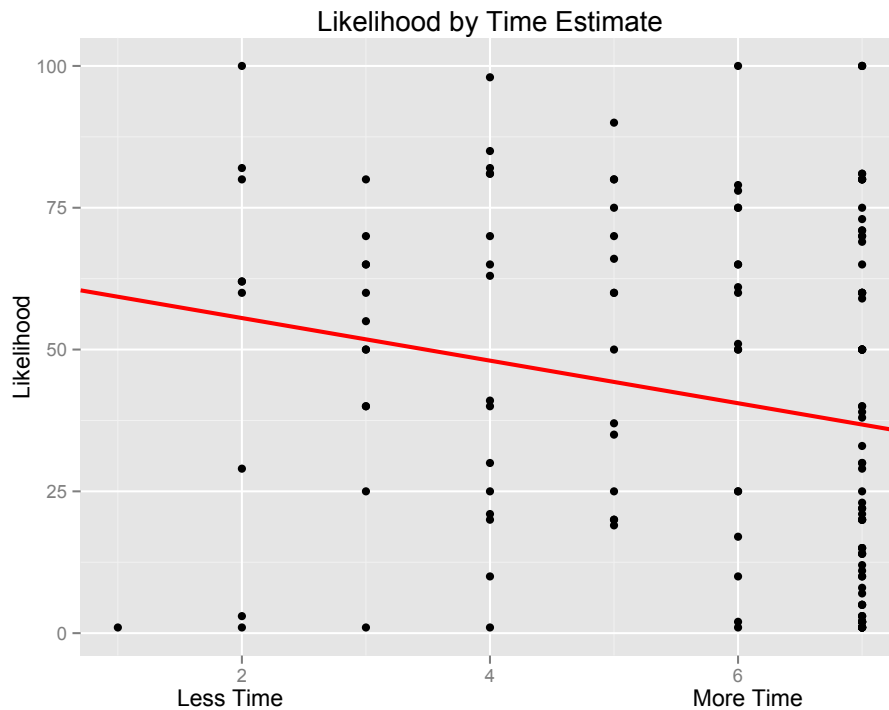


Figure 5.9. Correlation between Time Estimate and Likelihood Estimate of potential events. Black dots indicate participants' Time Estimate (1 seconds, 7 years) and Likelihood (1-100%) ratings.

In other words, although we cannot posit a causal relationship, the negative correlation suggests that the further away in time that a participant judges an event has taken or will take place, the less likely they predict that that event has happened or will happen. Or, the closer an event is in time, the more likely it is to have happened or to happen.

5.4.3 Discussion

Experiment 5 provides no clear evidence of a difference between *may* or *might* in terms of proximal or distal time. That is, *may* does not seem to encode proximal time nor *might* distal time in a non-spatial task. This is a surprising finding, especially given the results of Experiment 4a, where participants spatially separated past *may* and *might* sentences. However, Experiment 5 does not explicitly activate speakers' mental timelines, so this may be the reason for the lack of an effect in Experiment 5. Moreover, the paradigm for Experiment 5 does not distinguish between external and internal Deictic time. It is possible that English speakers only construe a

spatial *may/might* difference for external Deictic time (Experiment 4a) and not internal Deictic time (Experiment 5). Further research would be required to address this question.

Experiment 5 also finds no evidence that English speakers judge *may* events to be more likely than *might* events. This counters the predictions of the study as well as Langacker's (2008) claims. Since the spatial difference between the sentence placement of *may* versus *might* sentences in Experiment 4a is ostensibly caused by a difference in certainty about the event, then the results from Experiment 5 challenge the findings of Experiment 4a. Further research will be required to resolve this issue.

Despite these null results, Experiment 5 does indicate an important difference between the conceptualization of past and future events and the likelihood of those events. If *may* or *might* are used to describe a past event, the past event is judged to occur a shorter time span from the present (days to weeks on average) than the same event in the future (months to years on average). This result directly converges with the findings of Experiment 3. The only difference is that Experiment 5 examines potential events instead of actual/more certain events. Therefore, whether judging potential or actual/more certain events, English speakers judge past events to be temporally closer than future events. Next, the correlation between Time Estimates and Likelihood Estimates indicates that there is, indeed, a strong association between an event's likelihood and its time scale, such that more likely events occur in more proximal time (both in the past and future) compared to less likely events. The further away something is projected in time, the less likely it is to have occurred or to occur.

5.5 General Discussion

Experiment 4a shows that English speakers place irrealis past and future sentences using the verbs *may* and *might* behind and in front of an external deictic center. In other words,

participants in the study engage in space-time mapping even for potential events. This is an important contribution to the space-time mapping literature, extending the findings of Fernández de Lara (2012) with Spanish speakers to English speakers and to a paradigm that uses front-back physical space (as opposed to the left-right axis).

Participants place past and future sentences a greater distance apart for the image in which the man faces away from them, which is very similar to the findings of Experiment 2a (with grammaticalized constructions). This suggests that, in the absence of explicit time adverbials, attendance to an external deictic center is most likely when the image is congruent with the participants' internal Deictic time representation. These results are not necessarily the consequence of the Life is a Journey metaphor, as results from Experiment 4b show that speakers spatially separate past and future sentences when the chair faces towards them. It is unclear why this particular effect arises when the chair faces towards participants, but it is likely that my assumptions about the canonical front and back of the chair do not align with participants' assumptions.

In terms of fine-grained space-time topography, Experiment 4a demonstrates a proximal-distal distinction between the forms *may* or *might* only for past sentences. However, this distinction—with *may* describing a proximal past event and *might* a distal event—is only present for events in the past when the Life is a Journey metaphor is explicitly activated. The distinction between *may* and *might* for past sentences was not found in Experiment 5—which employs a non-spatial task—and this may be because the experiment does not explicitly activate speakers' mental timelines. These findings strongly support Langacker's (2008) model, but they also present a new question: why does the effect appear for the past and not for the future? I do not yet have an answer to this question, but there are fascinating possibilities. Given that a difference

between past and future event construal appears in multiple experiments in this dissertation, this issue will be further addressed in Chapter 7.

Lastly, Experiment 5 shows that English speakers estimate that an irrealis event (using *may* or *might*) occurred only days or weeks (on average) in the past, whereas the same event is judged to take place months to years (on average) in the future. In other words, there is a large discrepancy in the time estimates that people make about the past and future, where past events are temporally closer to the present. These are exactly the findings of Experiment 3, but Experiment 5 shows that English speakers make the same judgment for potential events as actual events. Moreover, these time estimate findings are mirrored in participants' estimates of the likelihood of past and future events, where a past event described using *may* or *might* is judged as more likely than the same event happening in the future. Again, however, these results are based on a paradigm in which participants only read one clause, *discover a planet*, and this event is not a particularly common one, so they should be taken with caution.

Experiment 5 also shows that participants correlate likelihood with an event's proximity in time. Events perceived as more proximal in time are judged to be more likely. This is the case for both past and future events that are described with *may* or *might*. This finding shows that, for irrealis sentences, likelihood and temporal distance are inextricable. When participants make an assumption about an event's place in time, they are making a simultaneous judgment about the possibility that it has happened or will happen.

In short, Experiment 5 demonstrates that (1) irrealis past events are temporally closer to the present than irrealis future events, (2) irrealis past events are more likely than irrealis future events, and (3) more proximal temporal events are more likely than distal temporal events. In

concert, these three findings suggest that English speakers may conceptualize even the potential past in a different manner than the potential future.

Chapter VI:

Internal Deictic Time and Spatial Perception

6.1 Introduction

The previous experiments have all examined English speakers' space-time topography with external Deictic time, or situations in which speakers co-locate the present with an external locus. These experiments have suggested, and logic would dictate, that internal Deictic time—where speakers co-locate the present with their own ego—is more primal or basic than external Deictic time. For example, in Experiment 2a, participants exhibited space-time mapping effects when the character was facing away from them and was thus congruent with their own internal Deictic time representation, but not when the character was facing towards them. Moreover, in natural speech, English speakers gesture backward when referring to past events and forward for future events, again indicating that internal Deictic time is more basic than external Deictic time (Cienki & Müller, 2008; Cooperrider & Núñez, 2009). Given the fundamental difference between external and internal Deictic time (Núñez & Cooperrider, 2013), the following experiments examine whether or not fine-grained space-time topography also manifests itself for internal Deictic time in English speakers. They do so through a novel, psychophysical experimental paradigm that shows that processing everyday temporal expressions influences spatial perception. The experiments require participants to process time-related sentences and then estimate physical distances behind them for events that occur in the past and in front of

them for events that take place in the future. The use of physical space behind and in front of the hearer encourages participants to recruit an internal conceptualization of Deictic time.

The present experiments thus speak to conflicting results in the experimental space-time mapping literature regarding proximal-distal time distinctions with internal Deictic time. Sell and Kaschak (2011), for example, developed a paradigm in which participants physically move their hands backward or forward to respond to a sentence (e.g., backward for a sentence in the past, forward for a sentence in the future). The researchers show that hearers are quicker to move their hand forward for future sentences (compared to past sentences) or backward for past sentences (compared to future sentences) when the sentence involves a distal temporal event (i.e., ‘next month’) but not a proximal one (i.e., ‘tomorrow’). Using the same paradigm, Ulrich et al. (2012) show the same effect for both distal and proximal events. However, as Walker et al. (2014) have observed, these studies do not actually examine internal Deictic time. Instead, they are limited to dependent measures of space and motion physically in front of the hearer. The present study overcomes this problem, as it examines proximal and distal space physically behind the hearer as well as in front of the hearer.

Importantly, however, processing temporal expressions may involve two completely different conceptualizations. As Lakoff and Johnson (1980) describe, in English, Time can be conceptualized with the ego moving over a physical landscape (sometimes called the ego-moving perspective) or with the event moving over a landscape towards the ego (the time-moving perspective). These two are exemplified in the following sentences:

Ego-moving perspective	<i>We are coming up on Thanksgiving.</i>
Time-moving perspective	<i>Thanksgiving is rapidly approaching.</i>

Ego-moving and time-moving perspective primes have played an important role in the experimental literature (Boroditsky, 2000; Gentner, Imai, & Boroditsky, 2002; Núñez, Motz, and

Teuscher, 2006, Matlock, Holmes, Srinivasan & Ramscar, 2011). For example, Boroditsky & Ramscar (2002) show that alternating physical primes (e.g., participants moving through a line versus standing stationary while observing moving vehicles) influences judgment on an ambiguous task about a future event. When given the ambiguous prompt, *Next Wednesday's meeting has been moved forward two days*, participants standing in line are more likely to choose Friday instead of Monday as the day of the meeting (consistent with an ego-moving perspective) and stationary participants watching moving vehicles are more likely to choose Monday over Friday (consistent with the time-moving perspective).

The present study attempts to reverse Boroditsky and Ramscar's effect in the context of language processing. Boroditsky and Ramscar (2002) essentially prove that English speakers are influenced by two motion types—motion congruent with an ego-moving perspective and motion consistent with a time-moving perspective—when making a judgment about time. In the present experiments, participants first listen to a time-related sentence. They then perform a bodily action to estimate a fixed physical distance. In Experiment 6, this bodily action is congruent with an ego-moving perspective, in that participants move their entire bodies to estimate the distance behind or in front of them. In Experiment 7, participants remain motionless, which is incongruent with an ego-moving perspective. Consequently, these experiments examine whether or not an ego-moving perspective is essential to English speakers' fine-grained representations of internal Deictic time, as suggested by Walker et al. (2014).

Lastly, examining space-time topography through this novel paradigm also offers an ideal lens with which to observe another critical question in the metaphor literature: the notion of metaphor asymmetry. As discussed in Chapter 2, experimental work has demonstrated effects confirming the psychological validity of conceptual metaphor theory (Lakoff & Johnson, 1980),

and these effects fall broadly into one of two categories: (1) concrete-to-abstract effects and (2) abstract-to-concrete effects (Lee & Schwarz, 2012). Concrete-to-abstract effects describe experiments that prime the concrete mental representation and predict a modulation in the abstract mental representation. Concrete-to-abstract effects have shown that holding a warm cup of coffee influences personality judgments (Williams & Bargh, 2008), smelling a fishy smell influences trust in an investment task (Lee & Schwarz, 2012), and washing one's hands reduces one's guilt (Zhong & Liljenquist, 2006). Concrete-to-abstract effects ostensibly support conceptual metaphor theory, which predicts that abstract mental representations will be structured by concrete mental representations, but not vice versa. In other words, there is an asymmetrical relationship between abstract and concrete domains.

This asymmetrical relationship has been called into question through a series of recent experiments that demonstrate the reverse effect, or abstract-to-concrete effects. Abstract-to-concrete effects have shown that differences in power descriptions influence height estimates (Schubert, 2005), feeling guilty about something influences hand washing (Zhong & Liljenquist, 2006), varying descriptions of importance influence the perceived weight of an object (Jostmann, Lakens, & Schubert, 2009), and being suspicious influences one's ability to identify a fish smell (Lee & Schwarz, 2012). Contrary to the predictions of conceptual metaphor theory, these experiments show a modulation in the concrete mental representation through the activation of the abstract domain.

These experiments have prompted researchers to revisit the asymmetrical conceptual theory model, as it does not explicitly account for these findings. Moreover, none of these experiments address the role of language processing, opting instead to largely focus on nonlinguistic primes, stimuli, and dependent variables. This is a glaring omission, as conceptual

metaphor theory is largely based on linguistic data. Slepian and Ambady (2014) help to remedy both of these problems by teaching participants novel conceptual metaphors in a lab setting. Participants were in one of two novel metaphor conditions. In the first condition, participants were told that the past weighs heavily on people. In the second condition, participants were told that the present weighs heavily on people. Participants then estimated the weight of a book. In one condition, the book was disguised to be old. In the second condition, the same book appeared to be new. The researchers show that participants in the past-heavy condition estimate the weight of the old-appearing book to be greater than the new-appearing book, and participants in the present-heavy condition estimate the new-appearing book to be heavier than the old-appearing book. In this way, participants were primed with abstract mental representations (through linguistic forms) and this modulated sensorimotor perception, or concrete mental representations.

The notion of fine-grained space-time topography allows for an experiment with a similar manipulation of English speakers' concrete representations as Slepian and Ambady (2014) demonstrate, but one that does not require teaching participants novel metaphors. Instead, it uses everyday, conventional time expressions. A modulation in spatial perception would show that, contrary to predictions of an asymmetrical metaphor model, processing time metaphors can influence spatial perception, or the source domain.

Consequently, through use of a novel experimental paradigm that examines actual physical space behind and in front of participants, the following experiments specifically address the notion of space-time topography with internal Deictic time. They examine whether or not English speakers process temporal events using fine-grained spatial distinctions both behind and in front of them. The paradigm simultaneously examines whether or not a particular bodily

action following metaphor processing—either congruent or incongruent with an ego-moving perspective—may modulate (reasoning based on) spatial perception. Lastly, it addresses the issue of metaphor asymmetry, as it measures participants’ estimates of physical space following their processing of everyday temporal expressions. Given that temporal adverbials yielded the strongest effect in the previous experiments, they are again used in this paradigm. Therefore, it addresses the following research questions, as outlined in Chapter 2:

Fine-grained Space-time Mapping

RQ2. Do English speakers construe coarse-grained (categorical front/back) or fine-grained (landscape) spatial representations when space-time mapping?

RQ2a. Does this vary based on speakers’ construal of external Deictic time versus internal Deictic time?

RQ2b. Do lexical adverbials encode fine-grained spatial representations?

RQ3. Do space-time construals involve static *spatial* representations or *motion* representations?

RQ4. Do English speakers recruit fine-grained spatial representations of Time for an abstract-to-concrete methodology?

Experiments 6 and 7, which were devised after extensive pilot study work (see Appendix D), specifically address these questions.

6.2 Experiment 6

In Experiment 6, participants estimate a distance behind and in front of them in a new experimental paradigm. Given the design of this paradigm, this experiment does not specifically address whether or not English speakers map the past physically behind them or the future in front of them. Rather, it addresses the specificity of mental representations for the past and future. Therefore, the hypothesis of this experiment is as follows: processing everyday metaphorical expressions about proximal and distal temporal events will influence English speakers’ spatial perception, such that they, when attempting to estimate a fixed location, will

estimate a shorter distance after processing a proximal temporal expression (e.g., ‘tomorrow’) compared to their estimate after processing a distal temporal expression (e.g., ‘next year’). Such a result would be evidence of their activation of a fine-grained spatial representation when processing everyday time metaphors, and it would also demonstrate an abstract-to-concrete effect, such that processing proximal and distal temporal expressions influences physical spatial estimation. As participants estimate physical space behind and in front of their bodies, it encourages an internal conceptualization of deictic time, with the present co-located with the ego. Moreover, participants physically move their bodies (or egos) after processing time-related sentences, and this motion is consistent with an ego-moving perspective of time.

Experiment 6 employed a 2x2 within subjects design, with Tense (Past vs. Future) x Temporal Distance (Proximal vs. Distal) as independent variables and Estimated Distance (in cm) as the dependent variable.

6.2.1 Methods

6.2.1.1 Participants

45 undergraduates from the subject pool of the Department of Linguistics at the University of Colorado Boulder participated in the study in exchange for extra credit. Based on results of a post-survey (found in Appendix C), five participants were removed from the study. Two were removed for not understanding directions, two for guessing the study’s intention, and one due to a technical malfunction. This resulted in 40 participants for the final analysis. All participants were right-handed, native speakers of English with normal to corrected vision.

6.2.1.2 Stimuli

Participants estimated distances behind and in front of them after listening to target sentences. Target sentences were in one of four conditions, as repeated from Experiment 1a:

Proximal Past	<i>Yesterday, he began a letter.</i>
Distal Past	<i>Last year, he stopped a fight.</i>
Proximal Future	<i>Tomorrow, he will win a bike.</i>
Distal Future	<i>Next year, he will discover a planet.</i>

There were a total of 16 target sentences distributed into four blocks, and all sentences were randomized within each block. Sentences were separated into blocks to give participants small breaks to remove the blindfold and to allow them to re-assess the distances to the fixed markers behind and in front of them (as described further in the Procedure section below). Participants also listened to 32 filler sentences (half describing past events, half describing future events) distributed across eight ‘distractor’ blocks (interspersed with the four ‘experimental’ blocks containing the target sentences), which were also randomized (filler sentence examples can be found in Appendix B). Participants were asked to remove the blindfold and examine the location of the markers between each block.

To avoid any confounds, sentences include only achievement verbs, the Aktionsart class of verbs that describe instantaneous events as categorized by Vendler (1957) (e.g., *discover*, *find*, etc.). This helps mitigate event duration from influencing conceptualization.

There were 64 final target sentences, as the 16 clauses in each of the four Temporal Distance x Tense combinations were cross-balanced across four groups, such that each clause was seen in each condition across all participants (e.g., *Next year, he will discover a planet* for Group 1, *Tomorrow, he will discover a planet* for Group 2, etc.). For the final analysis, there are ten participants from each group.

Target and filler sentences were recorded by a voice actor who was unaware of the intention of the study. This helped to eliminate the possibility that the aural stimuli would in any way influence the participants’ perception of their time course (e.g., spoken sentences that last longer may lead to longer distance estimates).

Participants listened to sentences via Modal Bluetooth wireless headphones via a Bluetooth connection to a Macintosh computer (2.66 GHz Intel Core 2 Duo). The experiment was conducted using experimental software Psychopy (Pierce, 2007) on the same Macintosh.

6.2.1.3 Procedure

Participants stood in the middle of a track apparatus with a small cart atop. The apparatus itself was propped on a desk directly to their right (see Figure 6.1). The track measures 152 cm in length by 18cm in width, and the cart measures 30.5 cm in length by 18.5 cm in width. Two small markers attached to the track indicated a distance of exactly 40 cm from the midpoint of the track in either direction, effectively marking 40 cm behind the participant and 40 cm in front of the participant. In addition, the cart was marked with a small arrow directly in the middle pointing downward. Participants were instructed to, after listening to a target sentence, move backward or forward while rolling the cart alongside on its track so that the center position of the cart aligned perfectly with the marker on the track behind or in front of them.

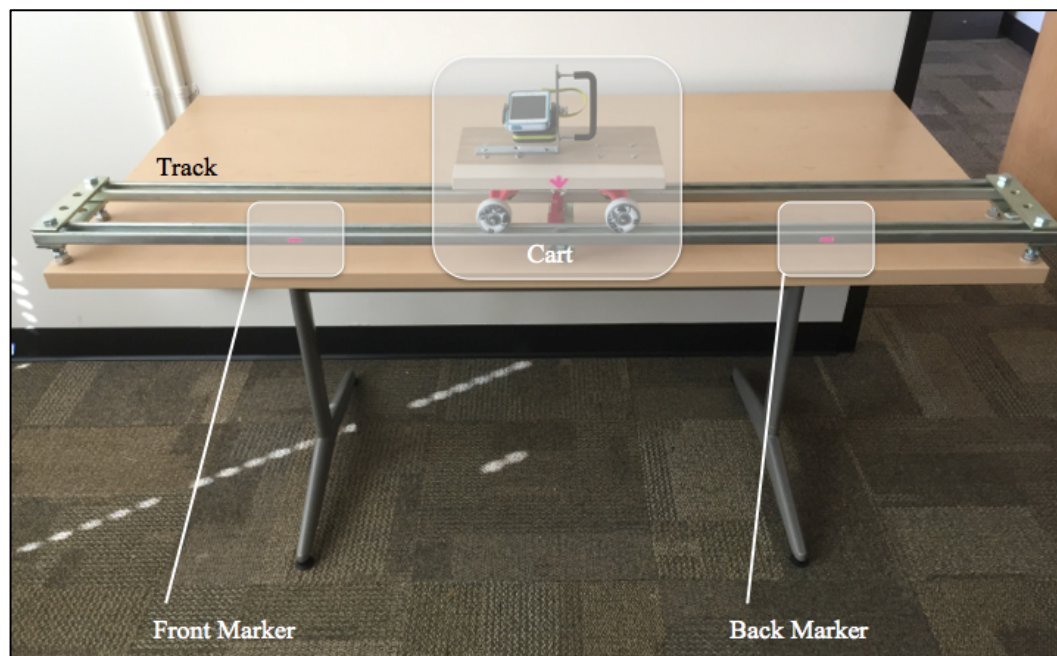


Figure 6.1. The moveable cart and track with markers physically behind and in front of the participant.

Participants were encouraged to examine the positions of the markers behind and in front of them. They were then instructed to put on a blindfold. The blindfold prevented participants from using any visual cues in the room (e.g., blemishes on the track, the end of the desk, etc.) to estimate the distances. Participants then listened to sentences and subsequently estimated the distance to the fixed marker either behind or in front of them by stepping backward or forward with the cart. Participants were explicitly instructed to estimate the distance to the marker behind them if the sentence described an event in the past or to estimate the distance to the marker in front of them if the sentence described an event in the future.

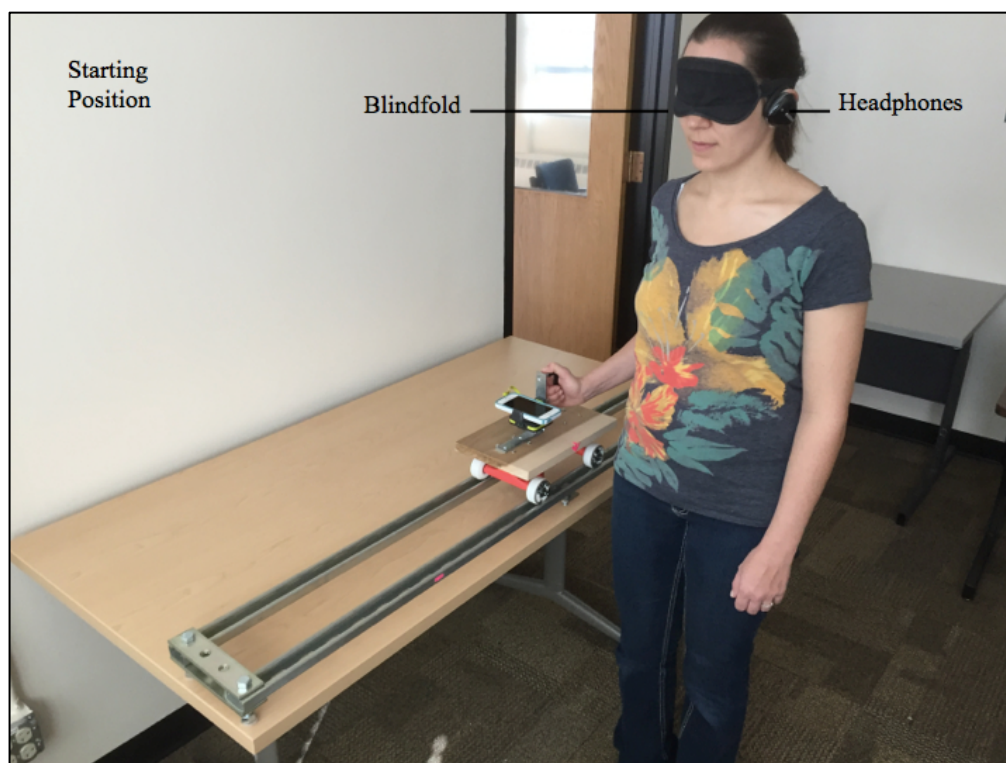


Figure 6.2. Example of a participant in Experiment 6 and 7, holding the cart to estimate distances behind and in front of her body. She wears a blindfold and wireless headphones for the experiment.

Participants listened to the stimulus, waited for a .5 second beep (which occurred exactly two seconds after the onset of the sentence), and then estimated the distance to the fixed marker by stepping backward or forward. This two-second window was intended to control for

differences in sentence length or differences in sentence reading times as confounding factors. Once at the marker, participants were asked to repeat the sentence to ensure comprehension. They then returned to the center position, which was marked by a magnet attached to the cart. The full procedure is outlined in Figure 6.3.

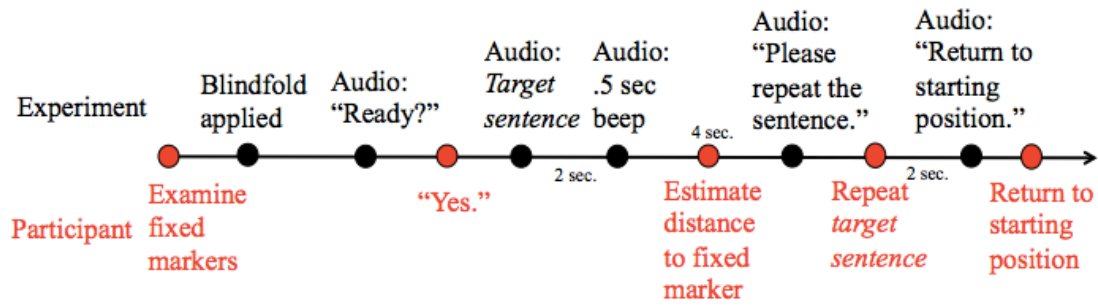


Figure 6.3. Sequence of the experimental procedure for Experiments 6 and 7.

6.2.1.4 Data Collection

Distance estimation was measured using a Ryobi laser distance measurer, which was attached to the center of the cart.

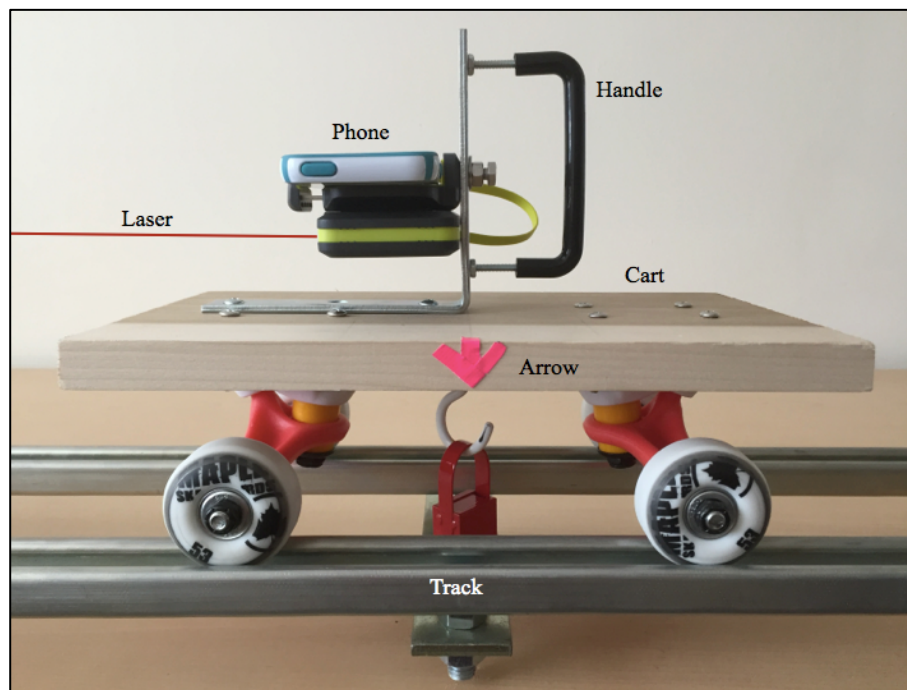


Figure 6.4. The cart with Ryobi laser and iPhone 6 attached. The laser measures the distance from the cart to the wall.

The measurer is accurate to within 1.5875 mm up to 27.432 m. The measurer displayed measurement readings on an iPhone 6 (Model MG5X2LL/A), which was attached to a MacBook Pro (1.8 GHz Intel Core i5). The MacBook Pro video recorded all measurement information using Quicktime software. In addition, I personally observed the MacBook Pro screen and logged data in real time.

6.2.2 Results

For the final analysis, eleven observations were removed due to participants repeating the incorrect sentence or estimating the distance to the incorrect marker, and five observations were removed due to technical errors. In addition, observations more than two standard deviations of the mean within each Tense x Temporal Distance condition were removed. This resulted in the removal of an additional 24 observations for a final analysis of 604 total observations, 304 for past sentences and 300 for future sentences. I used R (R Core Team, 2012) and lme4 (Bates, Maechler, & Bolker, 2012) to perform mixed effects analyses of the data. P-values were obtained with likelihood ratio tests of a model with the effect under examination compared to a model without the effect.

The statistical analysis tests whether or not participants estimated a shorter distance following proximal events ('yesterday' and 'tomorrow') compared to their estimated distance following distal events ('last year' and 'next year'). A mixed effects linear regression model was run using Estimated Distance (in cm) as the dependent variable. The model included random effects of Participant and Item. First, a likelihood ratio test that compared a mixed-effects model with Tense (Past vs. Future) and Temporal Distance (Proximal vs. Distal) with a model that included only Temporal Distance as the fixed effect revealed a main effect of Tense

($\chi^2(1)=26.647$, $p<.001$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table G in Appendix A. Next, I tested for a main effect of Temporal Distance by conducting a likelihood ratio test comparing a mixed-effects model with Tense and Temporal Distance with a model that included only Tense as the fixed effect. This likelihood ratio test revealed a near-significant main effect of Temporal Distance ($\chi^2(1)=5.9238$, $p=.052$). Lastly, the comparison between a model containing the fixed effects of Temporal Distance and Tense with a model including an interaction between Temporal Distance and Tense revealed a significant effect of the interaction term ($\chi^2(1)=5.0641$, $p=.02$).

In the above model, the main effect of Tense indicates that, on average, participants estimated a shorter distance for past sentences ($35.6\text{cm}\pm.42$) than for future sentences ($37.7\text{cm}\pm.37$). This is not a prediction of the study, but it is evidence that there may be an important difference between estimating a distance behind participants as opposed to in front of participants. The near-significant effect of Temporal Distance shows that participants nearly estimated a shorter distance for proximal sentences ($36.5\text{cm}\pm.4$) compared to distal sentences ($36.8\text{cm}\pm.4$). The significant interaction between Tense and Temporal Distance shows that the difference in Estimated Distance between proximal and distal sentences is different for past sentences compared to future sentences.

The significant interaction between Tense and Temporal Distance prompts separate post-hoc analyses of past sentences and future sentences. These analyses help clarify the difference in Estimated Distance across past versus future sentences.

	Estimated Distance (in cm) by Temporal Distance							
Tense	Proximal				Distal			
	N	Mean	SD	SE	N	Mean	SD	SE
Past	153	35.93	7.55	0.61	151	35.27	7.16	0.58
Future	150	37.02	6.45	0.53	150	38.37	6.55	0.53

Table 6.1. Experiment 6 Estimated Distances (in cm).

The second analysis thus investigates whether or not participants estimated a shorter distance after processing proximal past sentences (containing the adverbial ‘yesterday’) compared to their estimated distance after processing distal past sentences (containing the adverbial ‘last year’). A mixed effects linear regression model was run using Estimated Distance (in cm) as the dependent variable for past sentences. The model included random effects of Participant and Item. I tested for a main effect of Temporal Distance (Proximal vs. Distal) by conducting a likelihood ratio test comparing an intercept-only mixed-effects model with a model that included Temporal Distance as the fixed effect. The likelihood ratio test revealed no evidence for a main effect of Temporal Distance for past sentences ($\chi^2(1)=0.7408$, $p = 0.3894$). In other words, there is no significant difference in distance estimation after participants heard ‘yesterday’ (35.94cm±.61) sentences compared to ‘last year’ sentences (35.27cm±.58).

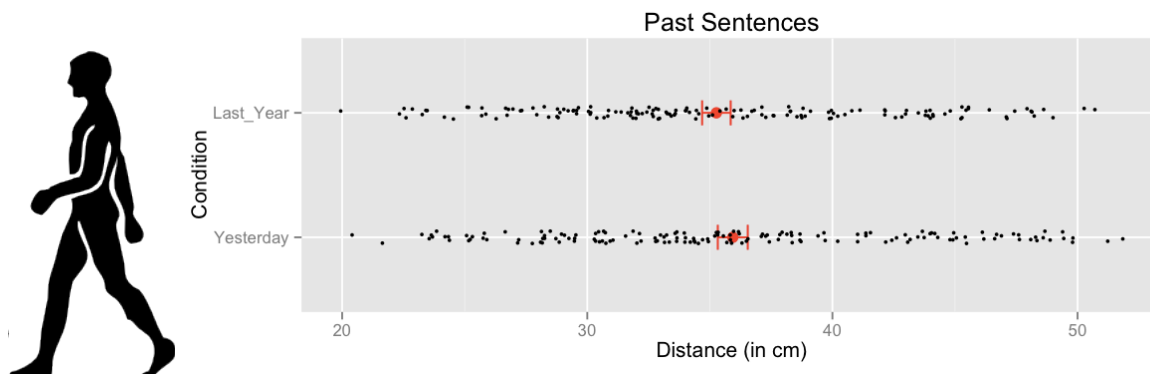


Figure 6.5. Estimated distances after past sentences in Experiment 6. Red dots indicate condition means and black dots indicate individual observations. The actual physical marker was at 40cm.

The third analysis tests whether or not participants estimated a shorter distance after processing proximal future sentences ('tomorrow') compared to their estimated distance after processing distal future sentences ('next year'). This time, a mixed effects linear regression model was run using Estimated Distance (in cm) as the dependent variable for future sentences. Again, the model included random effects of Participant and Item. I tested for a main effect of Temporal Distance (Proximal vs. Distal) by conducting a likelihood ratio test comparing an intercept-only mixed-effects model with a model that included Temporal Distance as the fixed effect. The likelihood ratio test revealed a main effect of Temporal Distance for future sentences ($\chi^2(1)=5.9263$, $p = .015$). In other words, on average, participants estimated a shorter distance after hearing a sentence about 'tomorrow' ($37.02\text{cm}\pm.53$) compared to their estimated distance after hearing a sentence about 'next year' ($38.37\text{cm}\pm.53$).

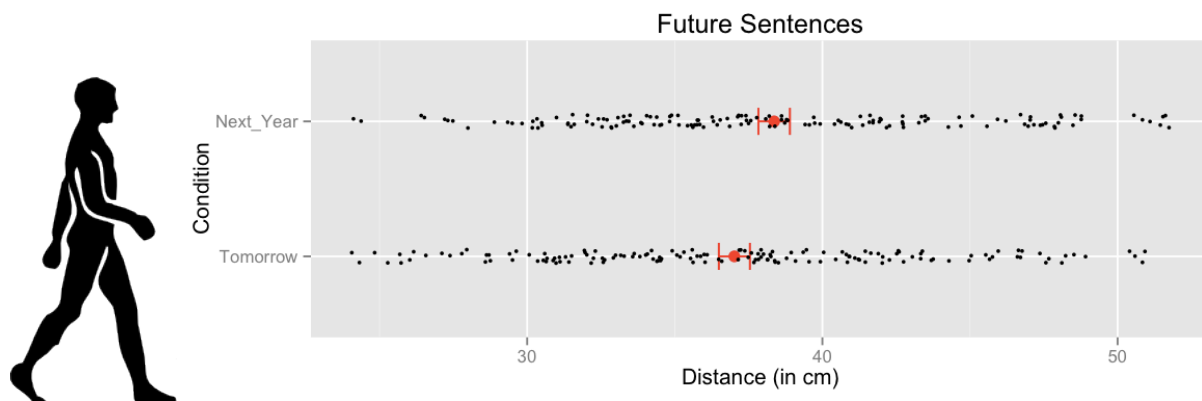


Figure 6.6. Estimated distances after future sentences in Experiment 6. Red dots indicate condition means and black dots indicate individual observations. The actual marker was at 40cm.

These post-hoc analyses, which examine past sentences separately from future sentences, show that the interaction from the first model are the result of participants estimating a shorter distance following proximal future sentences ('tomorrow') compared to their estimated distance following distal future sentences ('next year'), whereas the same effect is not present for past sentences.

6.2.3 Discussion

For sentences that describe future events, results of this study are exactly as predicted. Participants' spatial perception of a fixed distance is modulated through processing time sentences describing either proximal ('tomorrow') or distal ('next year') temporal events, such that participants estimate a shorter distance after processing a proximal temporal event compared to their estimated distance after processing a distal temporal event. This is confirmation of the space-time topography hypothesis for internal Deictic time.

This effect, however, is not present for past temporal events. There are three possible explanations for this. First, estimating distances behind the body is simply more difficult than estimating distances in front of the body. Consequently, though participants may have a fine-grained representation of Time, this particular methodology is unable to capture it. To remedy this, Experiment 7 below allows participants to remain motionless while estimating distances, thus making estimation behind the body easier.

Second, this result nicely aligns with Experiment 1a, which also shows an effect for future sentences but not for past sentences. Together, these experiments provide converging evidence for the claim that the past and future are fundamentally different concepts. In this case, processing the future involves the recruitment of fine-grained spatial representations. Processing the past, however, does not seem to involve this same recruitment. This may be evidence that the future, because it is unknowable, is inherently more abstract than the past—even for events that the hearer did not personally witness. Consequently, English speakers then recruit physical space in order to process the Future. Processing past temporal events does not necessarily require the recruitment of fine-grained space.

A third possibility, which is not mutually exclusive from the second, is that we, as embodied human beings, only encounter and navigate physical space in front of us. Therefore, when thinking about Time, we do not recruit representations of space behind us, as we are not accustomed to dealing with space behind us in our everyday physical interaction with the world. This possibility, however, would require further inquiry.

In short, Experiment 6 shows that processing sentences about the future influences English speakers' spatial perception. This is a clear abstract-to-concrete effect, one that challenges the notion of metaphor asymmetry. Moreover, in this experiment, spatial perception is modulated through a very specific bodily activity, one where participants physically move their entire bodies to estimate a distance behind or in front of them using the internal deictic perspective. This is very specific type of motion, one that is congruent with an ego-moving perspective of Time (e.g., *We are approaching Thanksgiving*). Since there is significant debate as to whether or not mental representations of internal Deictic time include both spatial and motion representations (see Walker et al., 2014), the next question is whether or not changing the bodily action (or the motion) type yields different results. Experiment 7 addresses this question.

6.3 Experiment 7

Experiment 7 examines whether or not processing time-related sentences influences spatial perception when participants perform a different bodily action: remaining motionless. By keeping their bodies still but moving only the cart on the track only with their arms, their bodily activity is incongruent with an ego-moving perspective. That is, the ego remains motionless. This experiment's hypothesis is identical to Experiment 6, that there will be a spatial difference in the distance estimates provided by participants depending on whether they listened to proximal or distal time sentences. Experiment 7 thus offers an opportunity to examine the extent to which the

type of motion (congruent with ego-moving vs. incongruent with ego-moving) is a component of English speakers' mental representations of internal Deictic time.

The experiment was again a 2x2 within subjects design, with Tense (Past vs. Future) x Temporal Distance (Proximal vs. Distal).

6.3.1 Methods

6.3.1.1 Participants

48 undergraduates from the Department of Linguistics at the University of Colorado Boulder participated in the study in exchange for extra credit. Eight participants were removed from the study. Four were removed for not paying attention (failure to correctly repeat sentences 80% of the time). One was unable to complete the task due to health reasons. Lastly, based on a post-survey (which can be found in Appendix C), three guessed the study's intention. This resulted in 40 participants for the final analysis. All participants were right-handed, native speakers of English with normal to corrected vision.

6.3.1.2 Stimuli

All stimuli were identical to those in Experiment 6.

6.3.1.3 Procedure

Experiment 7 used the same track and cart apparatus as Experiment 7. The only difference in procedure involved the bodily action of participants. Rather than step backward or forward for past and future sentences, participants were instructed to stand still and only move the cart. Two markers on the floor marked foot positions. Participants were instructed to use the markers to position their bodies at a 45-degree angle to the track, thus allowing for a comfortable position to move the cart backwards.

Again blindfolded, participants were explicitly instructed to move the cart backward if the event in the sentence took place in the past or move the cart forward if the sentence described an event in the future. After each sentence, their goal was to exactly align the marker on the cart with the markers on the track.

6.3.1.4 Data Collection

Data was collected in an identical manner as Experiment 6.

6.3.2 Results

For the final analysis, six observations were removed due to participants repeating the incorrect sentence or estimating the distance to the incorrect marker, and four observations were removed due to technical errors. In addition, all observations outside of two standard deviations of the mean within each Tense x Temporal Distance condition were removed. This resulted in the removal of an additional 14 observations for a final analysis of 618 total observations, 304 for past sentences and 314 for future sentences.

The following analysis tests whether or not participants estimated a shorter distance following proximal events ('yesterday' and 'tomorrow') compared to their estimated distance following distal events ('last year' and 'next year'). A mixed effects linear regression analysis was run using Estimated Distance (in cm) as the dependent variable. The model included random effects of Participant and Item. First, a likelihood ratio test that compares a mixed-effects model with Tense (Past vs. Future) and Temporal Distance (Proximal vs. Distal) with a model that includes only Temporal Distance as the fixed effect again revealed a main effect of Tense ($\chi^2(1)=48.809$, $p < .001$). The beta coefficients, standard errors, and p-values for the fixed effects are reported in Table H in Appendix A. Next, I tested for a main effect of Temporal Distance by conducting a likelihood ratio test comparing a mixed-effects model with Tense and Temporal

Distance with a model that included only Tense as the fixed effect. This likelihood ratio test revealed no main effect of Temporal Distance ($\chi^2(1)=1.4455$, $p=.49$). Lastly, the comparison between a model containing the fixed effects of Temporal Distance and Tense with a model including an interaction between Temporal Distance and Tense revealed no significant effect of the interaction term ($\chi^2(1)=0.0146$, $p=.9$).

	Estimated Distance (in cm) by Temporal Distance							
Tense	Proximal				Distal			
	N	Mean	SD	SE	N	Mean	SD	SE
Past	154	36.66	6.57	0.52	150	36.32	6.58	0.54
Future	158	34.49	6.31	0.5	156	33.99	6.06	0.49

Table 6.2. Experiment 7 Estimated Distances (in cm).

In the above analysis, the main effect of Tense indicates that participants estimated a greater distance for past sentences (36.4cm \pm .38) than for future sentences (34.2cm \pm .35). This is the opposite trend of Experiment 6, where participants instead estimated a greater distance following future sentences. While the reason for this difference is unclear (and not the focus of this study), it is most likely the result of the physical task, where moving the cart for future sentences required a greater stretch than for past sentences, as their bodies were at a 45 degree angle compared to the track. While this made estimating behind the participant easier, it may have simultaneously affected estimation in front of the participant. The lack of main effect for Temporal Distance shows that participants did not estimate a shorter distance for proximal sentences (35.6cm \pm .37) compared to distal sentences (35.1cm \pm .37). The lack of significant interaction between Temporal Distance and Tense shows that the difference in Estimated Distance between proximal and distal sentences is not different for past sentences compared to future sentences.

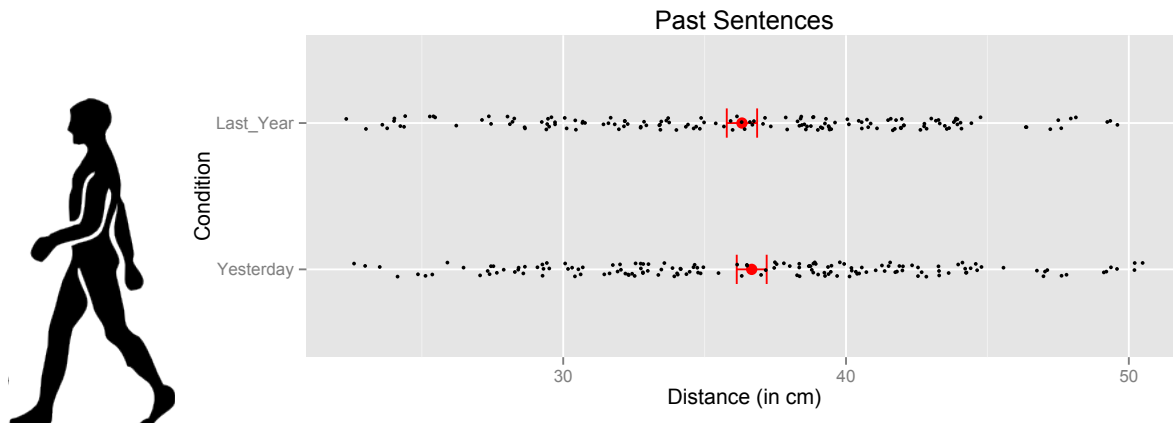


Figure 6.7. Estimated distances after past sentences in Experiment 7. Red dots indicate condition means and black dots indicate individual observations. The actual marker was at 40cm.

After hearing sentences with ‘yesterday,’ participants estimated $36.66\text{cm} \pm .53$, and they estimated $36.32\text{cm} \pm .54$ following sentences with ‘last year.’

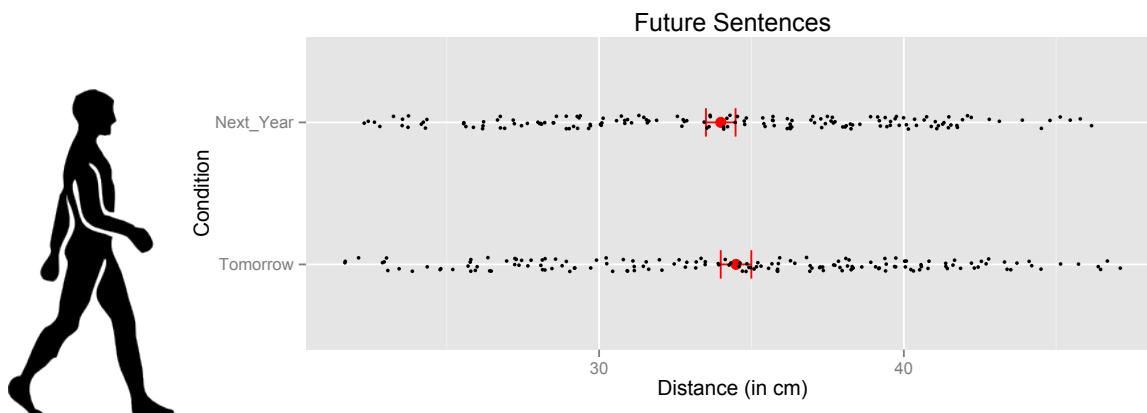


Figure 6.8. Estimated distances after future sentences in Experiment 7. Red dots indicate condition means and black dots indicate individual observations. The actual marker was at 40cm.

Lastly, participants estimated $34.49\text{cm} \pm .5$ after hearing a sentence about ‘tomorrow’ and $33.99\text{cm} \pm .49$ after hearing a sentence about ‘next year.’ As the model indicates, none of these differences are statistically significant.

6.3.3 Discussion

Contrary to predictions, processing everyday temporal expressions does not modulate spatial perception either behind or in front of participants when participants remain motionless for the task. This is particularly interesting in light of Experiment 6, as the only difference between the two experiments is bodily action. In Experiment 6, participants moved their bodies along with the cart, a motion that is congruent with an ego-moving perspective of Time. In Experiment 7, participants remained motionless, only moving the cart to estimate distances. This action is incongruent with an ego-moving perspective. When participants physically move the ego, a fine-grained distinction between proximal and distal sentence processing of future events is manifest. When participants remain motionless, this effect disappears.

6.4 General Discussion

These two studies contribute to the literature in three important ways. First, Experiment 6 demonstrates that English speakers recruit fine-grained spatial representations of internal Deictic time, such that processing proximal temporal events ('tomorrow') causes participants to estimate a shorter distance compared to their estimated distance after processing distal temporal events ('next year'). Interestingly, this effect is only present for future events. Second, a comparison of Experiment 6 and 7 shows that the proximal-distal effect can be modulated by the bodily action that participants perform when estimating the distance in front of them. When participants perform an action that is congruent with an ego-moving perspective (literally moving the ego), the proximal-distal effect emerges. When participants remain motionless, which is incongruent with an ego-moving perspective, the effect disappears. Since physical space remains constant across experiments and the only manipulation is motion type (though it is important to remember that Experiment 7 also involves motion of the arm as well as a shifted stance relative to the

track), this is evidence that motion (and not just physical space) is a critical component of English speakers' representations of internal Deictic time. Lastly, these experiments add to the growing number of studies demonstrating abstract-to-concrete effects of conceptual metaphors, where processing sentences describing proximal or distal temporal events influences spatial perception. In line with Slepian and Ambady (2014), it shows that processing sentences—not just nonlinguistic primes—can produce an abstract-to-concrete effect. Unlike Slepian and Ambady, however, it shows that these metaphors need not be novel. Everyday metaphors also influence spatial perception.

With the exception of a few studies that address proximal and distal events in space-time mapping (Bar-Anan et al., 2007; Sell & Kaschak, 2011; Ulrich et al., 2011), the experimental literature has largely treated the concept of Time as categorical, with the past behind the hearer and the future in front of the hearer. Experiment 6 shows that English speakers think about the future by recruiting a fine-grained spatial representation. This spatial representation is 'shorter' for proximal events ('tomorrow') and 'longer' for distal events ('next year'), as reflected in their varied estimates of the same marker in front of them. These results—which test internal Deictic time, or physical space behind and in front of the hearer—are consistent with the external Deictic time experiments described in earlier chapters. In this way, Experiment 6 serves as convergent evidence that English speakers do think about Time in terms of fine-grained physical space.

Unexpectedly, Experiment 6 also converges with Experiments 1a to suggest that English speakers think about the past and future in fundamentally different ways. Experiments 6 and 1a (in particular) demonstrate very clear proximal-distal spatial distinctions between 'tomorrow' and 'next year.' However, no such distinction is made in either experiment for 'yesterday' and 'last year.' There are many possible reasons why the future would involve the recruitment of

fine-grained physical space and the past would not. As Comrie (1985, p. 44) explains, the future is “unknowable,” whereas the past is composed of “analyzable” events. Another possible explanation pertains to embodiment. As embodied beings, we are accustomed to dealing with physical space in front of us, but not behind us. Consequently, it is much more natural to think about Time in terms of fine-grained physical space for frontal future events, but not for backward past ones. Of course, one could argue that the null results for past sentences in Experiment 6 are not the result of embodiment, but rather show that it is more difficult to estimate distances behind us than in front of us. While this is possible (as is evident in the higher standard error for past sentences than future sentences in Experiment 6), it does not explain Experiment 6’s convergent results with Experiment 1a. Given the convergent evidence across experiments, possible explanations for the difference between past and future event construal will be further addressed in Chapter 7.

The next important finding of this study is that participants’ bodily action influences the fine-grained space-time mapping difference for future sentences. In Experiment 6, participants step forward to estimate the distance in front of them. This bodily action is congruent with an ego-moving Time conceptualization, where the present is co-located with the ego and the ego literally moves after processing the future sentence. When participants perform an ego-moving action, they estimate a shorter distance following a proximal event compared their estimate following a distal event. In Experiment 7, on the other hand, participants remain motionless (with the exception of their arm) while estimating the distance in front of them. This is incongruent with an ego-moving perspective, where the ego remains motionless. When participants remain motionless, there is no difference between their estimates of proximal and distal future events. The present paradigm is thus the reverse of that employed by Boroditsky and

Ramscar (2002), who instead observed participants who had been primed by ego-moving motion events.

The difference between Experiment 6 and 7 is strong evidence that motion is a critical component of English speakers' mental representations of Future events of internal Deictic time (and not just physical space, as with external Deictic time from Experiments 1-5). Physical space is constant across both experiments. The only difference is the motion type when participants estimate the distance in front of them (as well as body positioning). Since manipulating the motion type (stepping forward vs. remaining motionless) modulates the spatial estimation effect, these experiments suggest that motion is a critical component of future events with internal Deictic time. In this case, participants apparently simulate the temporal event by recruiting a fine-grained physical spatial representation and a motion representation that is congruent with an ego-moving perspective. This result corroborates the findings of Walker et al. (2014), who also examined internal Deictic time by delivering aural prompts to participants with static speakers physically behind and in front of participants. Participants responded verbally 'past' or 'future' to events that they heard behind or in front of them. The researchers, however, found no effect for internal Deictic time prompts, concluding that it was possibly the result of their space-only (or motionless) task. Experiments 6-7 confirm this supposition, showing that the addition of an ego-moving bodily action results in a space-time mapping effect for internal Deictic time.

The remaining question is why results from Experiment 6 (congruent with ego-moving perspective) differ from Experiment 7 (incongruent with ego-moving perspective), as I did not have specific predictions as to which motion type would yield an effect. That is, English speakers have been shown to adopt both ego-moving and time-moving perspectives (the latter of which I am equating here with the 'incongruent with ego-moving perspective result of

Experiment 7) in experimental tasks, and both perspectives are encoded in language. Therefore, I predicted that both motion types would yield an identical effect. There are two possible explanations as to why this was not the case. One explanation is that processing temporal events using an ego-moving perspective is more basic/natural than processing sentences using a time-moving perspective (this hypothesis is supported by experiments which find more frequent effects for ego-moving primes than time-moving primes (e.g., Boroditsky, 2000; Boroditsky & Ramscar, 2002; Gentner, Imai, & Boroditsky, 2002). For example, Boroditsky and Ramscar (2002) asked people the ambiguous question, *Next Wednesday's meeting has been moved forward—What day is the meeting?*, to people standing in a lunch line waiting for food. Only people at the very end of the line, those furthest from food, consistently adopted a time-moving perspective over an ego-moving perspective (in this case, answered with 'Monday'). Consequently, performing an ego-moving task following an ego-moving perspective via sentence processing leads to a fine-grained mapping effect because participants most frequently recruit an ego-moving perspective versus a time-moving perspective. This also results in the null effect in Experiment 7.

The second explanation speaks to an interaction between language and motor action *planning*. Participants were asked to process the time course of sentences and then perform a physical task. So, while processing the sentence, they simultaneously planned their physical motion. It is possible that planning the physical task while processing the sentence influences participants' adoption of either ego-moving or time-moving perspective. In other words, when our motor planning and language processing faculties interact, it influences the perspective we take (ego-moving) or (time-moving) when processing a sentence. So, in Experiment 7, planning to remain motionless may have prompted participants to adopt a time-moving perspective,

similar to being primed with a time-moving prime. Adopting a time-moving perspective may somehow interfere with estimation in front of the body. This explanation speaks to a dynamic model of language and motor actions, such as that seen by Torralbo et al. (2006) and Brown (2012), where speakers adopt multiple (and almost unpredictable) construals of Time depending on the context and task. Disentangling these two explanations of the difference between Experiment 6 and 7 would require an experiment that separates motor action (explanation 1) and motor planning (explanation 2), as these are conflated in Experiments 6 and 7.

Lastly, the present experiment demonstrates a clear abstract-to-concrete effect, such that processing everyday temporal expressions involving proximal or distal events influences spatial perception. Many researchers have argued that conceptual metaphors are asymmetrical, where the source domain maps to the target domain, but not vice versa (see, for example, Casasanto & Boroditsky, 2008). By this model, only concrete-to-abstract effects are predicted. However, as Lee and Schwarz (2012) argue, conceptual metaphor theory does, in fact, accommodate abstract-to-concrete effects, so long as researchers make a distinction between metaphor structure and metaphor processing. As Lee and Schwarz (2012) observe, though Lakoff and Johnson (1980) do predict that metaphors will be structurally symmetrical (that is, the abstract will be structured by concrete representations), they say nothing about metaphor processing. When people process metaphors, such as *Next year, he will discover a planet*, they necessarily activate both target and source domains. Consequently, it makes perfect sense that metaphor processing would lead to both concrete-to-abstract effects as well as abstract-to-concrete effects.

Consequently, Experiments 6-7 add to the growing body of literature demonstrating abstract-to-concrete effects of conceptual metaphors, but they do not necessarily disrupt the foundations of conceptual metaphor theory. Rather, they speak to metaphor processing, not

necessarily metaphor structure. This is a stark contrast with Slepian and Ambady (2014), who specifically attempt to address metaphorical structure (and not necessarily metaphorical processing). They do so by providing participants with the ‘structure’ of the metaphors. That is, they teach participants “novel” metaphors, or the Past is Heavy versus Present is Heavy, for example. Doing so ensures that participants have a controlled metaphorical structure, unlike the present experiment, which examines well-established and conventional metaphorical structures. Therefore, though the present experiments cannot speak to the asymmetry of metaphorical structure, they do indicate that both target and source domains are activated during metaphor processing, and this creates symmetrical (i.e., both target and source domains are activated) effects.

6.5 Summary

Through the use of a novel experimental paradigm that requires participants to estimate physical distances behind and in front of them, this study demonstrates an abstract-to-concrete effect in which English speakers’ spatial perception is influenced by processing everyday time metaphors. The manipulation of spatial perception is modulated through the bodily action that participants perform, where an action congruent with an ego-moving perspective yields an effect, yet an action incongruent with an ego-moving perspective does not. This experiment is further evidence that English speakers process the future by recruiting fine-grained physical space for internal Deictic time, with proximal events involving shorter physical space than distal events.

Chapter VII:

The Map

7.1 Overview

This dissertation has employed two novel experimental paradigms to map the space-time topography of English speakers. The primary purpose of this study was to determine if English speakers construe temporal events using fine-grained physical space, such that proximal temporal events are construed as physically closer to a deictic center than distal temporal events. The results of Experiment 1a and Experiment 6, in particular, confirm the space-time topography hypothesis for both external and internal Deictic time. These findings are in line with other experiments that have addressed proximal-distal granularity (Bar-Anan et al., 2007; Sell & Kaschak, 2011; Ulrich et al., 2012), but they have extended previous findings by (1) disentangling external and internal Deictic time, (2) separately examining spatial and motion mental representations, and (3) using paradigms with front *and* back physical space relative to a deictic center.

Given that language is a primary source of evidence of space-time mapping, I have also explored the extent to which space-time topography is encoded in linguistic constructions about the past and future, or whether or not some grammaticalized English constructions encode proximal or distal spatial relationships (Brisard, 2001; Comrie, 1985; Langacker, 2008). I have shown that space-time mapping effects are robust for sentences with adverbials (e.g., ‘tomorrow’

versus ‘next year’), which are explicit about time granularity, but only for future events.

Linguistic constructions that do not explicitly encode proximal-distal distinctions (i.e., Present Perfect, Simple Past, *Be Going to* Future, and *Will* Future) do not yield such space-time mapping effects for physical distance. However, in a non-spatial task, Experiment 3 does find that English speakers judge sentences with the *Be Going to* Future as encoding a more proximal future than sentences with the *Will* Future. In turn, they judge the Present Perfect as encoding a more proximal past event than the Simple Past.

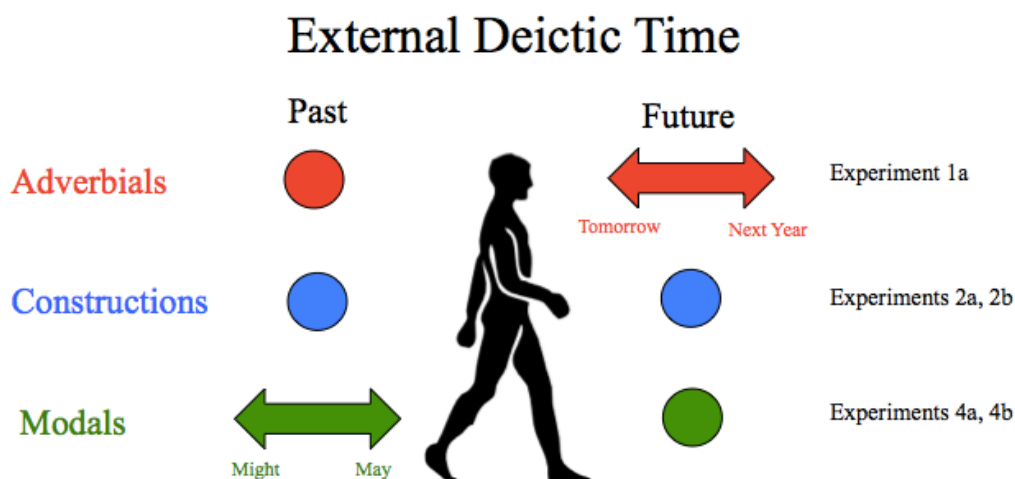


Figure 7.1. Results related to external Deictic time, where dots indicate no effect and arrows indicate a proximal-distal effect.

Lastly, Experiment 4a finds that the speaker’s certainty about an event, as encoded in modal verbs *may* and *might* (Langacker, 2008), also plays a role in space-time topography. Participants place *may* events closer to the deictic center than *might* events, but only for events in the past. Moreover, Experiment 5 finds that the further from the present a participant judges a potential event, the less likely they judge that event as having taken or taking place.

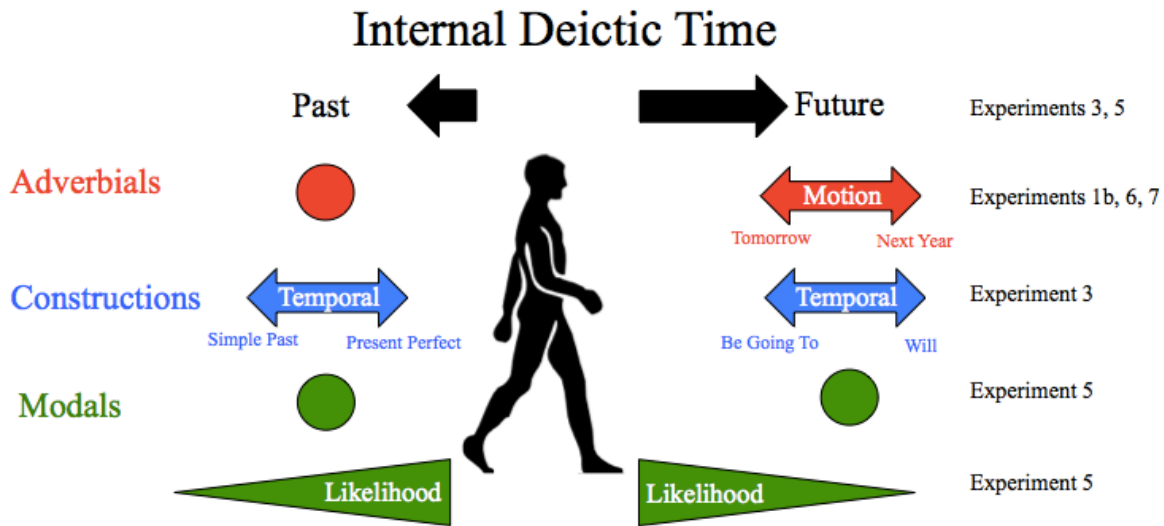


Figure 7.2. Results related to internal Deictic time, where dots indicate no effect and arrows indicate a spatial, temporal, or motion effect.

This dissertation has also examined the conditions under which participants, when space-time mapping, co-locate the present with an external locus. This has been observed with three primary manipulations: (1) an image with front-back physical depth, (2) reversing the direction of a character to face either away from or towards the participant, effectively creating a locus that is congruent or incongruent with his/her front-back internal Deictic time, and (3) explicitly or non-explicitly activating participants' mental timelines, as achieved through the depiction of a man on a street (the Life is a Journey metaphor) or a chair on a beach (Ulrich et al., 2012).

In general terms, as evident from Figure 7.3, results here are mixed. For example, in Experiment 1a, participants adopt the man on the street as a deictic center, both when he is facing away and facing toward them.

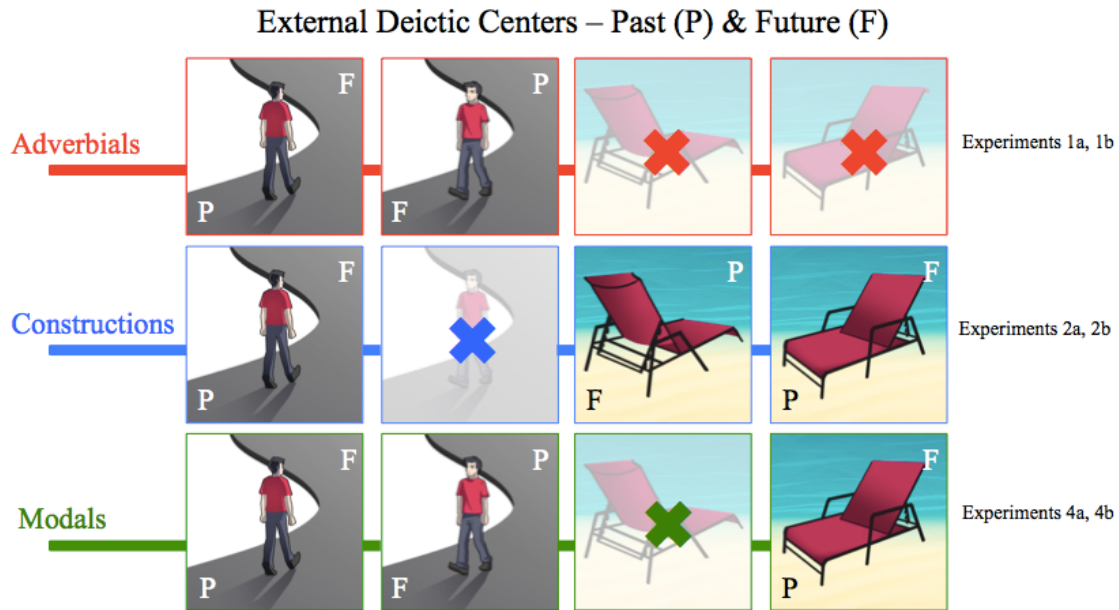


Figure 7.3. Images with loci that participants used as deictic centers, placing past (P) sentences ‘behind’ the locus and future (F) sentences ‘in front of’ the locus.

However, in Experiment 1b, when participants view a chair on a beach facing away and thus lack an obvious external deictic center, participants instead seem to adopt their own internal Deictic time conceptualization, placing proximal future sentences closer to themselves and distal future sentences further away. This effect changes when sentences include grammaticalized constructions. In Experiment 2a, participants only adopt the man on the street as a deictic center when he is congruent with their own internal Deictic time, or is facing away. In contrast, with Experiment 2b, participants co-locate the present with the chair both when it is congruent and incongruent with their internal Deictic time. Combined with the results of Experiments 4a and 4b, in which participants again adopt the man on the street in both directions but only adopt the chair when it is facing towards them, these results are difficult to interpret. There are two things that can be said with relative certainty, however. First, participants can and do co-locate the present with external locus that is incongruent with their own internal Deictic time. Second, the adoption of an external locus as a deictic center does not require the explicit activation of a

mental timeline.

The above-outlined results provide a new way of thinking about English speakers' conceptualizations of Time, and how thinking about Time interacts with language processing. Figures 7.1, 7.2, and 7.3 provide an overview of the results of these experiments. In essence, these are maps of English speakers' space-time topography. This dissertation thus contributes to our knowledge of space-time mapping as well as embodied cognition in general (Barsalou, 1999; Johnson, 1990; Lakoff & Johnson, 1980). It provides further insight into the minds of English speakers and how they construe temporal events metaphorically, through the activation of mental representations of fine-grained physical space and motion. Given the significance of these findings in our understanding of language and thought, I will discuss them in greater depth below.

7.2 The Past & Future

Perhaps the most robust and intriguing finding of this dissertation is the distinct differences that arise time and again for past and future events. Given that this dissertation includes some the first studies in the space-time mapping literature to incorporate physical space behind the deictic center, there is no obvious model with which to explain these findings. However, there are multiple possible explanations, and I will entertain a few below.

To begin, here is a summary of the repeated differences in the construal of past and future events across experiments. In Experiment 1a, participants clearly adopt the man on the street as a deictic center. They also demonstrate a fine-grained distinction between proximal and distal future events ('tomorrow' vs. 'next year') both when the character is facing away and towards them. In contrast, there is no effect for the past sentences in either image direction. This effect converges with the results of Experiment 6, which shows that participants estimate a shorter

distance in front of them after processing a proximal temporal event ('tomorrow') than they do after processing a distal temporal event ('next year'). There is no spatial estimation difference behind participants following proximal and distal past events.

Experiment 3 also shows a difference between the past and future, where participants reliably estimate a past event to have occurred a shorter temporal distance from the present (days to weeks) than the exact same event described in the future (months to years). Experiment 5 mirrors these findings with potential past and future events described with *may* or *might*. Experiment 5 also shows that, the further participants estimate a potential event in time, the lower they estimate its likelihood. In these ways, when participants think about a past event relative to a future event, they conceptualize the past event as more temporally proximal and likely.

Only two experiments reveal fine-grained proximal versus distal effects for past sentences. In Experiment 3, when participants are given two sentences, one in the Past Perfect (*He has discovered a planet*) and one in the Simple Past (*He discovered a planet*), they reliably estimate the Present Perfect event to have occurred more recently than the Simple Past event. Whether the result of the Present Perfect encoding proximal time or simply a strong association with the present (Comrie, 1985), this is an interesting result. In this experiment, participants are asked only to estimate the elapsed time since the event, and no physical space is involved.

In addition, Experiment 4a shows that English speakers construe potential past events using physical space. In comparing sentences like *He may have discovered a planet* (a more certain event) to *He might have discovered a planet* (a less certain event), participants place the *may* sentence closer to the deictic center than the *might* sentence (but only when the Life is a Journey metaphor has been activated with the image of the man on the street).

As mentioned in Chapter 2, Comrie (1985, p. 44) observes that the past and future are fundamentally different, as the past is “analyzable” but the future is “unknowable.” However, in the experiments reported here, participants did not directly *experience* any events—neither past nor future. Participants were not ‘analyzing’ past events that they had experienced compared to future ones that they had not. Therefore, accounting for the persistent differences in the construal of past versus future events in this dissertation requires an explanation that accommodates the construal of past and future events in general—not just those that the cognizer has encountered.

One possible explanation is that English speakers tend to conceptualize future events using ‘multiple branching tracks,’ whereas they conceptualize the past with few to none. This explanation aligns with Copley’s (2009) notion of a “branching future” (see also Ruppenhofer and Michaelis (to appear) for the role of frames, causality, and perspective on event construal), which suggests that any statement about the future (e.g., *He will discover a planet*) consists of a variable with multiple possible resolutions (e.g., he may *not* discover a planet, he may discover *multiple* planets, etc.). In this way, perhaps conceptualizing multiple possible future resolutions co-occurs with the construal of Time with physical space. This contrasts with the past, where the hearer may only conceptualize a single track, or no track at all. Then, when a speaker uses an epistemic modal verb like *may* or *might*, thus indicating that the past event is uncertain, this prompts the hearer to conceptualize multiple past tracks (e.g., he may have discovered a planet, or maybe he did not). This would explain the spatial effect of *may* and *might* in Experiment 4a. While this multiple track model does account for the data, it would require further investigation, perhaps with a paradigm that involves multiple possible past and future tracks.

A second explanation is that the future involves planning, whereas the past does not, as

the past cannot be changed. Research has shown that planning plays a critical role in cognizing future events (Hayes-Roth & Hayes-Roth, 1979), and it may even influence space-time topography. In fact, Torralbo and Liberman's (2010) Construal Level Theory shows that speakers tend to conceptualize and speak of more immediate temporal events using concrete, low-level construals (e.g., *candlelight dinner*) and more distal events using more high-level, abstract construals (e.g., *romantic evening*). This supposition was recently verified in an analysis of people's Twitter data (Bhatia & Walasek, 2016). Construal Level Theory is important here because researchers have shown that conceptualizations of psychological distance can influence how people choose to invest their money, how they make purchases, and how they assess risk (Trope, Liberman, & Wakslak, 2007). In other words, the fine-grained spatial results across experiments in this dissertation may largely be due to the necessity of planning future events, as future events are of paramount importance to our wellbeing. Moreover, an individual's actions in the present will necessarily have an impact on the future, so assessing the immediate future may be much more important than assessing distal or past events. Though the notion of planning does not necessarily account for the separation of *may* and *might* for past events in Experiment 4a, it does indicate that planning for future events may involve a different set of cognitive resources than simulating past ones. Further research could address the extent to which people also 'plan' for past events, or meditate on their ability to influence past events compared to future events. After all, we tell lots of stories about time machines.

A third explanation is that English speakers spend more cognitive resources (or effort) in cognizing past events compared to future events. In other words, mental simulations of past events may be more robust and detailed than future events. Future events, in contrast, may be more schematic and thus involve the construal of physical space. So, for example, perhaps

English speakers simulate the *discovery of a planet* in the past with a full set of cognitive resources, imagining everything from the color of the planet to its size and distance from Earth, whereas they only simulate a more schematic version when cognizing a future event—as they know that the speaker cannot possibly be 100% certain of that future event. When the event is in the future and is necessarily less certain, the hearer puts less ‘cognitive effort’ into simulating it. This explanation again accounts for the *may* versus *might* distinction in Experiment 4a, as it suggests that the speakers’ certainty about an event may modulate the schematicity with which it is simulated. If a past event is described in the irrealis, like an uncertain future event, it is not necessarily worth a full set of cognitive resources. This, of course, is purely speculation, but the present studies strongly indicate that it is a worthwhile avenue to pursue. This explanation aligns closely with the notion that English has no future tense at all, but rather realis versus irrealis moods (Comrie, 1985).

A final explanation is that we are simply not good at negotiating physical space behind deictic centers, both on an external image and behind the ego. This explanation has two facets. First, perhaps our poor negotiation of backward physical space transfers to space-time mapping such that we do not construe past events with the same level of fine-grained spatial detail as future events. In other words, this is an embodied explanation of space-time mapping. The second possibility is that the consistent lack of effect for past events in the studies reported here are simply a symptom of our inability negotiate backward space in the experimental paradigms, and we do, in fact, have fine-grained representations of past events. These possibilities could be addressed in two ways. First, participants could be encouraged to map past events to frontal space. So, with the spatial perception paradigm of Experiments 6 and 7, participants could be asked to perform the reverse task: for events in the future, estimate to the marker behind you, and

for events in the past, estimate to the marker in front of you. When participants are forced to use frontal physical space with past events, a proximal-distal distinction may emerge. Since participants would be using frontal physical space to construe past events, this would help disentangle if the past/future difference is one of space-time mapping or a simple inability to negotiate backward space. A second, perhaps more exciting option is to run the spatial perception paradigm with Aymara speakers, who have the reversed conceptualization of Time as English speakers, with the past in front of the ego and the future behind (Núñez & Sweetser, 2006). If Aymara speakers demonstrate a proximal-distal distinction for past events (front) and not future ones (back), this would be strong evidence of the embodied explanation, or the notion that we only cognize temporal events with fine-grained *frontal* space.

All of these explanations serve as hypotheses that could be tested with further research. Regardless of the model that eventually accounts for these and future data, the past/future distinction uncovered in this dissertation speaks to the importance of developing novel methodologies that include front-back space with reference to a deictic center when examining space-time topography.

7.3 Grammaticalized Constructions & Modality

Sentences with adverbials elicit clear space-time topography. However, with grammaticalized constructions and sentences with epistemic modal verbs, the story is more complex. To begin, grammaticalized constructions do not yield a fine-grained spatial distinction, but they do exhibit a fine-grained temporal distinction. Experiments 2a and 2b, both of which involve a spatial sentence placement task, show no fine-grained spatial distinction between past constructions (Present Perfect and Simple Past) nor future constructions (*Be Going to* Future and *Will* Future). However, in post-hoc Experiment 3, which involves a task wherein participants

only estimate the elapsed time since or until the *discovery of a planet*, participants judge the event with the Present Perfect to be more temporally proximal than the Simple Past and the *Be Going to* Future to be more temporally proximal than the *Will* Future. In other words, constructions for the past and future encode fine-grained temporal distinctions, but not necessarily spatial distinctions. There are two possible explanations for these results.

First, as opposed to lexical adverbials, grammaticalized constructions that encode fine-grained temporal distinctions have been abstracted away from their spatial (and motion) representations. Whereas grammaticalized constructions may diachronically link to fine-grained physical space, the more conventionalized they have become, the less English speakers recruit this fine-grained physical space when processing them (see, e.g., Gould, 2015 for effects of frequency on semantic simulation). As discussed in Chapter 4, this is highly consistent with Bowdle and Gentner's (2005) career of metaphor hypothesis, which observes that, as metaphors become more conventional, they are simultaneously abstracted away from their sensorimotor origins in the minds of speakers. This hypothesis has been confirmed in numerous studies, such as Desai et al. (2011), who show that processing sensorimotor metaphors with metaphorical terms (e.g., *The jury grasped the concept*) elicits motor cortex activation and the equivalent 'abstract' version of those metaphors (e.g., *The jury understood the concept*) do not. In this way, the grammaticalized constructions examined in this dissertation can be considered grammaticalized realizations of metaphors. Whereas they may have at one time encoded fine-grained physical space, they are essentially highly conventionalized metaphorical expressions, and these expressions no longer require the activation of physical space or motion to be cognized.

The second explanation pertains to the paradigm of Experiment 3. The paradigm, in

which participants are asked to process a sentence about the *discovery of a planet* either in the past or future and then estimate how long since that event occurred or until it will occur, does not distinguish between external and internal Deictic time. So, when participants are processing the target sentences in Experiment 3, they may, in fact, recruit spatial representations, but there is no way to know. Moreover, they are likely recruiting internal Deictic time instead of external Deictic time. These confounds were necessary given the paradigm, but future research could attempt to avoid them and help verify the validity of the first explanation above.

Lastly, following the research of Fernández de Lara (2012) and Kaup et al.'s (2007), Experiments 4a and 4b show that English speakers map physical space onto irrealis (and not just realis) Time representations. Participants attend to an external deictic center when placing potential events as indicated by the modal verbs *may* or *might*, placing potential past events behind the deictic center and potential future events in front of the deictic center. This confirms that English speakers construe irrealis events similar to realis counterparts. Second, they also demonstrate space-time topography with *may* or *might* sentences in the past, as both sentence types are placed a significant distance from the other both when the man on the street is facing away and towards the participant. These results add a further dimension to the notion of space-time topography, demonstrating that processing potential past events involves the recruitment of space, and the recruitment of this space can be modulated based on the linguistic forms that a speaker uses.

While the most robust effects in this dissertation are found with lexical adverbials, results from both grammaticalized constructions and modal verbs provide incredible insight into the nuance of space-time mapping and the extent to which fine-grained space is or is not encoded in linguistic expressions. It thus demonstrates the importance of considering various linguistic

constructions when examining the interaction of language and thought.

7.4 External Deictic Centers

Studies in this dissertation have examined the conditions under which English speakers adopt an external deictic center as opposed to an internal one. These conditions involve external loci that (1) have front-back depth, (2) are congruent and incongruent with participants' representations of internal Deictic time, and (3) explicitly do or do not explicitly activate a mental timeline in the minds of speakers. These conditions contrast with previous studies, which have primarily shown space-time mapping of external Deictic time along a left-right axis (Flumini & Santiago, 2013; Santiago et al., 2007; Weger & Pratt, 2008) and with stimuli congruent with participants' internal Deictic time representations (Torralbo et al., 2006). Previous studies have also suggested that space-time mapping—including the co-location of the present with an external deictic center—is a consequence of experiments that explicitly encourage participants to think about Time in terms of space, or activate a mental timeline (Ulrich et al., 2012). In addressing each of these issues, this dissertation furthers our understanding of English speakers' dynamic ability to map space onto time.

To begin, English speakers have been shown to map left space to the past and right space to the future. This is attributable to writing direction as well as other cultural conventions, such as calendars and timelines (Flumini & Santiago, 2013). However, English speakers do not frequently engage in space-time mapping with an external image that has front-back depth. Regardless, Experiment 1a strongly shows that English speakers readily co-locate the present with a locus on an image with front-back depth. This is evidence that English speakers are particularly dynamic in their space-time construals, and they map space to Time using physical space in situations that are not particularly conventional.

The studies in this dissertation also show that English speakers co-locate the present with external loci that are incongruent with their internal Deictic time representations. For each experiment, participants viewed a character that was facing away from them, congruent with their own front-back internal Deictic time, or towards them, incongruent with their own internal Deictic time. Experiments 1a, 2b, and 4a, where participants attend to the character in the image when facing both directions, are strong evidence that English speakers adopt an external deictic center when it is incongruent with their own internal Deictic time (or facing towards them). This is impressive, as it shows that English speakers are able to effectively reverse their conceptualization of Time given a particular external representation, even when it runs counter to their more basic internal conceptualization. This, again, speaks to a flexible ability to space-time map, one that is not necessarily based on cultural conventions.

I also tested English speakers' co-location of the present with an external locus with the explicit activation of a mental timeline and without. Some participants viewed images with the Life is a Journey metaphor (a man on a street), while others viewed an image that was not explicit about a mental timeline but still featured front-back depth (a chair on a beach). Experiments 1b, 2b, and 4b, which all involve the image of the chair on the beach, all yield space-time mapping effects. The results of Experiment 1b, where participants place sentences with adverbials on an image with a chair on a beach, are clearest: though they do not co-locate the present with the chair, participants place proximal future sentences closer to the ego and distal ones further away. Apparently, in the absence of an obvious external deictic center, participants co-locate the present with the ego but still adopt the front-back space of the image. These results indicate that, when participants cannot readily identify a viable external locus with which to co-locate the present, they 'default' to an internal Deictic time representation. This is

strong evidence that space-time mapping is not dependent upon explicit activation of a mental timeline (or the Life is a Journey metaphor). In other words, English speakers associate physical space with time-related sentences when they have not been explicitly encouraged to think about Time in terms of physical space. Construing Time through physical space, even outside of the body, is critical to cognizing temporal events.

Lastly, there is an important observation to be made about Experiments 2a and 2b. Experiment 2a, with the picture of the man on the street, is less explicit about the time of the event compared to Experiment 1a, as it uses grammaticalized constructions instead of explicit adverbials. In the absence of adverbials, participants only place past sentences behind the man on the street and future sentences in front when the man is facing away from them, or is congruent with their internal Deictic time representation. The problem is that Experiment 2a finds this effect only when the man is facing away, whereas Experiment 2b finds an effect both when the chair is facing away *and* towards the participant. This may speak to an interaction between the explicitness of the time scale in the sentence and the explicitness of the image with regard to activating a mental timeline. Perhaps the less explicit the sentence is about the time of the event, and the less explicit the image is about using physical space for time, the more inclined participants are to utilize the physical space available to them. These results will require further investigation.

7.5 Physical Space & Motion

Experiments 1, 2, and 4 provide strong evidence that external Deictic time does not necessarily include a mental representation of motion, either ego-moving or time-moving. The sentence placement task, in which participants place sentences on a static image of a man on a street or a chair on a beach, involves no motion. In other words, placing sentences is a strictly

spatial task. One could argue, of course, that the image with the man on the street has implied motion, which is accurate. The man is stepping. However, Experiments 2b and 4b, in which participants co-locate the present with the chair on the beach in placing sentences, suggests that the implied motion of the man on the street is not necessary for space-time mapping of external Deictic time.

The external Deictic time results contrast with Experiments 6-7, which explicitly address internal Deictic time. Experiments 6-7 show that ego-moving motion is a component of internal Deictic time. This is demonstrated through the fine-grained mapping effect between ‘tomorrow’ and ‘next year’ sentences in Experiment 6, where participants estimate the distance with a bodily action that is congruent with an ego-moving perspective (i.e., stepping forward, literally moving the ego). In Experiment 7, participants instead remain motionless (i.e., incongruent with an ego-moving perspective) and estimate the exact same distance, and there is no such fine-grained mapping effect. Since the only difference between these two experiments is motion type, this is strong evidence that English speakers recruit a representation of physical motion when processing internal Deictic time. Moreover, since the body motion congruent with an ego-moving perspective (Experiment 6) yields a fine-grained mapping effect, but the body motion that is incongruent with an ego-moving perspective (Experiment 7) does not, it seems reasonable to assume that the ego-moving perspective is in some way more primal or frequent than the time-moving perspective when English speakers process future events. Moreover, these results nicely align with contemporary literature on internal Deictic time, which demonstrate no front-back internal Deictic time effects in a non-motion task (Walker et al., 2014).

7.6 Abstract-to-Concrete Effects

Lastly, Experiments 6-7 show a clear abstract-to-concrete effect, where participants process language and then estimate a physical distance. Participants reliably estimate a shorter distance following a proximal sentence ('tomorrow') compared to their estimate following a distal sentence ('next year'). As addressed in Chapter 6, this result is not necessarily evidence of asymmetrical metaphorical *structure*. Rather, it speaks to metaphor *processing*. Specifically, it demonstrates that spatial and motion representations are activated when English speakers process sentences about the future. This dissertation thus contributes to a large body of evidence of abstract-to-concrete effects when processing conceptual metaphors (Jostmann, Lakens, & Schubert, 2009; Landau et al., 2010; Lee & Schwarz, 2012; Schubert, 2005; Zhong & Liljenquist, 2006).

7.7 Limitations & Future Directions

As with any experimental paradigm examining language, one has to question the ecological validity, or the extent to which the results reflect actual sentence processing. This is particularly problematic for the sentence placement paradigm, as it does not examine sentence processing per se. Rather, it essentially examines the extent to which English speakers associate—either through subconscious processing or through very conscious thinking—physical front-back space with the content of time-related sentences. Therefore, though I have repeatedly used the word 'construe' to describe the results of Experiments 1-5, it is important to remember that space-time mapping is not necessarily an unconscious process for these studies. However, it should also be noted that I did conduct a post-survey, and any participants who identified the intention of the study as associating time with space were removed from the final analysis. Experiments 6-7 also help mitigate the possibility of the effects of Experiments 1-5 being purely

based on conscious decisions, as participants are blindfolded when estimating distances and are thus influenced by sentence processing alone. Experiments 6-7 thus strongly suggest that fine-grained space-time topography also pertains to sentence processing, not just spatial associations.

One purpose of these experiments has been to open a new door in the space-time mapping literature. The notion of space-time topography presents several new and exciting avenues for researchers to pursue. In Experiments 1-7, I have primarily examined proximal versus distal events. However, this is hardly the limit to further inquiry. Landscapes have contours and obstacles. English speakers also speak of past and future events in terms of contours and obstacles. People can be at a ‘high point’ in their lives or a ‘low valley.’ Difficulties can be described as ‘hurdles’ or ‘walls.’ People can be engaged in an ‘uphill struggle’ or exclaim that ‘it’s all downhill from here.’ In short, the present dissertation demonstrates that English speakers think about the future, in particular, through the recruitment of fine-grained physical space and motion. Their mental representations of Time involve relatively detailed representations of space, or physical landscape. Future researchers can pursue this line of thought: just how detailed is this landscape?

Such research should not be limited to adult speakers. Based on informal data from my 3 year-old daughter, I strongly suspect that fine-grained topography develops at a young age—perhaps in conjunction with other major cognitive breakthroughs. For example, up until last month, my daughter referred to all past events with the word ‘yesterday’ and all future events with ‘tomorrow,’ regardless of how proximal or distal the event was with reference to the present. Future research could examine whether this observation is simply due to limited vocabulary, or whether children conceptualize Time differently from adults, and when exactly fine-grained conceptualizations begin to develop.

Lastly, this dissertation ends where it began. Just as other languages, such as Yupno and Bamileke-Dschang, inspired further inquiry into the space-time topography of English speakers, so, too should speakers of these languages and others be researched. Do speakers of other languages really think in terms of fine-grained space, and how fine-grained is this space? In languages other than English, what is the interaction between physical topography and linguistic codes? Are there further effects of differences in fine-grained topography? Chen (2012), for example, shows that speakers of languages with different future references may have different spending and saving habits. Crosslinguistic inquiry is certain to yield fascinating insights not only into the maps of speakers' space-time topography, but also into its real-world effects.

7.8 Final Words

Caltech researchers have discovered a new planet in our solar system. This past event is more temporally proximal and likely than if the event were described in the future. If it were in the future, you would recruit a more proximal physical representation for 'tomorrow' compared to 'next year,' and you would likely conceptualize the event through the recruitment of an ego-moving perspective. This is all the consequence of your space-time topography.

REFERENCES

- Bar-Anan, Y., Liberman, N., Trope, Y., & Algom, D. (2007). Automatic processing of psychological distance: evidence from a Stroop task. *Journal of Experimental Psychology: General*, 136(4), 610.
- (2006). The association between psychological distance and construal level: evidence from an implicit association test. *Journal of Experimental Psychology: General* 135(4), 609.
- Barsalou, L. W. (1999). Perceptual symbol systems. *Behavioral and Brain Sciences* 22, 577-609.
- Bates, D.M., Maechler, M., & Bolker, B. (2012). lme4: Linear mixed-effects models using S4 classes. R package version 3.2.3.
- Bender, A., Beller, S., & Bennardo, G. (2010). Temporal frames of reference: conceptual analysis and empirical evidence from German, English, Mandarin Chinese and Tongan. *Journal of Cognition and Culture*, 10(3), 283-307.
- Bergen, B. K. (2012). *Louder than Words: The New Science of How the Mind Makes Meaning*. Basic Books.
- Bergen, B. K., Lindsay, S., Matlock, T., & Narayanan, S. (2007). Spatial and linguistic aspects of visual imagery in sentence comprehension. *Cognitive Science*, 31(5), 733-764.
- Bhatia, S., & Walasek, L. (2016). Event construal and temporal distance in natural language. *Cognition*, 152, 1-8.
- Boroditsky, L. (2001). Does language shape thought?: Mandarin and English speakers' conceptions of time. *Cognitive Psychology* 43(1), 1-22.
- (2000). Metaphoric structuring: Understanding time through spatial metaphors. *Cognition* 75(1), 1-28
- Boroditsky, L., Fuhrman, O., & McCormick, K. (2011). Do English and Mandarin speakers think about time differently? *Cognition* 118(1), 123-129.
- Boroditsky, L. & Gaby, A. (2010). Remembrances of time East: Absolute spatial representations of time in an Australian Aboriginal community. *Psychological Science* 21(11), 1635-1639.
- Boroditsky, L. & Ramscar, M. (2002). The roles of body and mind in abstract thought. *Psychological Science* 13(2), 185-189.

- Bowdle, B. F., & Gentner, D. (2005). The career of metaphor. *Psychological Review* 112(1), 193.
- Brisard, F. (2001). Be going to: An exercise in grounding. *Journal of Linguistics* 37(2), 251-285.
- Brown, P. (2012). Time and space in Tzeltal: is the future uphill?. *Frontiers in Psychology* 3, 212.
- Bybee, J. (2006). From usage to grammar: The mind's response to repetition. *Language*, 711-733.
- Casasanto, D. (2009). When is a linguistic metaphor a conceptual metaphor. *New Directions in Cognitive Linguistics*, 127-145.
- Casasanto, D., & Jasmin, K. (2012). The hands of time: Temporal gestures in English speakers. *Cognitive Linguistics* 23(4), 643–674.
- Cienki, A., & Müller, C. (Eds.). (2008). *Metaphor and Gesture* (Vol. 3). John Benjamins Publishing.
- Chan, T.T., & Bergen, B. (2005). Writing direction influences spatial cognition. In *Proceedings of the Twenty-seventh Annual Conference of the Cognitive Science Society*.
- Chen, J. Y. (2007). Do Chinese and English speakers think about time differently? Failure of replicating Boroditsky (2001). *Cognition* 104(2), 427-436.
- Chen, M. K. (2012). The effect of language on economic behavior: Evidence from savings rates, health behaviors, and retirement assets. *American Economic Review* 2013, 103(2), 690-731.
- Clark, H. (1973). Space, time semantics, and the child. In T. E. Moore (Ed.), *Cognitive Development and the Acquisition of Language*. New York: Academic Press.
- Comrie, B. (1985) *Tense*. Cambridge: Cambridge University Press.
- Cooperrider, K., & Núñez, R. (2009). Across time, across the body transversal temporal gestures. *Gesture*, 9(2), 181-206.
- Copley, B. (2009). *The Semantics of the Future*. Routledge.
- Desai, Rutvik H., Binder, Jeffrey R., Conant, Lisa L., Mano, Quintino R., & Seidenberg, Mark S. (2011). The neural career of sensorimotor metaphors. *Journal of Cognitive Science* 23(9), 2376-2386.

- Dixon, R.M.W. (1977). *Yidiny*. Cambridge: Cambridge University Press.
- Fauconnier, G., & Turner, M. (2008). *The Way we Think: Conceptual Blending and the Mind's Hidden Complexities*. Basic Books.
- Fernández de Lara, R.A. (2012). *Spatial Mappings for Time and Epistemic Ambits of Events by Verb Forms*. Unpublished dissertation.
- Fillmore, Charles J. (1982). Towards a descriptive framework for spatial deixis. In R. J. Jarvella & W. Klein (Eds.), *Speech, place and action: Studies in deixis and related topics* (pp. 31–59). London: Wiley.
- (1966). Deictic categories in the semantics of *come*. *Foundations of Language*, 219-227.
- Flumini, A., & Santiago, J. (2013). Time (also) flies from left to right if it is needed. In *In: Proceedings of the 36th Annual Conference of the Cognitive Science Society* (pp. 2315-2320).
- Gaby, A. (2012). The Thaayorre think of time like they talk of space. *Frontiers in Psychology*, 3.
- Gentner, D., Imai, M., & Boroditsky, L. (2002). As time goes by: Evidence for two systems in processing space→ time metaphors. *Language and Cognitive Processes*, 17(5), 537-565.
- Gould, K. M. (2015). *Now You See It, Now You Don't: The Influence of Lexical Class, Usage Frequency, and Constructional Context on Semantic Simulation*. CU Boulder: Unpublished Dissertation.
- Hand, E. (2016). Astronomers say a Neptune-sized planet lurks beyond Pluto. *Science*. Retrieved from: <http://www.sciencemag.org/news/2016/01/feature-astronomers-say-neptune-sized-planet-lurks-unseen-solar-system>.
- Hayes-Roth, B., & Hayes-Roth, F. (1979). A cognitive model of planning. *Cognitive Science*, 3(4), 275-310.
- Hyman, L. M. (1980). Relative time reference in the Bamileke tense system. *Studies in African Linguistics*, 11(2).
- Johnson, M. (1990). *The Body in the Mind: The Bodily Basis of Meaning, Imagination, and Reason*. University of Chicago Press.
- Jostmann, N. B., Lakens, D., & Schubert, T. W. (2009). Weight as an embodiment of importance. *Psychological Science*, 20, 1169–1174.

- Kaup, B., Yaxley, R. H., Madden, C. J., Zwaan, R. A., & Lüdtke, J. (2007). Experiential simulations of negated text information. *The Quarterly Journal of Experimental Psychology*, 60(7), 976-990.
- Kranjec, A., & McDonough, L. (2011). The implicit and explicit embodiment of time. *Journal of Pragmatics*, 43(3), 735-748.
- Lacey, S., Stilla, R., & Sathian, K. (2012). Metaphorically feeling: comprehending textural metaphors activates somatosensory cortex. *Brain and Language*, 120(3), 416-421.
- Lai, V. (2009). *Understanding Metaphorical Expressions: Conventionality, Mappings, and Comparison Processes*. Unpublished Dissertation.
- Lakoff, G. (2008). The neural theory of metaphor. In Gibbs, Jr., Raymond W. (ed.). *The Cambridge Handbook of Metaphor and Thought*. Cambridge & New York: Cambridge University Press.
- (1993). The contemporary theory of metaphor. In Ortony, Andrew (ed.). *Metaphor and Thought*. 2 ed. Cambridge & New York: Cambridge University Press.
- (1987). *Women, Fire, and Dangerous Things: What Categories Reveal about the Mind*. Chicago and London: The University of Chicago Press.
- Lakoff, G. and Johnson, M. (1980). *Metaphors We Live By*. Chicago and London: The University of Chicago Press.
- Lakoff, G. & Turner, M. (1989). *More than Cool Reason: A Field Guide to Poetic Metaphor*. Chicago & London: The University of Chicago Press.
- Langacker, R. W. (2008). *Cognitive Grammar: A Basic Introduction*. Oxford: Oxford University Press.
- Lee, S. W., & Schwarz, N. (2012). Bidirectionality, mediation, and moderation of metaphorical effects: The embodiment of social suspicion and fishy smells. *Journal of Personality and Social Psychology*, 103(5), 737.
- Lehrer, A. (1990). Polysemy, conventionality, and the structure of the lexicon. *Cognitive Linguistics* 1, 207-246.
- Levinson, S. C. (1983). *Pragmatics*. Cambridge: Cambridge University Press.
- Liberman, N., Sagristano, M. D., & Trope, Y. (2002). The effect of temporal distance on level of mental construal. *Journal of Experimental Social Psychology*, 38(6), 523-534.

- Liberman, N., & Trope, Y. (2008). The psychology of transcending the here and now. *Science* 322(5905), 1201-1205.
- Lyons, J. (1977). Deixis, space and time. *Semantics* 2, 636-724.
- Matlock, T. (2004). Fictive motion as cognitive simulation. *Memory & Cognition* 32(8), 1389-1400.
- Matlock, T., Holmes, K. J., Srinivasan, M., & Ramscar, M. (2011). Even abstract motion influences the understanding of time. *Metaphor and Symbol*, 26(4), 260-271.
- McGlone, M. S., & Harding, J. L. (1998). Back (or forward?) to the future: The role of perspective in temporal language comprehension. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 24(5), 1211.
- McTaggart, J. (1908) The unreality of time. *Mind* 17, 457–474.
- Michaelis, L. (1994). The ambiguity of the English present perfect. *Journal of Linguistics*, 30(01), 111-157.
- 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(3), 759-776.
- Núñez, R., & Cooperrider, K. (2013). The tangle of space and time in human cognition. *Trends in Cognitive Sciences* 17(5), 220-229.
- Núñez, R., Cooperrider, K., Doan, D., & Wassmann, J. (2012). Contours of time: Topographic construals of past, present, and future in the Yupno valley of Papua New Guinea. *Cognition* 124(1), 25-35.
- Núñez, R. E., Motz, B. A., & Teuscher, U. (2006). Time after time: The psychological reality of the ego-and time-reference-point distinction in metaphorical construals of time. *Metaphor and Symbol*, 21(3), 133-146.
- Núñez, R., Neumann, V., & Mamani, M. (1997). Los mapeos conceptuales de la concepción del tiempo en la lengua Aymara del Norte de Chile [Conceptual mappings in the conceptualization of time in northern Chile's Aymara]. *Boletín de Educación de la Universidad Católica del Norte*, 28, 47-55.
- Núñez, R. E., & Sweetser, E. (2006). With the future behind them: Convergent evidence from Aymara language and gesture in the crosslinguistic comparison of spatial construals of time. *Cognitive Science* 30(3), 401-450.
- Palmer, F. R. (2001). *Mood and Modality*. Cambridge: Cambridge University Press.

- Peirce, J. W. (2007). PsychoPy—psychophysics software in Python. *Journal of Neuroscience Methods*, 162(1), 8-13.
- R Core Team (2012). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.
- Radden, G. (2003). The metaphor TIME AS SPACE across languages. *Zeitschrift für Interkulturellen Fremdsprachenunterricht*, 8(2).
- Ruppenhofer, J. & Michaelis, L.A. (to appear). Frames, polarity, and causation. *Corpora*.
- Santiago, J., Lupiáñez, J., Pérez, E., & Funes, M. J. (2007). Time (also) flies from left to right. *Psychonomic Bulletin & Review* 14(3), 512-516.
- Schubert, T. W. (2005). Your highness: Vertical positions as perceptual symbols of power. *Journal of Personality and Social Psychology* 89, 1–21.
- Scott, A. (1989). The vertical dimension and time in Mandarin. *Australian Journal of Linguistics* 9, 295–314.
- Sell, A. J., & Kaschak, M. P. (2011). Processing time shifts affects the execution of motor responses. *Brain and Language* 117(1), 39-44.
- Sinha, C., Sinha, V. D. S., Zinken, J., & Sampaio, W. (2011). When time is not space: the social and linguistic construction of time intervals and temporal event relations in an Amazonian culture. *Language and Cognition*, 3(1), 137-169.
- Shinohara & Pardeshi (2011). The more in front, the later: The role of positional terms in time metaphors. *Journal of Pragmatics* 43, 749-758.
- Teuscher, U., McQuire, M., Collins, J., & Coulson, S. (2008). Congruity effects in time and space: Behavioral and ERP measures. *Cognitive Science*, 32(3), 563-578.
- Torralbo, A., Santiago, J., & Lupiáñez, J. (2006). Flexible conceptual projection of time onto spatial frames of reference. *Cognitive Science* 30(4), 745-757.
- Traugott, E. (1978). On the expression of spatiotemporal relations in language. In J. H. Greenberg (Ed.), *Universals of Human Language: Word Structure* (Vol. 3, pp. 369–400). Stanford, CA: Stanford Univ. Press.
- Trope, Y., & Liberman, N. (2010). Construal-level theory of psychological distance. *Psychological Review*, 117(2), 440.
- Trope, Y., Liberman, N., & Wakslak, C. (2007). Construal levels and psychological distance: Effects on representation, prediction, evaluation, and behavior. *Journal of Consumer Psychology: The Official Journal of the Society for Consumer Psychology*, 17(2), 83.

- Ulrich, R., & Maienborn, C. (2010). Left–right coding of past and future in language: The mental timeline during sentence processing. *Cognition*, 117(2), 126-138.
- Ulrich, R., Eikmeier, V., de la Vega, I., Fernández, 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 & Cognition* 40(3), 483-495.
- Vendler, Z. (1957). Verbs and times. *The Philosophical Review*, 143-160.
- Walker, E. J., Bergen, B. K., & Núñez, R. (2014). Disentangling spatial metaphors for time using non-spatial responses and auditory stimuli. *Metaphor and Symbol* 29(4), 316-327.
- Wassmann, J. (1994). The Yupno as post-Newtonian scientists: the question of what is 'natural' in spatial description. *Man*, 645-666.
- Weger, U. W., & Pratt, J. (2008). Time flies like an arrow: Space-time compatibility effects suggest the use of a mental timeline. *Psychonomic Bulletin & Review* 15(2), 426-430.
- Williams, L. E., & Bargh, J. A. (2008). Experiencing physical warmth promotes interpersonal warmth. *Science* 322(5901), 606-607.
- Zhong, C.-B. & Liljenquist, K. (2006). Washing away your sins: Threatened morality and physical cleansing. *Science* 313, 1451–1452.

Appendix A: Statistical Models

Experiment 1a

Model 1: Logistic Regression

	Estimate	Std. Error	Z value
<i>Fixed Effects</i>			
(Intercept)	0.7463	0.1501	4.971
tensepast	-2.6247	0.2425	-10.824
char_dirforw	1.3341	0.2551	5.229
tensepast*char_dirforw	0.335	0.3487	0.96
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item	8.43E-05	0.00918	
Participant	1.55E-01	0.39394	

Model 2: Linear Regression

	Estimate	Std. Error	t value
<i>Fixed Effects</i>			
(Intercept)	11.1981	0.2557	43.8
tensepast	-5.639	0.3635	-15.52
char_dirforw	2.5551	0.3639	7.02
tensepast*char_dirforw	0.7762	0.5146	1.51
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	0.09349	0.3058	
Participant (Intercept)	0.03322	0.1823	

Model 3: Linear Model of Past Sentences

	Estimate	Std. Error	t value
<i>Fixed Effects</i>			
(Intercept)	5.7382	0.4353	13.183
distancedistal	-0.3071	0.5097	-0.602
char_dirforw	3.5204	0.51	6.903
distancedistal*char_dirforw	-0.4283	0.7157	-0.598
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	0.3016	0.5492	
Participant (Intercept)	3.4096	1.8465	

Model 4: Linear Model of Future Sentences

	Estimate	Std. Error	t value
<i>Fixed Effects</i>			
(Intercept)	10.70455	0.34199	31.3
distancedistal	0.98716	0.44197	2.234
char_dirforw	2.58287	0.43441	5.946
distancedistal*char_dirforw	-0.06345	0.6137	-0.103
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	1.04E-14	1.02E-07	
distancedistal	1.15E-13	3.39E-07	
Participant (Intercept)	1.49E+00	1.22E+00	
distancedistal	6.91E-01	3.39E-07	

Table A. Experiment 1a statistical models.

Experiment 1b

Model 1: Logistic Regression

	Estimate	Std. Error	Z value
<i>Fixed Effects</i>			
(Intercept)	-0.6253	0.2241	-2.79
tensepast	-0.3332	0.2716	-1.226
char_dirforw	2.113	0.2935	7.2
tensepast*char_dirforw	0.2255	0.2255	0.547
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	0	0	
Participant (Intercept)	0.51485	0.71753	

Model 2: Linear Regression

	Estimate	Std. Error	t value
<i>Fixed Effects</i>			
(Intercept)	8.172	0.3831	21.332
tensepast	-0.3919	0.4654	-0.842
char_dirforw	3.655	0.47	7.776
tensepast*char_dirforw	0.946	0.6628	1.427
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	4.93E-15	7.02E-08	
Participant (Intercept)	1.29E+00	1.14E+00	

Model 3: Linear Model of Past Sentences

	Estimate	Std. Error	t value
<i>Fixed Effects</i>			
(Intercept)	7.4907	0.5119	14.633
distancedistal	0.5976	0.6322	0.945
char_dirforw	4.7609	0.6347	7.501
distancedistal*char_dirforw	-0.3536	0.8998	-0.393
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	0	0	
Participant (Intercept)	2.061	1.436	

Model 4: Linear Model of Future Sentences

	Estimate	Std. Error	t value
<i>Fixed Effects</i>			
(Intercept)	7.4902	0.519	14.433
distancedistal	1.348	0.6413	2.102
char_dirforw	4.6331	0.6518	7.108
distancedistal*char_dirforw	-1.9147	0.9141	-2.095
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	0	0	
Participant (Intercept)	2.055	1.434	

Table B. Experiment 1b statistical models.

Experiment 2a

Model 1: Logistic Regression

	Estimate	Std. Error	Z value
<i>Fixed Effects</i>			
(Intercept)	0.4365	0.1747	2.498
tensepast	-1.2516	0.227	-5.513
char_dirforw	0.4678	0.1992	2.349
tensepast*char_dirforw	0.7723	0.2959	2.61
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	1.99E-14	1.41E-07	
tensepast	8.80E-02	2.97E-01	
Participant (Intercept)	7.59E-01	8.71E-01	
tensepast	5.11E-01	7.15E-01	

Model 2: Linear Regression

	Estimate	Std. Error	t value
<i>Fixed Effects</i>			
(Intercept)	10.57	0.375	28.19
tensepast	-2.6954	0.4928	-5.47
char_dirforw	1.2117	0.4924	2.461
tensepast*char_dirforw	1.5801	0.6976	2.265
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	0.8065	0.8981	
Participant (Intercept)	1.3249	1.151	

Model 3: Linear Model of Past Sentences

	Estimate	Std. Error	t value
<i>Fixed Effects</i>			
(Intercept)	7.88489	0.58117	13.567
distancedistal	0.02482	0.82268	0.03
char_dirforw	2.85343	0.81898	3.484
distancedistal*char_dirforw	-0.17501	1.16122	-0.151
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	1.5911	1.2614	
Participant (Intercept)	0.1548	0.3935	

Model 4: Linear Model of Future Sentences

	Estimate	Std. Error	t value
<i>Fixed Effects</i>			
(Intercept)	10.6654	0.4668	22.85
distancedistal	-0.1797	0.5465	-0.329
char_dirforw	0.6172	0.5484	1.125
distancedistal*char_dirforw	1.1804	0.7779	1.517
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	0.1797	2.111	
Participant (Intercept)	4.4548	2.111	

Table C. Experiment 2a statistical models.

Experiment 2b

Model 1: Logistic Regression

	Estimate	Std. Error	Z value
<i>Fixed Effects</i>			
(Intercept)	-1.6617	0.2744	-6.055
tensepast	0.5739	0.354	1.621
char_dirforw	3.0346	0.386	7.863
tensepast*char_dirforw	0.8011	0.5793	1.383
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	2.16E-01	4.65E-01	
Participant (Intercept)	1.44E-10	1.20E-05	

Model 2: Linear Regression

	Estimate	Std. Error	t value
<i>Fixed Effects</i>			
(Intercept)	6.2861	0.4021	15.633
tensepast	0.9312	0.5661	1.645
char_dirforw	5.9898	0.5675	10.555
tensepast*char_dirforw	0.4705	0.8052	0.584
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	0.984	0.992	
Participant (Intercept)	0	0	

Model 3: Linear Model of Past Sentences

	Estimate	Std. Error	t value
<i>Fixed Effects</i>			
(Intercept)	7.4189	0.5687	13.045
distancedistal	-0.3918	0.776	-0.505
char_dirforw	6.068	0.7839	7.74
distancedistal*char_dirforw	0.9309	1.1138	0.836
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	0.9021	0.9498	
Participant (Intercept)	0.8091	0.8995	

Model 4: Linear Model of Future Sentences

	Estimate	Std. Error	t value
<i>Fixed Effects</i>			
(Intercept)	6.201	0.5217	11.886
distancedistal	0.161	0.7266	0.222
char_dirforw	7.0016	0.7291	9.603
distancedistal*char_dirforw	-1.9757	1.0253	-1.927
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	0.5977	0.7731	
Participant (Intercept)	0.3216	0.5671	

Table D. Experiment 2b statistical models

Experiment 4a

Model 1: Logistic Regression

	Estimate	Std. Error	Z value
<i>Fixed Effects</i>			
(Intercept)	0.551	0.2689	2.049
tensepast	-0.9124	0.3561	-2.562
char_dirforw	0.3903	0.3639	1.073
tensepast*char_dirforw	0.592	0.5109	1.159
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	0.3171	0.5631	
Participant (Intercept)	0.2543	0.5043	

Model 2: Linear Regression

	Estimate	Std. Error	t value
<i>Fixed Effects</i>			
(Intercept)	10.6855	0.4961	21.539
tensepast	-2.3557	0.6453	-3.65
char_dirforw	0.8408	0.6481	1.297
tensepast*char_dirforw	1.9236	0.9174	2.097
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	1.079	1.039	
Participant (Intercept)	1.1	1.049	

Model 3: Linear Model of Past Sentences

	Estimate	Std. Error	t value
<i>Fixed Effects</i>			
(Intercept)	9.4809	0.68	13.943
distancedistal	-2.3438	0.9373	-2.501
char_dirforw	2.2422	0.9373	2.392
distancedistal*char_dirforw	1.0808	1.329	0.813
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	1.457	1.2072	
Participant (Intercept)	0.8	0.8944	

Model 4: Linear Model of Future Sentences

	Estimate	Std. Error	t value
<i>Fixed Effects</i>			
(Intercept)	11.01786	0.61539	17.904
distancedistal	-0.60714	0.7256	-0.837
char_dirforw	0.80726	0.73662	1.096
distancedistal*char_dirforw	0.03194	1.03917	0.031
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	7.41E-15	8.61E-08	
Participant (Intercept)	3.23E+00	1.80E+00	

Table E. Experiment 4a statistical models.

Experiment 4b

Model 1: Logistic Regression

	Estimate	Std. Error	Z value
<i>Fixed Effects</i>			
(Intercept)	-2.1497	0.3708	-5.798
tensepast	-1.007	0.6175	-1.631
char_dirforw	3.6408	0.4745	7.673
tensepast*char_dirforw	1.39	0.7382	1.883
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	1.26E-09	3.54E-05	
Participant (Intercept)	2.33E-01	4.82E-01	

Model 2: Linear Regression

	Estimate	Std. Error	t value
<i>Fixed Effects</i>			
(Intercept)	5.9749	0.3357	17.796
tensepast	-0.7256	0.4692	-1.547
char_dirforw	6.267	0.4641	13.505
tensepast*char_dirforw	1.5279	0.6572	2.325
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	0	0	
Participant (Intercept)	0.06319	0.2514	

Model 3: Linear Model of Past Sentences

	Estimate	Std. Error	t value
<i>Fixed Effects</i>			
(Intercept)	4.9773	0.439	11.337
distancedistal	0.5455	0.6209	0.879
char_dirforw	7.6397	0.6109	12.506
distancedistal*char_dirforw	0.3375	0.871	0.388
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	0	0	
Participant (Intercept)	0	0	

Model 4: Linear Model of Future Sentences

	Estimate	Std. Error	t value
<i>Fixed Effects</i>			
(Intercept)	5.7907	0.5017	11.541
distancedistal	0.3649	0.7016	0.52
char_dirforw	6.2093	0.6979	8.897
distancedistal*char_dirforw	0.1134	0.9813	0.116
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	2.41E-13	4.91E-07	
distancedistal	7.94E-13	8.91E-07	
Participant (Intercept)	3.26E-12	1.81E-06	
distancedistal	1.12E-12	1.06E-06	

Table F. Experiment 4b statistical models.

Experiment 6

Linear Regression Model			
	Estimate	Std. Error	<i>t</i> value
<i>Fixed Effects</i>			
(Intercept)	0.37117	0.0093	39.91
tensepast	-0.010109	0.005337	-1.89
distancefar	0.012108	0.005372	2.25
tensepast:distancefar	-0.017046	0.007556	-2.26
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	0	0	
distancefar	3.90E-19	6.25E-10	
Participant (Intercept)	2.88E-03	5.37E-02	
distancefar	3.49E-06	1.87E-03	

Table G. Experiment 6 statistical model.

Experiment 7

Linear Regression Model			
	Estimate	Std. Error	<i>t</i> value
<i>Fixed Effects</i>			
(Intercept)	0.3447743	0.0085632	40.26
tensepast	0.0232195	0.0045032	5.16
distancefar	-0.0042088	0.0044864	-0.94
tensepast:distancefar	0.0007737	0.0063964	0.12
	Variance	Std. Dev.	
<i>Random Effects</i>			
Item (Intercept)	0	0	
distancefar	1.92E-17	4.38E-09	
Participant (Intercept)	2.50E-03	5.00E-02	
distancefar	4.66E-07	6.82E-04	

Table H. Experiment 7 statistical model.

Appendix B: Stimuli & Fillers

Target sentence clauses:

find a cave
recognize a friend
forget a phone
release a bird
finish a book
win a bike
light a match
start a fire
notice a stain
lose a tooth
leave a note
discover a planet
catch a bus
stop a fight
begin a letter
spot a moose

Filler sentences with adverbials:

Curiously, he will cross a finish line.
Curiously, he will solve a problem.
Curiously, he will realize a mistake.
Curiously, he will bump a car.
Sadly, he will reach a decision.
Sadly, he will slam a door.
Sadly, he will crash a bike.
Sadly, he will hit a wall.
Fortunately, he will kick a ball.
Fortunately, he will turn on a light.
Fortunately, he will smash a glass.
Fortunately, he will bounce a check.
Luckily, he will gain a friend.
Luckily, he will acquire a business.
Luckily, he will declare a war.
Luckily, he will land on a beach.
Curiously, he crossed a finish line.
Curiously, he solved a problem.
Curiously, he realized a mistake.
Curiously, he bumped a car.

Sadly, he reached a decision.

Sadly, he slammed a door.

Sadly, he crashed a bike.

Sadly, he hit a wall.

Fortunately, he kicked a ball.

Fortunately, he turned on a light.

Fortunately, he smashed a glass.

Fortunately, he bounced a check.

Luckily, he gained a friend.

Luckily, he acquired a business.

Luckily, he declared a war.

Luckily, he landed on a beach.

Appendix C: Post-surveys

Experiments 1a, 1b, 2a, 2b, 3, 4a, 4b, & 5

- 1 Which image did you prefer?**
 - a The man on the street
 - b The beach scene
 - c The house scene
- 2 What color was the man's shirt?**
 - a Yellow
 - b Blue
 - c Red
 - d Green
- 3 Which of the following animals was mentioned?**
 - a Wolf
 - b Moose
 - c Dog
 - d Not sure
- 4 Any guesses as to what this study is about?**
- 5 Did you develop a strategy when choosing how to place the text? If so, what was it?**
- 6 Which best describes you?**
 - a I am right-handed
 - b I am left-handed
 - c I use both hands regularly
- 7 Are you a native speaker of English? If not, what is your native language?**

Experiments 6 & 7

- 1 Age?**
- 2 Do you have any guesses as to the intention of the study?**
- 3 Did you develop a strategy for completing the task? What was it?**
- 4 Is your native language English?**
- 5 Do you speak any other languages? If so, which?**
- 6 Are you right-handed or left-handed?**
- 7 Are you color blind?**
- 8 Do you wear glasses or contacts?**
- 9 Would you describe yourself as a procrastinator?**

Appendix D: Pilot Studies

The sentence placement experiments set the stage for further study in space-time topography. To this end, I piloted two separate studies to replicate the effect in a new paradigm.

As demonstrated in the previous experiments, the most robust space-time topography effects were found when sentences make explicit reference to proximal and distal temporal events through adverbials and the image makes explicit reference to space-time mapping (i.e., the character on the road). Therefore, finding a new paradigm necessarily involved the use of target sentences with adverbials and explicit reference to Time in terms of space.

Reaction Time Pilot

The first pilot aimed to utilize the exact same materials as Experiment 1a, but replicate the findings with a new paradigm. Using the same images of the character on a street and target sentences with adverbials, it was reasoned that participants would demonstrate a processing reaction time difference depending on where sentences appeared on the image.

The first pilot was written in Psychopy. Using identical target sentences as Experiment 1a (with adverbials).

Method

22 undergraduates at the University of Colorado Boulder participated for extra credit in the Department of Linguistics.

Participants viewed a sentence in one of four locations on the image of the character on the street (facing either away or towards the participant). Participants were given two sentences in the same location in sequence: first, they read a sentence about the character 'Bill,' and second, they read the target sentence. Their task was to determine if the second sentence was related to the first sentence. For example, they would read the first sentence *Bill is an astronomer* and, after a two second delay, the sentence *Next year, he will discover a planet*. Reaction times to process the target sentence (the second sentence) were the dependent measure of the study.

Results

Results from the pilot were inconclusive and the pilot was discontinued. There are several reasons for this. First, preliminary results suggested that processing times were more greatly influenced by screen position in general (without reference to the image). In other words, participants were faster to process sentences in the upper right than the lower left. This was likely a symptom of reading patterns in general and thus did not contribute to the hypotheses of the study. Second, processing times did not follow any predictions of the study, and processing time differences did not appear to be trending towards statistical significance. This may have been the consequence of people adopting an internal Deictic time perspective as opposed to co-locating the present with the external locus, similar to effects found in studies such as Bar-Anan et al. (2007).

Another possibility is that this particular paradigm did not make explicit reference to Time in terms of space, and therefore no effect was found.

Discussion

The reaction time pilot intended to replicate Experiments 1-3 with a sentence processing paradigm. It aimed to again examine external Deictic time. However, mixed, inconclusive results led to its discontinuation.

However, the failure of this pilot led me to think of ways to examine sentence processing and internal Deictic time, similar to Walker et al. (2014) and drawing inspiration from Slepian and Ambady (2014).

Spatial Perception Pilot

Examining space-time mapping from an internal Deictic time construal requires a paradigm that uses physical space behind and in front of the participant.

Method

Nine undergraduates from the University of Colorado Boulder Department of Linguistics participated in the pilot in exchange for extra credit.

The experiment was designed using Psychopy software. 16 target sentences were randomly delivered via wireless headphones. Blindfolded, participants were instructed to estimate physical distances to markers behind and in front of them. Participants estimated four different distances: 100cm behind, 100 cm in front, 50cm behind, and 50 cm in front. Participants were explicitly told to estimate the distances of markers in front of them when the sentence described an event in the future and distances behind them when the sentence described an event in the past.

Participants were told the following cover story: The researchers believed that walking with headphones impacted vision. Therefore, participants were given four breaks in which they read from an eye exam poster on the wall.

Though blindfolded, participants were able to step in front of and behind themselves with guidance from a cloth tape measurer that was attached to both walls. To avoid the confound of participants feeling the marker on the tape, they held only a ring that seamlessly glided over the tape. The researcher marked the estimated distance after each trial.

Results

Results from the pilot were not significant; however, they trended in the predicted direction: participants estimated a further distance after processing distal temporal events compared to proximal temporal events. This effect seemed more pronounced for the more proximal physical marker.

Discussion

The spatial perception pilot led to the final paradigm of Experiments 6-7, one that did not involve the experimenter measuring after each trial. The laser was born.