2009

The Influence of Movement on the Directionality of Space-Time Representation Mappings

Andrea J. Sell

THE FLORIDA STATE UNIVERSITY

COLLEGE OF ARTS AND SCIENCES

THE INFLUENCE OF MOVEMENT ON THE DIRECTIONALITY OF SPACE-TIME REPRESENTATION MAPPINGS

By

ANDREA J. SELL

A Thesis submitted to the
Department of Psychology
in partial fulfillment of the
requirements for the degree of
Master of Science

Degree Awarded:
Fall Semester, 2009

The members of the committee approve the thesis of Andrea Sell defended on August 5, 2009.

_____
Michael Kaschak
Professor Directing Thesis

_____
Jon Maner
Committee Member

_____
Colleen Kelley
Committee Member

The Graduate School has verified and approved the above-named committee members.

To my family

ACKNOWLEDGMENTS

I would like to thank my advisor, Dr. Michael Kaschak, for his guidance throughout my research project.

I would like to express gratitude to Jackie Coyle and John Jones, fellow graduate students, for their valuable suggestions, comments, and discussions, which have aided my research and have made my time in graduate school a lot more enjoyable than it otherwise would have been.

TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

When talking about time, we often refer to space. It is has been proposed that the concept of time employs the same representational structure of that of space (e.g. Lakoff & Johnson, 1980). There is both linguistic and experimental evidence that points toward the use of space when thinking or speaking about temporal concepts, such as *tomorrow* or *last month*. Linguistically, evidence exists in metaphors with which we use to talk about time. For example, we use metaphors that imply time is space that we move through, or that time is an object in space moving toward us, such as "We're almost to the weekend," or "last month went by quickly," (Santiago, Lupianez, Perez, & Funes, 2007; Lakoff & Johnson, 1980). In addition, a number of experimental studies have shown clear activation of certain spatial schemas when people think about temporal phrases. However, these studies seem to show conflicting findings in terms of the direction of the time to space mappings. Some studies show activation of the front/back axis, while others show activation on the left/right axis. With the data presented here, I offer an explanation for the directional differences previously observed, and argue that self-movement is a key factor in the directionality of the conceptual mappings of time onto space.

CHAPTER 1

INTRODUCTION

The idea that spatial relational structures are used in organizing the abstract domain of time is well documented. Theories such as the Metaphoric Structuring view (Boroditsky, 2000) and the Metaphoric Representation view (Lakoff & Johnson, 1980) propose that the abstract domain of time is organized and processed using relational information from the domain of space. That is, to understand something abstract, such as time, we borrow or import relational structures from something more concrete, like space (Lakoff & Johnson, 1980, 1999). Until recently, these views were only supported with linguistic evidence, such as in the metaphorical way we describe temporal information with spatial language such as, "the past is behind you now." (Lakoff, & Johnson, 1980; Radden, 2004). Typically, we talk about time in terms of space relative to a certain reference point (Nunez, 2006). The reference point can either be ourselves or an event in time. When using an event as a reference point, people talk as if they are moving forward in time toward the event, such as "We're almost to the weekend." This is called the ego-moving perspective. However, when using themselves as a reference point, people talk as if time is moving toward them, as in "The weekend is fast approaching." This is called the time-moving perspective (Clark, 1973).

The two perspectives are of interest because each may activate very different spatial representations (McGlone & Harding, 1998). The ego-moving perspective activates the representation of someone moving through space, while the time-moving perspective activates the representation of someone standing still in space, with time moving around them (i.e. Casasanto, 2006). People who read a sentence using one perspective take longer to process a subsequent sentence in which the contrasting perspective is used (Getner, Imai, and Boroditsky, 1999). These findings support the idea that the ego-moving and time-moving perspectives are based on two different conceptual schemas (Getner, Imai, and Boroditsky, 1999; McGlone & Harding, 1998). Additionally, these two structural mappings are subject to spatial priming. If people are using two different spatial representations to structure their temporal representations, these temporal representations should be differentially affected by spatial priming, and indeed, this has been found to be the case. For example, when given an ambiguous temporal question such as, "Next Wednesday's meeting has been moved forward two days. What day is the meeting now?" Participants' answers will change depending on what spatial conceptualization they are using. If a participant is using the ego-moving perspective in which they conceptualize themselves as moving forward in space as they are moving through time, they will answer, "Friday". However, if a participant is using the time-moving perspective in which they conceptualize themselves as static in space while time moves toward them as it progress, they will answer, "Monday" (Boroditsky, 2000). The spatial conceptualization participants use to answer this question can be biased by having participants think about different spatial schemas. When primed with a spatial schema of a person pulling a chair toward themselves, participants were more likely to use the time-moving perspective in answering the ambiguous temporal question. When primed with a

spatial schema of a person walking toward the chair, participants were more likely to use the ego-moving perspective (Boroditsky and Ramscar, 2002). Similar results were found for participants who saw images of a person walking toward an object, and a person sitting and letting objects come to them via a conveyor belt (Boroditsky, 2000). Thus there is clear evidence for the use of spatial representations in temporal thinking.

A question that arises then, is what dimensions of space are most useful in temporal organization? Linguistically, we have metaphors that use front and back referents, such as "the past is behind you now" and "look to the future before you" (Raden, 2004). However, space has many possible directions: front, back, left, right, etc. Yet we do not have any linguistic evidence that people use directions besides the front and back in their spatial schemas for temporal representations (Radden, 2004). In terms of experimental evidence, there are thus far only a handful of studies that test the spatial direction of temporal metaphors. In all of the above mentioned studies, the theoretical focus is on the use of spatial structure in temporal thought and was not on direction of movement in space. Because of this, only the front-back direction was used, while the right-left directionality was counterbalanced and not included as a factor.

However, recent research evaluating the SNARC (Spatial Numerical Association of Response Codes) effect, has implicated the left-right direction in numerical organization (Dehane 1993). The SNARC effect is characterized by faster responses to questions about the magnitude of smaller numbers with the left hand on the left side of the body and faster responses to larger numbers with the right hand on the right side of the body (Dehaene, Bossini,Giraux, 1993). This effect has been explained by Dehaene et al. (1993) as the activation of a spatial representation of a mental number line across the participant's body, consisting of small numbers on the left continuing toward larger numbers on the right. Additionally, numerical durations were found to have similar left-right representational mappings. Vallesi, Binns and Shallice (2008) found that participants responded to longer durations of a visual stimulus faster on the right side, while responding to shorter durations of the stimulus faster on the left side.

Time, much like numbers in a sequence on a line, is linear, and is often portrayed as such in pictorial renderings of time, such as a timeline (e.g. Santiago, Lupianez, Perez & Funes, 2007). Given the SNARC findings, it would not be surprising for temporal words to also show some spatial activation like the left-right SNARC effects, such that time progresses from the left, to the right, as it does on a typical timeline. Thus far, a few studies have tested use of the left-right axis in spatial temporal mapping around the body using a method similar to that used in the studies which find SNARC-effects. (Santiago, Lupianez, Perez and Funes, 2007, Torralbo et al, 2006). Santiago, et al. (2007), citing both SNARC-type findings, and reading direction research by Maas and Russo (2003) and Chatterjee, Maher, Gonzalez-Rothi & Heilman, (1995), hypothesized that because English speakers are biased from their reading direction to conceptualize events as occurring from left to right, they may also conceptualize time as progressing along the left-right axis. Santiago et al (2007) asked participants to categorize words as referring to either the past or future by pressing a button which was either on the left or right of a person's midline. Participants pressed the left button with their left hand, and right button with their right hand. Santiago found that reaction times were faster when response direction matched the temporal dimension (future words mapped to a right key, and past words mapped to a left key), and slower when the mapping assignments were switched

(future words mapped to left key, past words mapped to right key).

Torralbo, Santiago, and Lupianez (2006) also found activation of the left-right axis when testing with past and future words. They asked participants to categorize temporal words at different spatial locations. They found that participants responded faster when the word matched the metaphorical spatial location (i.e. front-future, back-past). In addition, after alerting participants to the left-right axis by changing the mode of response from vocal to button press, participants responded faster when a left button was matched with a past-tense word, and a right button was matched with a future-tense word. Thus, there is some evidence for participants mapping temporal words to the left-right axis.

Why do we sometimes map time onto the front and back space as seen in the Boroditsky et al (2000, 2002) studies, while at other times map it to the horizontal space as we saw in the Torralbo et al (2007) and Santiago et al (2006) studies? One explanation could be that of movement. In both ego-moving and time-moving perspective, a key element to what spatial schema will be used in thinking about time is whether or not the person is moving in space. If a person is moving, or thinking about moving themselves, they are more likely to take an ego-moving perspective, as if they are moving ahead in a race. For example, they move forward through time just as they do through space, as in "I am almost to the weekend." The opposite is true for the time-moving perspective. When the participant is not thinking about moving, they are more likely to set themselves as the static reference point, and take on a passive perspective such that time is moving around them, as in "the weekend is fast approaching us," (Boroditsky, 2002). Boroditsky (2002) asked passengers of a train an ambiguous temporal question at three different points in their journey: as they got on the train, while they were seated in the train, and while they were exiting the train. People were more likely to use an ego-moving perspective to answer the question while they were entering and exiting the train than when they were seated on the train. However, while noting that movement is a key factor in what spatial temporal perspective one takes, the researchers hypothesized that people must be thinking about themselves moving for movement to influence their thoughts about time. Boroditsky (2002) contends that merely moving through space is insufficient to influence thinking about time, since people sitting on the train are technically moving (and quite quickly) through space, they still use a time-moving perspective to answer the ambiguous temporal question. However, Boroditsky's (2002) findings may indeed support the idea that actual movement, regardless of the thought about the movement, can influence temporal thinking. Participants, who are seated in a moving train, while still moving, are not engaging in self-movement. That is, they are passively being moved, and are not actively moving themselves, which fits best with a time-moving perspective. In this respect, Boroditsky's (2002) findings may support the idea that self-movement can in fact influence the perspective one takes while thinking about time.

Given the findings that thought about movement is a central component to which perspective one takes when answering ambiguous temporal questions, it is our belief that movement is a key component in what axis is used in temporal metaphoric mappings. Moving one's arm may activate an ego moving perspective; as in "I am running head on into the weekend." In the case of self movement, the easiest axis on which to conceptualize moving may be the front/back axis, since that is the axis we usually move on (e.g. Radden,2004; Nunez, 2006). However, the absence of movement allows for the

use a time-moving perspective, in which people speak passively, as though they are "watching time go past." Using this perspective people put themselves outside the scene, and thus we may be able to see more influence from factors such as reading direction, which would map time onto space on the left-right axis (Santiago et al 2007; Maass & Russo, 2003; Chaterjee et al 1995). Reading direction has been implicated as a strong contributing factor to the SNARC effect. Arabic readers, who read from right to left, show the reverse SNARC-effect; they map larger numbers to the left, while mapping smaller numbers to the right (Shaki, Fischer, & Petrusic, 2009). Additionally, Nunez and Sweetster (2006) noted that when Aymara Indian speakers are talking about time as a general motion versus themselves moving in time, they tend to gesture nondeicticly on the left-right axis. In fact, in the studies in which participants showed left-right axis effects with temporal words, they were not moving their arm. In both the Torralbo et al (2006) and the Santiago (2007) study, participants responded with both hands. The left button was pressed with the pointer finger of the left hand, and the right button was pressed with the pointer finger of the right hand. Thus, movement, whether consciously thought of or not, should affect what perspective one takes when reading temporal phrases, such that moving one's arm to respond will activate a toward and away directionality, while responding without large movements in space, (i.e. pressing a button directly under hand) should not activate an ego-moving perspective, and thus allow for factors such as reading direction to be seen, providing similar results to SNARC-like findings in which past and future can activate the left and right spatial areas of the body. In this paper I hypothesize that movement will define perspective used, ego-moving or time-moving, which will in turn determine the axis, front/back, or right/left that will be activated when thinking about temporal statements.

.

CHAPTER 2

GENERAL METHOD FOR EXPERIMENTS 1 THROUGH 4

I conducted four experiments to test the prediction that movement will define perspective used, ego-moving or time-moving, which will in turn determine the axis, front/back, or right/left that will be activated when thinking about temporal statements. In each experiment, I asked participants to make a sensibility judgment about past or future events. To indicate their judgment, participants pressed a button in one of four locations; forward, back, right or left. Additionally, some participants moved their arm from a central button to the response button, while others held their hand statically over the response button. In each experiment, I will look for an interaction between temporal phrase type, direction, and condition of movement. I expect participants to be faster when moving away in response to future statements, while faster when moving back when responding to sentences about the past, but only when moving to respond. When not moving to respond, I expect participants to be faster to respond to the future on the right, and the past on the left.

Additionally, I wanted to test whether smaller time shifts differed spatially from larger time shifts. Recently, some interesting results have been observed in narrative concerning magnitude of time shifts and response times. Participants who read a story that contained temporal phrase shifts that were relatively short, such as "a moment later" were quicker to respond to a probe word than when the temporal phrase shift was relatively longer, such as "a month later" (Zwaan, 1996). These findings led us to wonder if temporal phrase shift magnitude had similar properties when mapped to space. Would one month into the future be different spatially than one day into the future? I tested this by including "day" and "month" phrase types in the target sentences.

2.1 Method

2.1.1 Participants

A separate group of participants participated in each experiment. Participants were students in Florida State general psychology classes and participated in exchange for course credit.

2.1.2 Materials

The same stimuli were used in all four experiments. Twenty four temporal sentences were used (see appendix C). Each temporal statement consisted of a temporal clause at the beginning of the sentence, followed by the rest of the sentence. For example, "Tomorrow she will learn about paintbrushes." Each sentence had a future version and a past version, "Yesterday she learned about paintbrushes." All temporal sentences were unbiased in terms of perspective. Twelve of the twenty four temporal sentences referred

to a “day” time shift, while the other twelve referred to a “month” time shift. However, each sentence strictly referred to either day or month, and did not have a version of each. Two counterbalanced lists were created containing one version of the temporal sentence, in its past or future form.

Twenty eight nonsense statements were created as foils. For example, “Their cat has needles like a fish,” and eleven sensible yet non-temporal statements were also created as further fillers. These nonsense and filler sentences were included on both counterbalanced lists. In addition, each statement was sandwiched in between two other simple, but semantically similar sentences, creating the feel of a mini-story. The sentences before and after the target sentence did not have a temporal component. For example, one complete sentence triad was; “Jackie is taking a painting class. Tomorrow she will learn about paintbrushes. It is important to know paintbrush techniques.” In total, participants saw sixty-four sentence groups, twenty four of which contained a temporal sentence, twenty eight contained nonsense statements, and eleven contained sensible non-temporal sentences.

2.1.3 Design

Each experiment used a mixed design, with two factors considered within subjects: Time (Past vs. Future), and Time Type (Day vs. Month) and one considered between subjects; Direction of Motion (Right vs. Left, or Toward vs. Away). The dependant variable was the latency time measured from the beginning of the “start” key press to the lift-off of the key. Move times from the “Start” key to the “P” key are also recorded. To account for different sentence lengths, I corrected the data by performing a regression analysis, with sentence length added as a predictor variable. The regression analysis was performed on target trials only. I calculated a separate regression analysis for each participant. The residuals were then trimmed by first removing participants who were more than 50% inaccurate in any one condition. Second, trials in which the participant responded outside of 2 standard deviations of their latency times in that condition were cut. The remaining data were analyzed using a 2x2x2 mixed model ANOVA. I used this procedure for all four experiments.

2.1.4 Procedure

The same procedure was used in all four experiments, with only slight variation across experiments.

In all experiments, each sentence of the triad was presented individually, and the triads were separated by a short reminder of the instructions. Participants were instructed to determine if the sentence they were reading was sensible or not. Speed and accuracy were emphasized.

One factor I was interested in investigating was movement. For two experiments, participants had to move their arm to respond to the sentence. For the other two experiments, participants had to press a button to respond, while keeping their hands in place over the keyboard.

For the movement condition, participants were told to hold down a “START” key

while reading the sentence. If the sentence was sensible they were to lift up on the start key, and move their hand to press the "P" key, which was always approximately 12 inches away from the "START" key on the keyboard. Participants pressed all keys with their right hand and pointer finger. If the sentence was not sensible, they were to press the "X" key which was about .5 inches from the "START" key. The participants were told that if they needed a break, they could take a break at one of the reminder screens.

For the non-movement condition, participants used both hands to respond. They used their left pointer finger to press the "START" key to start reading the sentence. When they decided that it was sensible, they lifted off of the tab key and press the "P" key with their right pointer finger. A response indicating an insensible statement was done with the left hand, since the insensible key is very close to the "START" key.

Another factor I was investigating is axis of orientation. To investigate this, an experimenter situated the keyboard in one of four ways for each experiment. The first two orientations used the front-back axis. For this orientations, the keyboard was rotated 90* from its standard position to the either the right or the left. This rotation meant that the TAB key was either the furthest key from the participant's torso, or the closest key to the participant's torso. The second two orientations use the right-left axis. For these orientations, the keyboard was only moved slightly to the right or to the left, so that one edge of the keyboard, either the left or right, was in line with the participant's midline. See Appendices A and B for depictions of keyboard orientations.

2.2 Results

In each experiment, the critical effect I was looking for was a facilitation of response when the temporal phrase is congruent to the direction or orientation of movement, such that phrases that include future words are responded to faster on the right, and/or away from the body, while phrases including past words are responded to faster on the left, and/or toward the body. In addition, I was looking for an Movement x Axis effect, such that we should see the critical congruency effect when the keyboard is oriented in a toward and away position, and participants move to respond, and we will see the critical congruency effect when the keyboard is orientated in a left-right position only when participants do not move to respond.

CHAPTER 3

RESULTS
EXPERIMENTS 1 THROUGH 4

3.1 Experiment 1
Left Right Non-Movement Response

The first experiment tested static responses on left-right axis. Figure 1 displays the mean residual latency RTs for correct responses for static responses for both the right and left directions and for day and month separately. Data from 66 participants has been collected. Thirty-one participants responded to the left, while thirty-five participants responded to the right. The critical 3-way interaction of Temporal phrase type (future or past) X Temporal phrase shift (Day or Month) X Direction (toward or away) was significant [F1(1,64)= 4.02, p=.049; F2 F(1,22)=9.813, p<.005] indicating that the effect was different across the two temporal phrase types . Within the individual temporal phrase type conditions, there was a significant interaction between temporal phrase type (Future/Past) and direction in the month condition [F1(1,64)=3.294, p=.074; F2(1,64)=4.879, p<.049], but not for the day condition , [F1(1,64)= 1.774, p>.188; F2(1,22)=5.416, p<.04. Thus, participants were quicker to respond to sentences about the future when not moving to respond to the right from their bodies, and quicker to respond to sentences involving the past when not moving to respond to the left of their bodies, but only for sentences with a month temporal phrase, and not with day sentences. In essence, the results of this experiment can serve to replicate Torallabo et al. (2006) and Santiago et al. (2007) who find the past is responded to quicker with the left hand on the left side of the body, and the future is responded to quicker with the right hand on the right side of the body. Additionally, I observed the same main effect as in experiment 2; past is responded to quicker than future; [F1(1,64)= 8.11, p<.006; F2(1,22)=9.779, p<.005]. The three way ANOVA for Temporal phrase type (future or past) X Temporal phrase shift (Day or Month) X Direction (toward or away) also revealed a significant main effect in F1 for Temporal Phrase shift, such that day shifts were responded to quicker than month shifts, [F(1, 64)=8.11, p<.006].

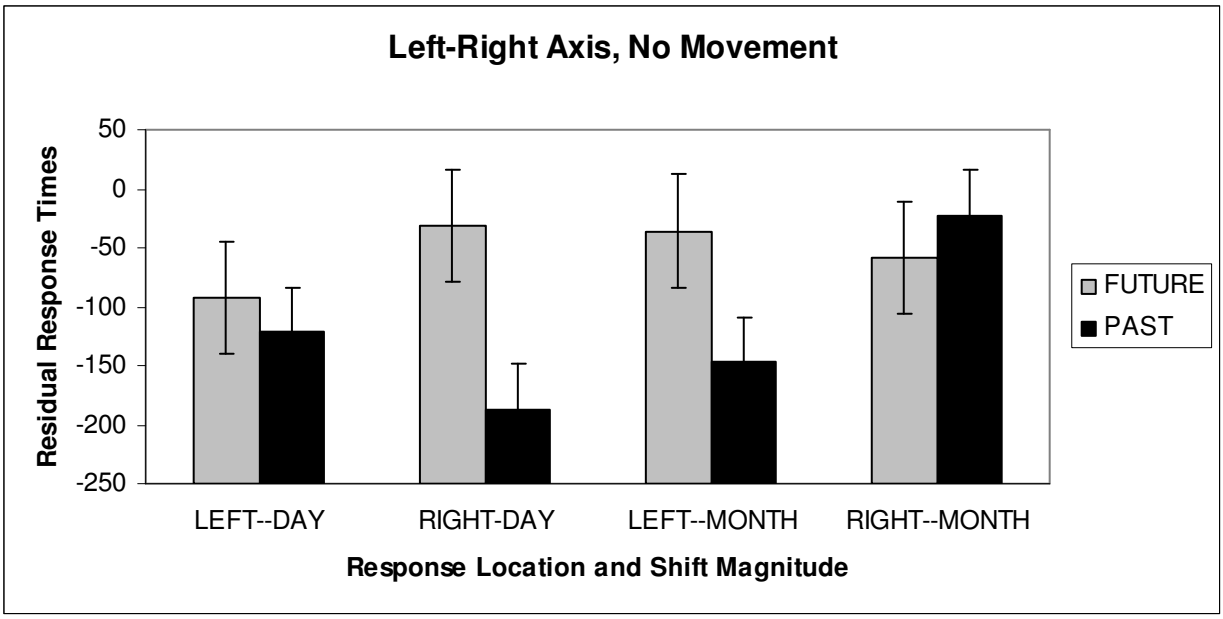

Figure 1. Residual response times (with standard deviations) from Experiment 1.

3.2 Experiment 2
Left Right Response Movement

The second experiment tested movement on the left-right axis. Figure 2 displays the mean residual latency RTs for correct responses for movement for both the left and right directions and for day and month separately. Data from 40 participants have been analyzed using a 3-way mixed model ANOVA. Nineteen participants responded to the Right, while 21 participants responded to the left. The critical interaction of Temporal phrase type (future or past) and Temporal phrase shift (Day or Month) and Direction (toward or away) was not significant [F1(1, 38)= .040, $p > .843$; F2(1,22)=.147, p>.705]. Thus participants were no quicker to respond to sentences about the day or month when moving to respond on the left or right side of their body. No other main effects or interactions were significant.

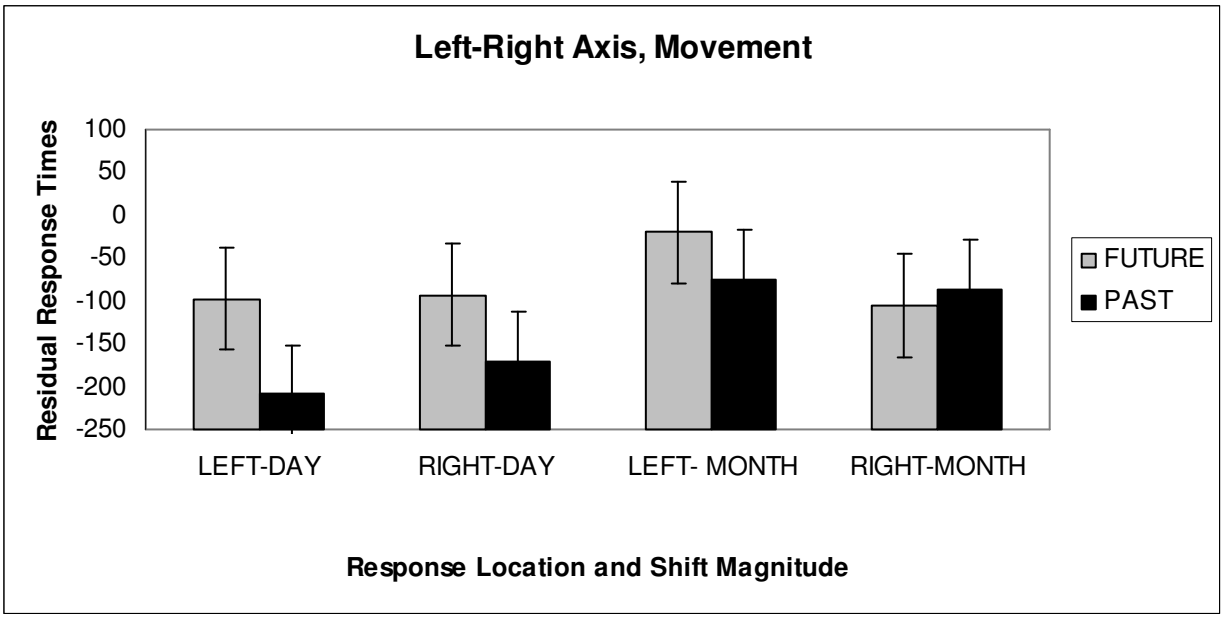

Figure 2. Residual response times (with standard deviations) from Experiment 2.

3.3 Experiment 3
Toward and Away Non-Movement Response

The third experiment tested static responses on toward-away axis. Figure 3 displays the mean residual latency RTs for correct responses for static responses for both the toward and away directions and for day and month separately. Data from 58 participants has been collected. Twenty-six participants responded toward themselves, while thirty-two participants responded away from themselves. The critical 3-way interaction of Temporal phrase type (future or past) and Temporal phrase shift (Day or Month) and Direction (toward or away) was not significant [F1(1,56)= .228, p=.635; F2(1,22)=.262, p>.614]. Within Individual temporal phrase shift conditions, The interaction of Temporal phrase type (Future/Past) X Direction (Left/Right) was also not significant, for both day [F(1,56)= .643, p>.426, p>.188; F2(1,11)=2.37, p>.152] and month sentences [F1(1,56)=1.477, p=.229; F2(1,11)=1.336, p<.272]. Thus, participants were no quicker to respond to sentences about the future when not moving to respond away from their bodies, and no quicker to respond to sentences involving the past when not moving to respond toward their bodies, and this held true for both month and day sentences. Additionally, I observed the same main effect as found in the other experiments, past sentences were responded to quicker than future sentences, this main effect was found only in the subject analyses [F1(1,56)=3.852, p=.055; F2(1,22)=3.028, p=.096].

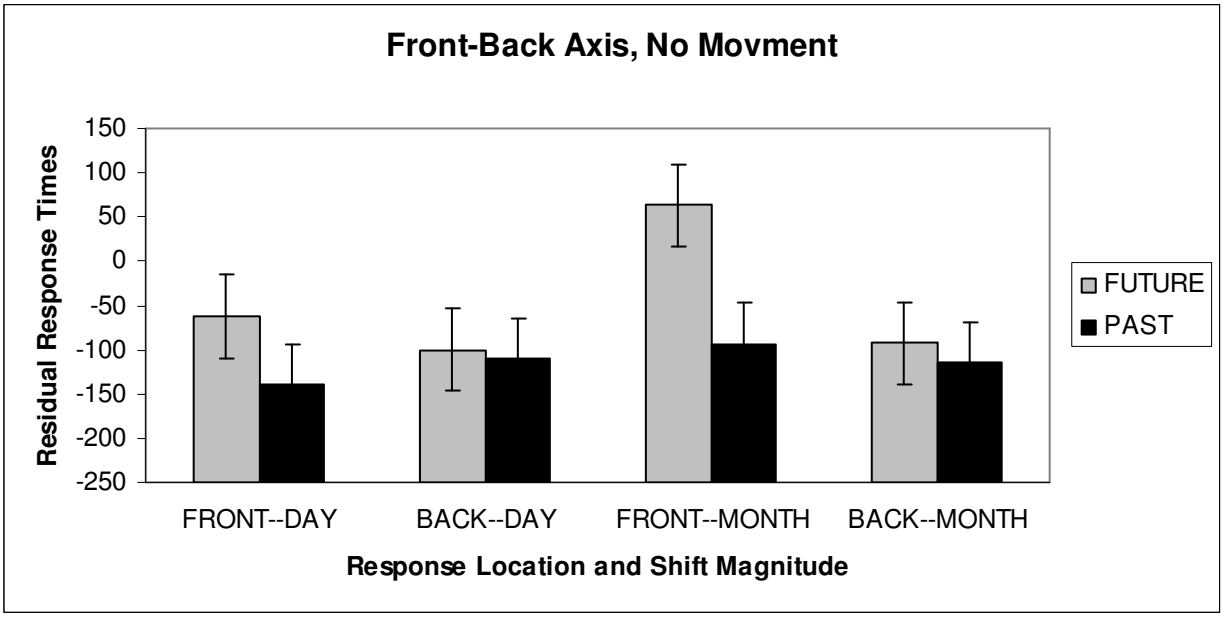

Figure 3. Residual response times (with standard deviations) from Experiment 3

3.4 Experiment 4
Toward and Away Response Movement

The fourth experiment tested movement on front-back axis. Figure 4 displays the mean residual latency RTs for correct responses for movement for both the toward and away directions and for day and month separately. Data from 92 participants has been collected. Forty-six participants responded toward themselves, while a separate group of forty-six participants responded away from themselves. The critical 3-way interaction of Temporal phrase type (future or past) X Temporal phrase shift (Day or Month) X Direction (toward or away) was significant [F1(1, 90)= 3.766, p=.055; F2(1,22)= 4.5, p=.045] indicating that the effect was different across the two temporal phrase types. Within the individual temporal phrase type conditions, there was a significant interaction between temporal phrase type (Future/Past) and direction in the month condition [F1(1,90)=4.566, p=.035; F(1,22)=8.94, p<.012] but not the day condition [F1(1,90)= .384, p>.537; F2(1,22)=.417, p>.5]. Thus, participants were quicker to respond to sentences about the future when moving to respond away from their bodies, and quicker to respond to sentences involving the past when responding toward their bodies, but only for sentences with a month temporal phrase, and not for sentences with a day temporal phrase. Additionally, in both the subject analysis and item analysis, I observed a main effect for Temporal phrase type, (future/past) such that past was responded to quicker than future subject [F1(1,90) = 6.692, p<.01; F2(1,22)= 8.43, p<.008].

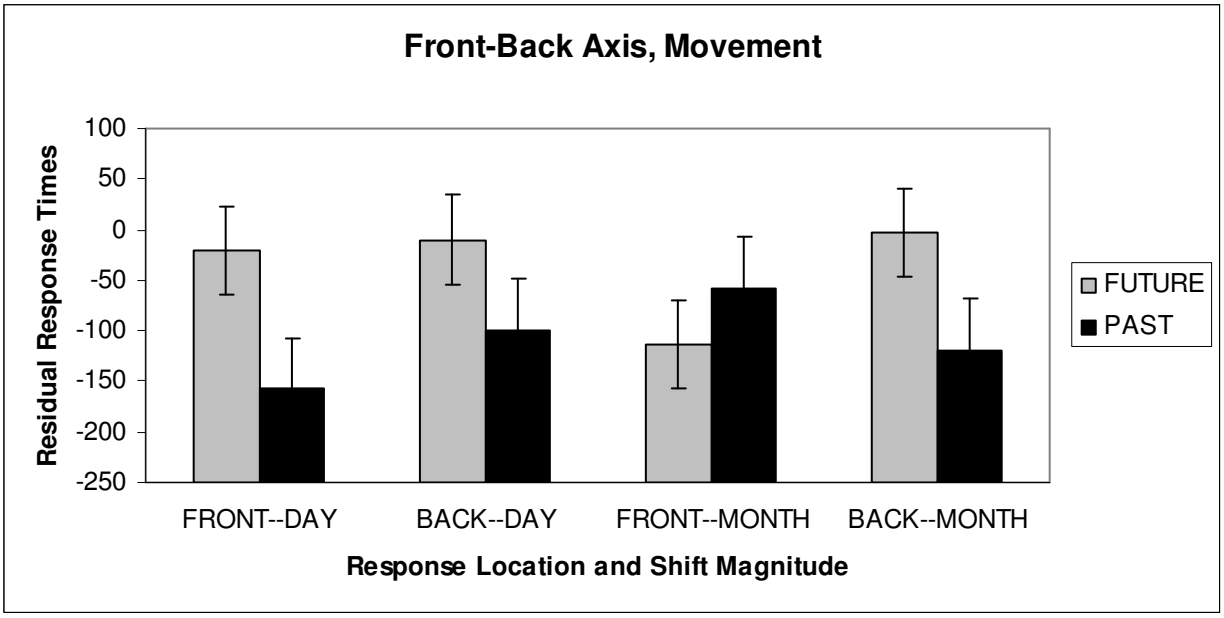

Figure 4. Residual response times (with standard deviations) from Experiment 4.

CHAPTER 4

GENERAL DISCUSSION

As predicted, temporal phrase type interacted with spatial location such that participants were faster to respond to future statements when responding to the right, and faster to respond to past statements when responding on the left. However, this effect was only found when participants were not moving their arm to respond. When moving to respond, participants were faster to respond to future statements when moving away out in front of their body, and faster to respond to past statements when moving in, toward their body. These findings both replicate and extend previous findings by Torralbo et al (2006) and Santiago (2007) and Matlock (2005), which show spatial mappings for temporal words on the left/right axis. Additionally, this data adds online RT data to previous data on perspective in temporal comprehension, which until recently has only been the products of temporal phrase and space processing, and not online-RT collection (Boroditsky et al, 2002; Boroditsky et al 2000). Thus from the data presented here, we can draw several conclusions. The first is that self movement, whether consciously thought of or not, influences the directionality of conceptual mappings to space. Movement, as seen in Boroditsky et al. (2002; 2000) greatly influences what perspective one takes when answering ambiguous temporal questions. In this study, I find that due to this movement aspect, the perspective we take also influences the axis of spatial mapping we use in temporal phrases. Such that when moving, we generally move forward and backward, and thus the front-back axis becomes most useful for temporal organization. Participants who are not moving to respond are not subject to this front-back bias, and thus, other effects can shape response facilitation, such as reading direction.

The present results may also help to clarify some important questions that have arisen in previous papers in terms of the role of consciousness and attention in the flexible nature of conceptual mappings. Work by Torralbo et al. (2006) and Boroditsky et al. (2002) implies that conscious attention to spatial experiences is needed to change the metaphoric perspective primed by the spatial primes (Torralbo 2006; Santiago, 2007; Boroditsky & Ramscar, 2002). Torralbo et al. (2006) conclude, in line with Boroditsky's (2002) train study findings, that the flexibility of spatial mappings is due to attentional factors. Whatever axis is being attended to be the axis which will be most useful for conceptual mapping. However, in the present study, I deliberately designed the experiment so that participants would not be responding with ordered pair responses; participants only responded in one direction, either left, right, toward, or away. Participants did not respond to the future on one side while responding to the past on the other side, (direction was a between participants variable.) Thus, attention was brought only to direction of response, and not to the entire axis. Additionally, if participants were made aware of the axis, despite the procedure of only responding in one direction, and this awareness was driving the effect, we would have observed facilitation on whatever axis the participant was responding on; despite the movement manipulation. However, that was not the case in these results. We saw facilitation of motor response on the front

and back axis only when participants were moving, and facilitation of motor response on the left-right axis only when participants were not moving. Thus, while the flexible nature of time-space mappings may still be attributed to an attentional mechanism, the mappings are not as flexible as we may have previously thought. Even when attention is not brought to a certain direction of response, the participant's perceptuomotor schema of movement still inflicts a heavy bias.

Another issue which I would like to address is that of how the present data fit into either the strong or weak metaphor view. The metaphor view proposes that abstract concepts are understood in terms of representations based on more concrete physical experiences (Lakoff & Johnson, 1980, Boroditsky, 2000). In Boroditsky's strong metaphor view, concepts such as time literally use the same representations that they are grounded by. In the weak view, these conceptualizations are transferred from the more physical concept (in this case, space) and used as a copy for the abstract concept (time). In this sense, abstract concepts in the weak view are independent from their grounding concept. Most data that has been collected up to this point supports the weak view (Matlock et al, 2005; Boroditsky et al, 2002; Torralbo et al 2006; Casanto et al, 2008). Priming between temporal and spatial schemas has been found to be uni-directional; spatial representations can prime temporal representations, but not the other way around. This finding has been taken for evidence that the spatial schemas used for temporal concept structuring are indeed separate from the original spatial representation. Our data, at first glance, seems to favor the stronger view. Participants were not consciously thinking of spatial schemas, yet their motor responses in space were affected by certain temporal phrases. Additionally, participants were not made consciously aware of the axis due to the non-ordered nature of response and stimuli. Thus, our results hint that perceptual motor system does seem to be directly connected to abstract representation.

There are two ways that I may reconcile this data with those data supporting the weak metaphor view. The first is that I tested motor response in space and collected online processing information, while a majority of the previous studies that have examined this question tested spatial and temporal representations as a product, such as in the ambiguous temporal question paradigm (Boroditsky & Ramscar, 2002; Boroditsky and Ramscar, 2000). Given our results, it can be noted that thinking about temporal information facilitated a motor response in certain spatial areas, depending on the condition. Thus, in this online processing test, spatial responses were facilitated by thinking about temporal information.

The second, more speculative, theory as to how this data may fit with other data in the area is through a closer look at Lakoff's (1980) metaphor theory. Until now, temporal representations have been thought of as "structured" by spatial representations (Boroditsky, 2000). However, perhaps temporal representations cannot prime spatial representations because temporal representations are not entirely structured or do not at some point borrow spatial representations per se, but are actually organized by the physical experience of space. This idea follows Lakoff's (1980) idea of Orientational Metaphors. Lakoff (1980) describes orientation metaphors as distinct from structural metaphors, in that orientational metaphors organize a system of concepts with respect to another, while structural metaphors structure one concept in terms of another. Time is undoubtably more abstract of a concept than space, which is purely experiential and physical. But perhaps when we theorize temporal concepts are structured by spatial

concepts, we are underestimating the physical aspects of time. Perhaps time and space are so closely related physically that conceptually we need not fully structure time in terms of space, but only use space to organize, or orient, our representations of time. In fact, Lakoff (1980) lists temporal metaphors such as "the future ahead is looking good" as orientational metaphors, and not structural metaphors. The weak metaphor view implies people need to think about space in order for temporal representations to be primed, however in the present study, I find that people are not thinking directly about space, or the temporal concept, in its entirety. The participants were asked to make sensibility judgments, and respond accordingly. In this case then, I show that conscious thought of either space or time is not necessary to show priming between the two. Perhaps, using an orientational metaphor view, merely being physical and having physical experiences is enough to organize temporal representations. In this case, spatial *representations* would not be subject to priming from temporal representations, but space itself, or our movements in real space, may be subject to temporal priming.

One last finding I would like to discuss from this data concerns the interesting results of month sentence versus day sentences. In work on situation models, Zwaan (1996; 1995) finds that as chronological distance of temporal phrase shifts increases, reading time also increases. Such that one moment into the future takes less time to process than one day, or one month into the future. In the present experiment I was interested in investigating the differences in time shifts on a spatial representational level. I found that month and day sentences performed differently. I only observed the desired interaction between direction and phrase type (Past/Future) in the Month sentences. Day sentences did not show any reliable effects. I believe these results are in line with Zwaan's (1996) findings concerning magnitude of temporal shift. The response distance from the start key to the response key was fixed and the same for both month and day sentences. Therefore, if a participant were to construct a sort of mental timeline around their body, with the past to the left, the future to the right and the present right at midline, the day point should be closer to midline than the month point. Therefore, the month mapping would need to be mapped to the farthest possible key. In this experiment, I only had one key, and thus, perhaps month was mapped to that key, and day sentences would have fallen to close spatially to the body to see any effects. I have planned more experimentation which will further investigate the details of how certain time shifts are mapped. Additionally, one main effect that I did not anticipate is that of temporal phrase type (past/future). In three of the four experiments, I found that the past phrases were responded to quicker than future phrases. I may explain this by saying that the past is processed more easily than the future, simply because the past has already happened. It may be easier to create a simulation of past events because they have already occurred, and one does not need to re-create a simulation. However, this explanation is not quite sufficient to explain our results. In this experiment, all of the temporal statements were novel to the participant. If a participant read sentences about events that had happened personally, we may expect facilitation of response for past phrases. However, since each sentence, both about the past and future, was novel, participants would have to simulate each phrase for the first time. Perhaps the explanation is cultural. We may be able to process text in the past tense easier than future simply because most of the information we read is in the past tense. Further research will need to be done to investigate the processing differences between past and future narratives.

In conclusion, my goal in designing this study was to investigate the role of self movement in the representational mappings between time and space. I find compatibility effects such that with temporal statements about a month time-shift, participants are faster to respond to future-related temporal statements when responding away from their bodies, and faster to respond to past-related temporal statements when moving toward their bodies, but only when they are moving to respond. Additionally, participants are faster to respond to future-related statements when responding on their right, and faster to respond to past-related statements when responding on the left, but only when they are not moving their arm to respond. I explain this in terms of the different spatial schemata used in ego and time-moving perspectives. Participants who are moving to respond are more likely to use a spatial schema of themselves as moving through space toward an event in time, in this case, the easiest spatial axis to map the concept of time to is the front-back direction, since that is the direction one usually moves in. However, when not moving to respond, participants are not biased to use an ego-moving spatial schema, and thus we can see influence from weaker effects, such as reading direction. Thus our findings are quite interesting. Participants unconsciously use the space around their bodies to process abstract information such as time. Additionally, movement within this space influences the directionally of the mappings of abstract representations of time to this physical space.

APPENDIX A

KEYBOARD ORIENTATIONS FOR LEFT-RIGHT DIRECTION

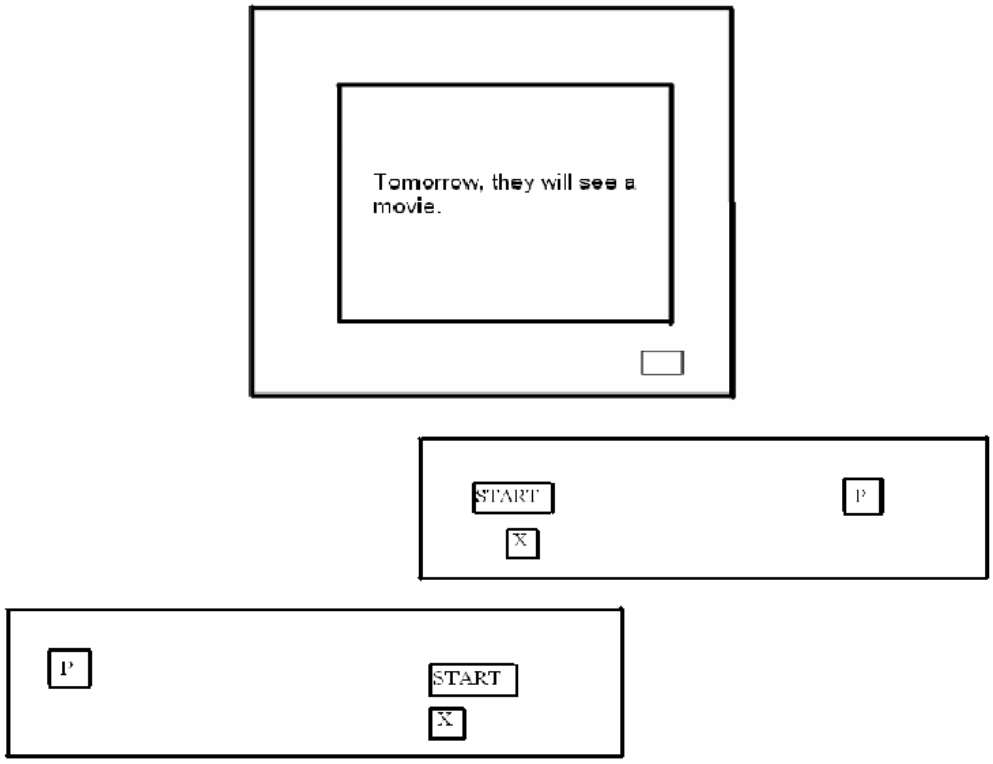

Figure 5. Keyboard configuration for left-right axis experiments (left-to-right configuration on top).

APPENDIX B

KEYBOARD ORIENTATION FOR TOWARD-AWAY DIRECTION

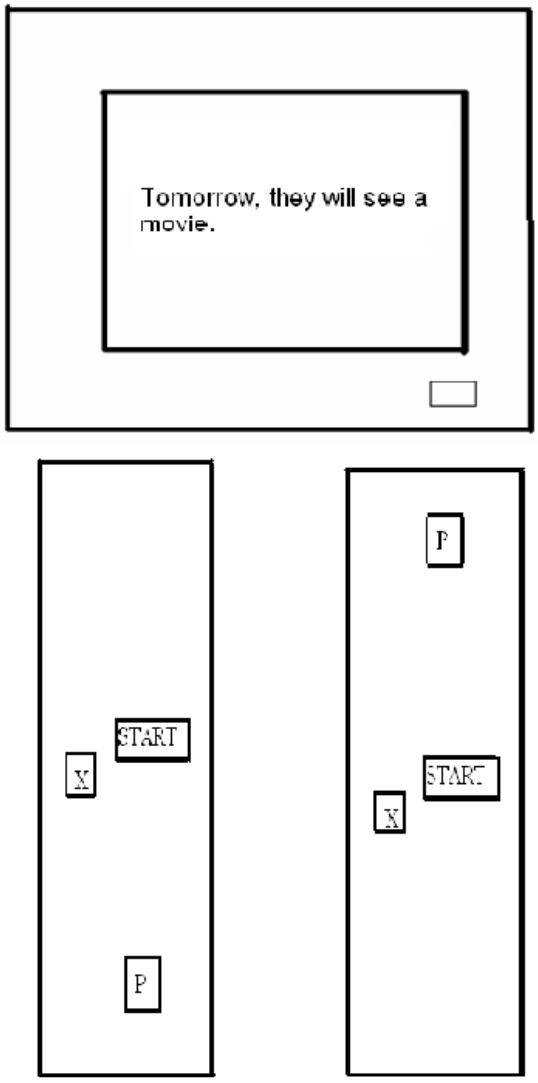

Figure 6. Keyboard configuration for front-back axis experiments (front-to-back configuration on left).

APPENDIX C

CRITICAL SENTENCE TRIADS

Jackie is taking a painting class.
Tomorrow she will learn about paint brushes
It is important to know paintbrush techniques.

My brother is awesome to hang out with .
Tomorrow we will hang out at his house.
We will play video games together.

My dog is a very fast runner.
Tomorrow he will run around the block.
He runs in races often.

The Andersons live in a rough area of town.
Tomorrow they will make sure to lock their door.
Televisions disappear from houses in that neighborhood everyday.

The neighborhood sponsors a yearly picnic.
Tomorrow we have to buy food for the picnic.
We need hot dogs, hamburgers and drinks.

The workers dig holes.
Tomorrow they will dig two new holes.
The workers must dig new holes or they will not get paid.

Fifty people live in this complex.
Yesterday, they had to pay rent.
The rent is high, but most people are happy to pay it.

George is in the market for a new car.
Yesterday he looked at sports cars.
Decisions this large are difficult to make.

My mother usually washes the dishes.
Yesterday I washed the dishes.
She says I need more responsibilities.

Prashant is a wonderful cook.
Yesterday he made an awesome dinner for his friends.
He uses expensive foreign ingredients.

Susan loves swimming in the pool.
Yesterday she practiced for a swimming competition.
Her friends can't keep up with her in the pool.

The Johnson's baby is really sweet.
Yesterday her family dressed her up for church.
Everyone at church likes to hold her.

My roommate is studying to be a veterinarian.
Next month she will bring home two cats.
The animals she brings home are really cute.

Rory likes to knit sweaters.
Next month she will knit a sweater for her friend.
She buys colorful yarn from the local store.

The boy is confident in his test taking skills.
Next month he will try to get an A on the test.
The principle is proud of the boy.

The dancer has a beautiful dress.
Next month she will dance in the competition.
The dress is perfect for twirls.

The politician speaks at this civic center.
Next month he will speak on popular environmental issues.
Many people attend his speeches.

The Smith family travels often.
Next month the Smith family will travel to Peru.
They have only a few suitcases.

Julie rides her bike to school.
Last month, gas prices went up.
Biking is a good way to save money.

Many people try to quit smoking every year.
Last month we attended a class on respiratory health.
Smoking is generally a bad habit to form.

My father hardly ever sleeps.
Last month he got tested at a sleep clinic.
Occasionally he takes drugs to help.

My sister is working this semester.
Last month she was able to afford a new desk.
She works at the neighborhood ice cream parlor.

Stephanie likes to go out.
Last month she tried a few new places.
She enjoys spending time with her friends.

The surgeon here is new.
Last month the surgeon performed his first bypass.
Real surgery is nothing like what's on T.V

APPENDIX D

IRB APPROVAL LETTER

Office of the Vice President For Research
Human Subjects Committee
Tallahassee, Florida 32306-2742
(850) 644-8673 · FAX (850) 644-4392

RE-APPROVAL MEMORANDUM

Date: 7/30/2009

To: Michael Kaschak

Address: Department of Psychology, FSU
Dept.: PSYCHOLOGY DEPARTMENT

From: Thomas L. Jacobson, Chair

Re: Re-approval of Use of Human subjects in Research

Your request to continue the research project listed above involving human subjects has been approved by the Human Subjects Committee. If your project has not been completed by 7/29/2010, you are must request renewed approval by the Committee.

If you submitted a proposed consent form with your renewal request, the approved stamped consent form is attached to this re-approval notice. Only the stamped version of the consent form may be used in recruiting of research subjects. You are reminded that any change in protocol for this project must be reviewed and approved by the Committee prior to implementation of the proposed change in the protocol. A protocol change/amendment form is required to be submitted for approval by the Committee. In addition, federal regulations require that the Principal Investigator promptly report in writing, any unanticipated problems or adverse events involving risks to research subjects or others.

By copy of this memorandum, the Chair of your department and/or your major professor are reminded of their responsibility for being informed concerning research projects involving human subjects in their department. They are advised to review the protocols as often as necessary to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

Cc:
HSC No. 2009.2997

APPENDIX E

INFORMED CONSENT

INFORMED CONSENT FORM

I freely and voluntarily and without element of force or coercion, consent to be a participant in the research project entitled “Memory and Language Processing.” This research is being conducted by Dr. Michael Kaschak at the Department of Psychology, Florida State University. I understand that the purpose of this research project is to understand the ways that specific kinds of experience affect the way that we subsequently process language. I understand that if I participate in this study, I will be asked to perform one of the following tasks that are checked off below:

__x_ Reading or listening to short stories or sentences
_____ Completing a series of sentence stems or describing pictures
_____ Learning a made-up language
_____ Taking a memory test for materials presented in the experiment
_____ Judging the grammaticality of sentences

I understand that I must be at least 18 years of age in order to participate. The total time commitment would be between 30 and 60 minutes, and I will be compensated by receiving either: 1) a credit point toward my research requirement in General Psychology, or 2) extra credit points (if participating for a course other than General Psychology). I understand that my participation is totally voluntary and I may stop participation at anytime. If I decide to stop participation, I will still be entitled to the research credit or extra credit point. All the data collected from me will be confidential to the extent allowed by law and will not be connected to me by name or other identifying information. In addition, my name will not appear on any of the results. No individual responses will be reported in any presentations or publications that come from this work. Only group findings will be reported. I understand that all data relevant to the study will be kept in a locked file cabinet or on a password-protected computer in the researcher’s laboratory space for 10 years (until September, 2019).
I understand that the experiment does not in any way constitute a risk to me.
I understand that there are benefits for participating in this research project. First, I may gain insight into how different kinds of experience shape the way that I learn, understand, and use language. I will also be providing researchers with valuable insight into these issues.
I understand that this consent may be withdrawn at any time without prejudice, penalty, or loss of benefits to which I am otherwise entitled. I have been given the right to ask and have answered any inquiry concerning the study. Questions, if any, have been answered to my satisfaction.

Initials: _____

I understand that I may contact Dr. Michael Kaschak, Florida State University, Department of Psychology, Psychology, Room 435, 644 – 9363, for answers to questions about this research or my rights. Group results will be sent to me upon my request. If I have questions about my rights as a subject/participant in this research, or if I feel I have been placed at risk, I can contact the Chair of the Human Subjects Committee, Institutional Review Board, through the Office of the Vice President for Research, at (850) 644-8633.

I have read and understand this consent form.

_____ _____

(Participant Signature) (Date)

_____

(Participant printed name)

IF THE EXPERIMENT INVOLVES THE RECORDING OF YOUR VOICE:
I understand that my participation in this experiment requires my voice and speech to be recorded. I understand that the experimenters have taken steps to ensure the confidentiality of the recording, namely: identifying the recordings by participant number only, and not by name; keeping the recordings in a locked cabinet or on a password-protected computer to which only authorized lab personnel have access; and prohibiting the recordings from being taken outside the laboratory. In keeping with the standards of the American Psychological Association, the recordings will be kept for a period of 10 years, after which they will be destroyed.
I understand that my voice will be recorded during this experiment, and give my consent to this procedure.

_____ _____

(Participant Signature) (Date)

_____

(Participant printed name)

REFERENCES

Boroditsky, L. (2000). Metaphoric structuring: understanding time through spatial metaphors. *Cognition*, *75*, 1-28.

Borodtisky, L., Ramscar, M. (2002). The roles of body and mind in abstract thought. *Psychological Science, 13*(2), 185-189.

Casasanto, D. (2006). Space for Thinking. In V Evans & P. Chilton (Eds.), *Language, Cognition and Space*. London: Equinox Publishing.

Chatterjee, A., Maher, L.M., Gonzales-Rothi, L.J., & Heilman, K.M. (1995). Asyntactic thematic role assignment: The use of a temporal-spatial strategy. *Brain and Language, 49*, 125-139.

Chatterjee, A., (2001). Language and space: some interactions. *Trends in Cognitive Sciences, 5*(*2),* 55-61.

Chatterjee, A., Southwood, M.H., Basilico, D. (1999). Verbs, events and spatial representations. *Neuropsychologia, 37*, 395-402.

Clark, H.H. (1973). Space, time, semantics, and the child. In T.E. Moore (Ed.), *Cognitive development and the acquisition of language.* San Diego: Academic.

Dehaene, S., Bossini, S., & Giraux, P. (1993). The mental representation of parity and number magnititude. *Journal of Experimental Psychology: General*, 122, 371-396.

Genter, 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,

Lakoff, G., & Johnson, M. (1999). *Philosophy in the flesh: The embodied mind and its challenge to the Western thought.* New York: Basic Books.

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

Maass, A., Russo, A. (2003). Directional bias in the mental representation of spatial events: Nature or culture? *Psychological Science, 14(4),* 296-301.

Matlock, T., Ramscar, M., Brorditsky, L. (2005). On the experiential link between spatial and temporal language. *Cognitive Science, 29*, 655-664.

McGlone, M.S., Harding, J.L., (1998). Back (or Forward?) to the Future; the role of perspective in Temporal Language Comprehension. *Experimental Psychology; Learning, Memory and Cognition*, 24, 1211-1223.

Nunez, R.E., Sweetser, E. (2006). With the future behind them: Convergent evidence from Aymara language and gesture in the cross linguistic comparison of spatial construal of time. *Cognitive Science,* 20, 410-450.

Santiago, J., Lupianez, J., Perez, E., Funes, M.J. (2007). Time (also) flies from left to right. *Psychonomic Bulletin & Review,14(3),* 512-516.

Shaki, S., Fischer, M.H., Petrusic, W.M. (2009). Reading habits for both words and numbers contribute to the SNARC effect. *Psychonomic Bulletin & Review*, 16(2), 328-331.

Torralbo, A., Santiago, J., Lupianez, J. (2006). Flexible conceptual projection of time onto spatial frames of reference. *Cognitive Science, 30*, 745-757.

Radden, G. (2004). The metaphor TIME AS SPACE across languages. In N. Baumgarten et al. (Eds.), *Uebersetzen, interkulturelle kommunikation, spracherwerb und sprachvermittlung--Das leben mit mehreren sprachen: Festschrift fuer juliane house zum 60. geburtstag* (pp 225-238). Bochum, Germany; aks-verlag.

Vallesi, A., Binns, M.A., Shallice, T. (2008). An effect of spatial-temporal association of response codes: Understanding the cognitive representations of time. Cognition, 107, 501-527.

Zwaan, R.A., Magliano, J.P., & Graesser, A.C. (1995). Dimensions of situation-model construction in narrative comprehension. *Journal of Experimental Psychology*: Learning, Memory, and Cognition (21), 386-397.

Zwaan, R.A. (1996). Processing narrative time shifts. *Journal of experimental Psychology: Learning, Memory, and Cognition*, 22, 1196-1207.

BIOGRAPHICAL SKETCH

Andrea J. Sell

Andrea grew up in Naples, Florida and attended college at the University of Florida. In the summer of 2006, Andrea graduated from the University of Florida with a Bachelor of Science degree in Psychology. Andrea enrolled in the Master's program in Cognitive Psychology at Florida State University in the Fall of 2007.

Andrea's research interests include; language, abstract thought, embodiment, spatial schemas, and memory.