

## SPATIAL DEPTH CUES IN TEMPORAL REASONING

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SPATIAL DEPTH CUES IN TEMPORAL REASONING

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### **Abstract**

Space is a foundational schema for reasoning about time and as a result time is conceptualized in terms of spatial reality. The ego-moving cognitive metaphor suggests that time is static and immobile and the self moves through it. Conversely, the time-moving cognitive metaphor suggests time moves through a stationary being and is not subject to manipulation from the observer. The present study examined the relationship between the two temporal orientations and spatial depth cues. Four depth cues were tested: relative size, atmospheric disturbance, object occlusion and linear perspective. Participants were primed by reading temporal sentences imbued with either ego-moving or time-moving characteristics. Participants then viewed images containing the depth cues and answered questions regarding time. After this, they answered eight temporal questions and completed the Zimbardo Time Perspective Inventory survey. There was a marginal main effect of priming condition indicating that there was a tendency for people to take a higher proportion of ego-moving responses in the ego-moving condition. The proportion of responses varied as a function of the cue that was viewed. There was a significant tendency for people to give a time-moving response orientation to the atmospheric disturbance depth cue and a tendency for people to give an ego-moving orientation to the linear perspective depth cue across the two conditions. There were no significant correlations between the ZTPI and any of the depth cues or conditions. These results suggest that the temporal perceptions of time in relation to depth cues are distinct from linear perceptions of time.

**Keywords:** Space, time, ego, motion, depth cue, metaphor, schema, construct, context.

### **Spatial Depth Cues in Temporal Reasoning**

Reasoning about abstract concepts such as justice, free will and time requires the ability to analyze information and solve problems on a complex, theoretical level. It can be difficult to visualize something that has never been seen, felt, or heard. Additional difficulty presents itself when articulation of that abstraction is required. For instance, it is easy to visualize a strawberry, as it is something that most people in our society have seen, touched, smelt, tasted and even eaten. The strawberry is a physical object that has been encountered in objective reality. When contact with the physical object occurs, our senses are actively engaged with the object. Our brain is decoding and registering its physical properties and attributes, and hence a subjective experience with the object then occurs. After contact, we now have memory of the object and of its characteristics, and we may apply this knowledge to a variety of other domains even if the object is not physically present. The acquired understanding of an object's components may be generalized to other objects, used for analysis, visualization, analogy, metaphor and numerous other cognitive applications. Abstractions sometimes have no reference to material objects and have no specific examples to illustrate them. There may not be prototypes that are readily and directly applicable to abstract concepts. There is a body of research evidence that suggests that abstract concepts are understood by relating them to concrete schematic domains (Genter, Imai & Boroditsky, 2002). Abstractions are conceptualized and represented on the basis of analogous relationships to physical, tangible entities. The structure of concrete representations is imported and applied to the abstraction so that it can be understood (Boroditsky & Ramscar, 2002).

Human beings have interacted so profusely with space that concepts of its structure are thoroughly imbued within the psyche. These spatial representations can be applied to other concepts that do not have readily functioning frameworks. Time is an abstraction that does not have a readily functioning framework. Space is a schema built upon our concrete experiences can be used to conceptualize time.

A schema is an organized cluster of knowledge that allows us to organize and interpret information according to cognitive models. Schemas are frameworks that help us to organize information more rapidly. Schemas are often, but not always, contingent upon experiential knowledge. Schemas develop in our minds mostly from our own experiences and their generation is therefore automatic. Schemas allow us to know what to expect in certain situations and how to think about things. For example, many of us have schemas for a typical grocery store. We know from experience that we can expect there to be items for purchase on shelves, various kinds of foods organized categorically into different aisles, we can expect there to be other consumers there shopping, we can expect there to be lines of people waiting to be checked out and so on. We have a concept in our minds for what a grocery store is, hence the schema. Schemas are used to filter and organize new information (Hollman, & Siewierska, 2011).

As stated, space is presumably a foundational schema for reasoning about time and as a result time is an abstraction that is usually conceptualized in terms of spatial reality (Boroditsky & Ramscar, 2002). There exists a complex and systematic relationship between space and time in the English language. The words that are used to

describe space are identical to the words used to describe time. The following phrases to the left depict spatial representations and their temporal counterparts are listed to the right

<u>Space</u>	<u>Time</u>
<i>at the corner</i> .....	<i>at noon</i>
<i>from here to there</i> .....	<i>from two o'clock to four o'clock</i>
<i>through the tunnel</i> .....	<i>through the night</i>
He stood <i>before</i> the house.....	it happened <i>before</i> evening
He was running <i>ahead</i> of me.....	He arrived <i>ahead</i> of me
(from Genter, et al., 2002).	

Numerous experimental studies conducted by psychologists have suggested that our understanding of time is in part founded upon a complex linguistic, schematic and metaphorical relationship with space. Time is perceived to exist and move in a linear fashion, from one event to the next. The words that are typically applied to time are unidirectional in nature (up/down, forward/backward) as opposed to words that encompass multiple dimensions (shallow/deep, narrow/wide; Genter, et al., 2002)

Boroditsky & Ramscar (2002) have theorized that there are two primary schematic systems used to convey time through spatial means. When asked the ambiguous question: "Next Wednesday's meeting has been moved forward two days. What day is the meeting, now that it has been rescheduled?", responses are presumed to concur with either the ego-moving or the time-moving perspective. If a person responds with "Friday" it is then assumed that they have adopted the ego-moving perspective. The ego-moving metaphor suggests the ego moves forward through time. Time is rather



immobile from this perspective and the ego is able to move through it at will. Genter, Imai and Boroditsky (2002) state that in the ego-moving perspective, *front* is assigned to the future. For instance, one can say, “the war is behind us” or “his whole future is before him.” From this perspective, the past is typically conceived as being that which is *behind*. Conversely, if a person responds with “Monday” it is assumed that they have adopted the time-moving perspective. The time-moving metaphor suggests time can be conceptualized as an active and dynamic entity that moves in a linear fashion independently of the observer. Time moves through a stationary being and is not subject to manipulation from the observer (Nunez, Motz & Teuscher, 2006). In the time moving system, front is assigned to the past (earlier) event. For instance one can say, “I will see you before four o'clock.” or “The reception after the talk” (Genter, et al., 2002). From this perspective, the past is typically conceived as being in *front*, and the future as that which is *behind*. The past is assigned to the front because one has seen the past, they have lived it, they know what it entails, however the future is *behind* because it has not yet been experienced and is unseen from the reference point.

A series of principal studies by Boroditsky and Ramscar (2002) showed that a variety of spatial contexts may induce one of the two time perspectives. According to the time perspectives, if a person is moving forward through space, then they should also simultaneously view themselves as moving through time, hence the adoption of the ego-moving perspective. Researchers approached people standing in a lunch line and asked them the ambiguous question about next Wednesday's meeting. Researchers found that the further along the people were in the line, the more likely they were to also think of

themselves as moving through time (Boroditsky & Ramscar, 2002, Study 2). Presumably, the further they had progressed in the line, the more forward spatial motion they had experienced, the more likely they were to adopt the ego-moving perspective and say that the meeting had been moved to Friday (Boroditsky & Ramscar, 2002).

Boroditsky and Ramscar (2002, Study 3) approached people in an airport and asked if they were waiting for someone to arrive, waiting to depart or if they had just flown in and asked the question about next Wednesday's meeting. They found that those who had just flown in were most likely to adopt the ego-moving perspective and those who were about to fly also responded with Friday, indicating the ego-moving perspective (Boroditsky & Ramscar, 2002). Boroditsky and Ramscar 2002 concluded that this effect occurred because those that had just gotten off planes had been traveling through space for an extended period of time, and the close association between space and time produced the notion of traveling forward in time. Also, researchers speculated that those who were awaiting departure primarily choose Friday responses because they were already thinking about moving through space, and hence they had already begun thinking about moving through time. For those awaiting the arrival of another, responses between Monday and Wednesday were almost identical, although there were slightly more Friday, ego-moving responses. (Boroditsky & Ramscar, 2002). Similarly, when Boroditsky & Ramscar (2002, Study 5) approached people at a horse racing track and proposed the question, those who had bet on more races were more likely to adopt the ego-moving perspective. Presumably because the more they bet, the more they became involved in the forward motion of the horses and hence an ego-moving state was d. (Boroditsky &

Ramscar, 2002).

### ***The Conceptual Relationship Extends Beyond Linguistics***

It is plausible that the associations between space and time exist on an exclusively linguistic level. Is the abstract domain of time dependent on the concrete metaphor space, purely in the linguistic sense? Or is this comparison deeper, beyond just the verbal aspects? Casasanto and Boroditsky (2008) conducted a series of experiments investigating if this dependency of time on space is limited to language, or it extends beyond even that, into more cognitive and structural levels of concept formation. Casasanto and Boroditsky 2008 removed linguistic variables to see if the association between space and time was still present (Casasanto & Boroditsky, 2008). In one experiment, Casasanto and Boroditsky (2008; Experiment 1) presented participants with lines of different lengths. The lines extended from left to right by varying increments until they reached maximum displacement and then they disappeared. Participants viewed 162 growing lines one at a time. The word “ready” appeared in the center of the screen for two seconds before the line appeared. After each line was shown, participants had to either read the line's displacement or its duration. Casasanto and Boroditsky 2008 found that for stimuli of the same duration, lines that moved a shorter distance were judged by participants to take a shorter amount of time. Lines that traveled at longer distances were judged to take a long time. These findings suggest that subjects had incorporated spatial information into their temporal judgments about duration; however, subjects did not incorporate temporal information into their spatial judgments of distance. (Casasanto & Boroditsky, 2008). Time was spoken about in terms of space more so than

space was about time, which suggests an asymmetrical relationship. The asymmetry hypothesis states that time is linguistically dependent on space, but space is not necessarily dependent on time (Casasanto & Boroditsky, 2008). These results support the asymmetry hypothesis which argues that time is dependent on the concrete elements of space to conceptualize the abstract domain of time. However, the abstract domain of time is not dependent or necessary to conceptualize the concrete domain of space.

In the previous study, the lines were in motion. Casasanto and Boroditsky (2008, Experiment 1) wanted to investigate if the motion was necessary to the asymmetrical relationship between distance and duration, or if the effect would still be present with non-moving stimuli. Thus, in experiment 6 by Casasanto and Boroditsky (2008), participants did not view growing lines, instead they viewed stationary lines of various spatial lengths. Participants had to estimate either the lines displacement from one end to the other or the amount of time that the lines had remained on the screen. The results showed that estimates of duration were strongly and asymmetrically dependent on the spatial length of the lines. This again suggests times dependency on space. It also demonstrates that motion is unnecessary to the asymmetry between estimates of distance and duration. (Casasanto & Boroditsky, 2008).

In an additional experiment by Casasanto and Boroditsky (2008, Experiment 5), participants viewed a dot that moved horizontally, left to right, across the middle of a screen. Unlike the growing lines that could be seen in their full spatial extent, the traveling dot's full spatial extent could not be seen, as it was a single unit moving through space. The actual path of the dot had to therefore be imagined, from its starting point to

its end point. The results of this experiment indicated yet another asymmetrical relationship of space on time. The perception of a long line was unnecessary to lengthen a participant's judgment of time. (Casasanto & Boroditsky, 2008). These effects were found in tasks that did not involve or require any linguistic responses. These findings provide evidence that the relationship extends beyond a linguistic similarity and that the metaphorical relationship is present even in more basic conceptual representations of distance and time. The relationship is not exclusively dependent on language alone.

### ***Left and Right as the Past and Future***

It has been assumed that literate speakers and writers of languages that go in a left to right direction also conceptualize time as moving from left to right. This is presumably most prominent among Western cultures. The future is imaged as a point off the right and the past as a point far out to the left. To test this hypothesis, Santiago and colleagues (Santiago, Lupianez, Perez & Funes, 2007) presented a group of participants with words on a computer screen that referred to either the past or future. Participants had to respond by pressing either the “f” key on the computers keyboard, corresponding to the left hand, or the “j” key, corresponded to the right hand. Participants were informed that the words would appear randomly, on different areas of the screen but that this was irrelevant to the task. Researchers found that when participants judged the temporal reference of a word, they were affected by the words spatial location (Santiago et al., 2007). Responses were faster when words that dealt with the past corresponded to the left side of the screen, and when words that dealt with the future corresponded to the right side of the screen. The fact that participants responded in congruence with the hypothesized relationship between

spatial location and corresponding temporal orientation of the words suggests that there is a conceptual mapping present between the two domains. Researchers believed that this was evidence to support the idea that there exists a specific mapping between the past and left space, and the future and right space. (Santiago et al., 2007). However, it is possible that participants in this study could have noticed patterns that suggested ordered pairs, and perhaps found that certain sequences tended to be shifted to either the left or right. It may therefore be this relation as opposed to a temporal one that produced the results.

### ***Time and Motion***

Time is perceived to move in a linear manner however, space is vastly complex, multidimensional and multi directional. There is evidence to suggest that it is not just space itself, but also the aspect of *motion* through space that may also effect a person's understanding of time (Matlock, Ramscar & Boroditisky, 2005). Simply thinking about moving through space is enough to influence a person's perception of time. Fictive motion is the term applied to thinking about motion. In order to see if fictive motion can in fact change in a person's thinking about time, Matlock and colleagues (2005) conducted several studies testing the assumption. Researchers gave their participants a sentence that was based on fictive motion, such as "the road runs along the coast" or "the tattoo runs along his spine" and other participants were given a motionless oriented sentence, such as "the road is next to the coast" or "the tattoo is next to his spine". Participants were then asked to draw a picture of what they had envisioned the sentence to look like, and then asked them the ambiguous question about next Wednesday's meeting. Participants who were given the fictive motion sentences were more likely to

say that the meeting had been moved to Friday. Conversely, those who were given the motionless sentences were more likely to say that the meeting had been moved to Monday. Researchers interpreted these results to mean that the sentences embedded with fictive motion made participants think about moving through time because they were also about spatial movement (Matlock et al., 2005).

In another study, (Matlock et al., Experiment 2, 2005) participants were given an ego-moving fictive motion sentence, “*The road goes all the way to New York.*” Researchers speculated that thinking about the road going from Stanford University (where the study was conducted) to New York would be congruent with the ego-moving metaphor, and would a Friday response. In another condition, participants were given an object-moving fictive motion sentence, “*The road comes all the way from New York.*” The researchers predicted that this would promote a time-moving, Monday response. The results confirmed the researchers’ expectations. They found that when people thought about fictive motion as traveling away from them, they were more likely to respond with Friday. When they had thought about fictive motion as something coming toward them, participants were more like to respond with a Monday (Matlock et al., 2005).

These results show that simply thinking about motion through space is enough to influence people’s perceptions of time and how they relate to it. Just thinking about fictive motion influenced participants to adopt an ego-moving perspective and to think of themselves as moving forward through time. These results are fairly predictable, as the initial statements “*The road goes all the way to New York*” and “*The road comes all the way from New York*” essentially embody the time-moving and ego-moving metaphors.

The first statement signifies something 'going' and the second as something 'coming' and hence the ego as an entity that is going, and the time-moving as something approaching the observer. Even though subjects are indirectly primed to think of something as either going away or coming towards them, that information still carried over into a separate domain.

### ***Depth: The Third Dimension***

These studies have compared time to space, but yet still treat space as a linear and uni-directional entity. Time is perceived to move in a linear manner, but space is vastly complex, multidimensional and multi-directional. Space is not linear but these aspects seem to be ignored when discussed in relation to time. Space is symmetrical in all directions. It is possible to move and function in any direction. Time is asymmetric in organization. Directionality is an aspect that is still somewhat ignored, which is in part due to the assumption that time is strictly linear. Depth has not yet been considered as extensively as it should be.

The present study investigated how depth cues may affect conceptualizations of time. Four spatial depth cues were selected for use in this study. Object occlusion is the transposition of one object over another. From the observer's perspective, the object that is covering the other object appears closer to the observer in space and the object that is covered (i.e., occluded) is perceived to be further away. Atmospheric disturbance is the perception that as objects appear to recede to the horizon atmospheric pollutants cast a haze over them, reducing their image quality and cause objects appear lighter in color. The further away objects are from the observer, the more atmospheric disturbance those



objects appear to have. Another depth cue that was used is relative size. Distant objects appear smaller to the observer and objects that are closer to the observer appear larger. Objects that are the exact same size appear to be different sizes depending on their spatial location in space. Finally, one-point linear perspective was also used. Linear perspective assumes vision from the observer's standpoint. It contains some qualities of the other depth cues such as occlusion and relative size and in some instances atmospheric disturbance and is therefore the most realistic cue.

As mentioned earlier, there are certain words that are used to describe both spatial and temporal contexts. We can say within the spatial context that we have “passed our papers *forward* to the front of the room” and that we have “walked *ahead* of the other passengers” or that the “pencil fell *behind* the desk.” We can also say within the temporal context that we are “looking *forward* to a brighter tomorrow” and that we are “proposing theories *ahead* of our time” or that we are “falling *behind* schedule” (Genter et al., 2002).

For a further example, compare the following scenarios:

(a) They moved the truck forward two meters.

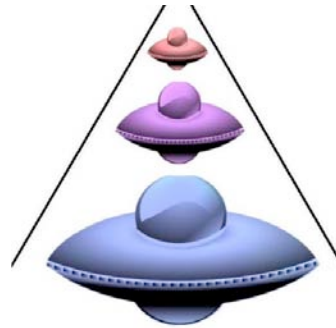
(b) They moved the meeting forward two hours.

(Casasanto & Boroditsky, 2008).

Four specific word pairs were selected for examination in this study because they can be used to describe both spatial and temporal contexts. The four word pairs were: 1) Ahead/Behind, 2) Precede/Follow, 3) Before/After, and 4) Forward/Backward. These target words can be conceptualized differently depending on the two temporal perspectives. According to previous researchers, in the ego-moving

perspective, *front* is assigned to the future. For instance, one can say, “the war is behind us” or “his whole future is before him”. From this perspective, the past is typically conceived as being that which is *behind*. In the time-moving system, in contrast, *front* is assigned to a past (earlier) event. For instance one can say, “I will see you *before* 4 o'clock.” or “The reception *after* the talk” (Genter, et al., 2002).

For a further example, consider the following image:



**Figure 1:** Linear Perspective Example

People were primed into adopting either the ego-moving perspective or the time-moving perspective by reading priming sentences. If participants are told that these spaceships are racing and asked which is *ahead* of the others the answer will vary depending on the two time perspectives. If a person is primed to be in the ego-moving frame of mind, they will likely say that the red space ship is ahead since that ship is presumably moving toward the horizon, the same way a person would see the object if they were walking toward it. Conversely, if a person is primed to be in the time-moving frame of mind, they are more likely to say the blue space ship is *ahead* because the blue ship would appear to be coming toward the observer, just as in the time-moving perspective time comes toward the observer. It was hypothesized that people would

respond in accordance to the perspective that they were primed with.

None of the studies described previously explicitly addressed whether or not participants in the studies already held certain views of time. Dr. Philip Zimbardo has recently developed the ZTPI, the Zimbardo Time Perspective Inventory ([www.thetimeparadox.com](http://www.thetimeparadox.com)). It is based upon the ways in which individuals develop their own orientations toward specific temporal perspectives as a result of their life experiences. The inventory is designed to assess people's views toward the past, present, and future, and views about a possible transcendental future which deals with a person's views of an afterlife. The inventory categorizes people into several temporal perspectives: the past-negative, past-positive, present-fatalistic, present-hedonistic and future time perspectives independently. It is of interest to see if any of the ZTPI profiles correlate with either the ego-moving orientation or the time-moving orientation. The ZTPI was therefore included in this study to address this concern.

## **Methods**

### ***Participants***

Approval from the Institutional Review Board at Texas State University was obtained prior to the start of this study. A sample of 125 undergraduates was recruited from Texas State University - San Marcos. There were 97 female participants and 28 male participants. The sample consisted of 91 white participants, 7 African American participants, 3 Asian participants, 3 Native American participants and 17 participants who were of unknown ethnicity. The majority of participants' ages were from 18 to 22 and the mean age was 20. However, age ranged from 18 to 43. Participation was on a

volunteer basis and extra course credit was offered as compensation. Participants were randomly assigned to either the ego-moving condition or the time-moving condition. Informed consent was obtained from the participants prior to the start of the study.

### ***Materials***

All of the materials were presented electronically and all responses were entered and saved electronically. Participants were randomly placed in either the time-moving or the ego-moving condition to test the relationship between depth cues and the temporal perspectives. Using ego-moving or time-moving oriented sentences as a priming technique was adopted from Genter, et al., 2002. Once in the condition, twelve priming sentences were presented in random order. Participants were primed for either the ego-moving perspective or the time-moving perspective. Examples of ego-moving prime sentences are “Childhood comes **before** adulthood. Adulthood comes **after** childhood” and “Some students work their way through the summer that **precedes** the fall semester. The fall semester **follows** summer”. Example time-moving primes are “Day **precedes** night. Night **follows** day” and “Christmas is **ahead** of New Years. New Years is **behind** Christmas.” For more examples, please refer to appendix A.

The test image set consisted of fifteen static color photos presented in random order and each featured a pictorial depth cue. There were four images of occlusion, relative size, atmospheric disturbance and three images of linear perspective. Most of the images were created by the researcher on GIMP, a free software raster graphics editor. Other images were adapted from the Google images search engine and underwent

modifications. Some of the colors of the objects were changed to make them distinct from the rest to prevent confusion. The images were approximately 500 x 300 pixels in dimension. All of the objects depicted were not oriented toward any specific direction. The objects depicted were hot air balloons, balls, cubes and round space ships. These objects were chosen because they do not have a face or specific orientation and therefore can be interpreted in more than one way and were not biased in any particular direction (see Appendix B).

### ***Procedure***

Upon entering the testing center, participants signed their name on the sign-in sheet so they could obtain their extra credit. Absolutely no information about their identity was linked to their responses to the study; their answers were anonymous. Participants were then escorted to the testing area by the researcher. The participants signed a consent form and were asked for their age and if they were on any medication. Participants were informed that the study would take approximately twenty minutes to complete and that they should approach the researcher if they had any questions or were experiencing confusion. The researcher then exited the participant's cubicle and sat quietly in a room adjacent to the participants testing area.

The stimuli were presented using Superlab 2.04 (Cedrus, San Pedro, CA). Participants were randomly assigned to either the time-moving or ego-moving conditions. Participants first read twelve priming sentences each containing two of the target words. Participants then viewed a series of fifteen images each accompanied with a question regarding the spatial orientation of the images imbued with the target word pairs

(Ahead/Behind, Precede/Follow, Before/After, Forward/Backward). Example: “These hot air balloons are racing. Which balloon is ahead and which is behind?” or “Does the black cube precede the red cubes, or does the black cube follow behind the red cubes?” (See appendix B). Participants were given two answer choices, either a time-moving response or an ego-moving response. The answer choices were inputted and recorded into the computer by pressing either a “1” or “3” response key. The answers were presented in randomized orders to prevent answer bias. The participant's response times were recorded to ensure that they were reading the materials and not arbitrarily answering in haste. After this, participants answered eight questions regarding time which also contained the target words (See appendix C). After completing the computerized task, participants were asked to complete the fifty six item Zimbardo Time Perspective Inventory (ZTPI) which investigates relationships between personality characteristics and views of time (See Appendix D). The ZTPI is open to the public and was used free of charge. The survey was presented and responses were recorded via an online service called Survey Monkey ([www.SurveyMonkey.com](http://www.SurveyMonkey.com)). After completing the experiment, participants were debriefed and encouraged to ask questions about the study.

### ***Analytic Strategy***

The proportion of ego-moving responses for statements was computed for each of the pictorial cue types and the eight questions about time that followed. In order to determine whether there were differences in the proportion of ego-moving responses across the different depth cue types, a mixed ANOVA was conducted. Prime condition (ego-moving vs. time-moving) was the between-subjects factors and depth cue type

(atmospheric disturbance, occlusion, relative size, vs. linear perspective) was the within-subjects factor. It was hypothesized that the majority of the responses would be in congruence with the ego-moving orientation and that there would be a main effect for image type and prime condition. In the case of a cue type x prime condition interaction, Bonferroni-corrected paired samples *t* tests with prime condition as the between groups factor were then conducted to compare the proportion of ego-moving responses given in each prime condition for each of the four depth cue types. Specifically, these comparisons were made to determine if there were differences across depth cue types within a particular prime group.

To determine whether there was a significant effect of prime condition on the eight sentences that followed the depth cue task, an independent groups *t*-test, with prime condition as the between subjects factor, was conducted on the proportion of ego-moving responses over the eight questions. It was predicted that responses to the eight ambiguous temporal questions would be consistent with the prime condition. Participants who were primed to adopt the ego-moving perspective would choose the ego-moving answer choices. Similarly, those who were primed to adopt the time-moving perspective would choose the time-moving answer choices.

In order to determine whether there was a systematic bias to respond in an ego-moving or time-moving manner to a particular depth cue, one-sample *t*-tests were performed for each depth cue type to see whether the proportion of ego-moving responses was significantly different from 50% chance. It was hypothesized that there is a significant difference between the means of the depth cues across the ego-moving and

time moving conditions. It was hypothesized that the difference between the two conditions were not due to chance alone. For the ZTPI, five factors were identified, the past negative, present hedonistic, present, past positive, present hedonistic. The scores for the items that comprise each factor were added together after reverse-coding 5 items. After adding the scores for each factor, the total score was divided by the number of questions that comprise each factor. This resulted in an average score for each of the five factors.

## Results

Table 1				
<i>Paired-samples <math>t</math> tests Depth Cue Comparisons Across the Two Conditions</i>				
Depth Cue	Atmospheric Disturbance	Occlusion	Relative Size	Linear Perspective
Atmospheric Disturbance	--	--	$t = -2.57^*$	--
Occlusion	$t = -2.16^*$	--	--	$t = -2.65^*$
Relative Size	--	$t = -.29$	--	--
Linear Perspective	$t = -4.56^*$	--	$t = -2.26^*$	--
<i>Note.</i> * indicates significance of $p < .05$ ; $df = 119$				

There was a main effect of image type,  $F(3,354) = 7.66$ ,  $p < .001$ , for the mixed ANOVA, indicating that there was a significant mean difference between the two independent ego-moving and time-moving conditions as a function of depth cues.



Bonferroni-corrected paired samples  $t$ -tests were conducted to compare the means of the depth cues across the two conditions. Differences between the cues for the two conditions were computed and tested to determine if the average difference was significantly different from zero. The results of are displayed in Tables 1 and 2 below.

Based upon the results displayed in table 1, there were a significantly higher proportion of ego-moving responses to occlusion relative to atmospheric disturbance. There were a higher proportion of ego-moving responses to relative size than to occlusion. Similarly, there were a higher proportion of ego-moving responses to linear perspective than relative size. For the actual values, please refer to tables 1 and 2.

Table 2 <i>Means and (Standard Deviations) of the Paired-samples <math>t</math> tests</i>				
Depth Cue	Atmospheric Disturbance	Occlusion	Relative Size	Linear Perspective
Mean (Standard Deviation)	0.44 (0.26)	0.50 (0.30)	0.51 (0.31)	0.58 (0.26)

The results of the one-sample  $t$  test showed that there was a significant tendency for people to give a time-moving response orientation to the atmospheric disturbance depth cue across the two conditions ( $t(119) = -2.378, p < .01$ ). Similarly, there was a significant tendency for people to give an ego-moving orientation to the linear perspective depth cue across the two conditions ( $t(119) = 3.669, p < .001$ ).

There was no significant difference in the proportion of ego-moving responses to the eight ambiguous temporal questions as a function of priming condition. There were no significant correlations between the Zimbardo Time Perspective Inventory and any of

the depth cues or condition effects in this study.

## **Discussion**

Abstractions sometimes have no reference to material objects and have no specific examples to illustrate them. Therefore, they are conceptualized and represented on the basis of analogous relationships to tangible domains. Space is a foundational schema for reasoning about time. Time is therefore conceptualized in terms of spatial characteristics. In the present study, spatial depth cues were tested to see if they influence a person's thinking about time.

There was a marginal main effect of priming condition: participants had the tendency to respond with a higher proportion of ego-moving responses when primed to the ego-moving condition. This marginal effect was not originally predicted. There are several interpretations of this effect. One explanation is that the priming manipulation was not sufficient to fully induce the temporal perspectives. Another possible interpretation is that depth cues are not as susceptible to manipulation as other spatial cues. Finally, there may not have been enough statistical power present to detect the differences. There was a main effect of cue type regardless of the cue types. Proportions of ego-moving response was not equivalent across the depth cue types.

Based on the results of the Bonferroni-corrected paired samples *t*-tests, the mean for atmospheric disturbance ( $M = 0.44$ ) was lower than all of the other depth cues. This means that atmospheric disturbance was the least likely depth cue to elicit an ego-moving

perspective. This runs contrary to the majority of studies that stated that the ego-moving perspective was adopted by default. The atmospheric disturbance cue is mostly present when looking at scenery that spans over large distances. Most objects viewed in everyday life are not subject to the intense atmospheric noise that this cue illustrates. Future research should replicate and elaborate on this finding.

In comparison with the other depth cues in proportion of ego-moving responses, the mean for occlusion ( $M = 0.5$ ) was only higher than atmospheric disturbance and was lower than all of the other depth cues. This could be a result of the fact that in this study occluded objects were presented in a limited context. In realistic scenes, no two objects are excluded from their surrounding environment. In addition, this depth cue in particular may have been susceptible to a high degree of ambiguity in terms of the observer's viewpoint. A person may be equally likely to view an occluded object as being in front of another object just as likely as they are to view it as being behind another object. These distinctions could be arbitrary even without any sort of manipulation.

In comparison with the other depth cues in proportion of ego-moving responses, the mean for relative size ( $M = 0.51$ ) was higher than of atmospheric disturbance and for occlusion. This could in part be explained because relative size is more perspicuous and is therefore more rapidly detectable than atmospheric disturbance. If a person is seen on a scenic landscape, it is obvious to the observer that the closer the person is to the horizon, the smaller they will appear. However, since the observer can judge the persons true size, a working context is established and a sense of spatial distance can be derived.

In comparison with the other depth cues in proportion of ego-moving responses,

the mean for linear perspective ( $M = 0.58$ ) was higher than atmospheric disturbance, occlusion and relative size. This can be due to the fact that linear perspective is the closest cue to matching realistic perspective. People see realistic spatial contexts through the form of linear perspective. Linear perspective also embodies qualities of the other depth cues. For instance, when looking at a scene, objects recede toward the horizon and appear smaller the closer they are to the horizon (relative size) and naturally objects that are closer to the horizon are subject to more atmospheric disturbance. Objects are naturally occluded by other objects as well.

Priming effects were not apparent in the responses to the ambiguous temporal questions. This may have occurred because the priming effects did not last long enough to have an effect on the questions by the time they were answered.

There were no significant correlations between the Zimbardo Time Perspective Inventory and any of the depth cues or conditions. The ZTPI measures a person's orientation toward time based upon their life experiences and personality characteristics. The orientation toward time in this study is dependent on the context. The same person can adopt both the time-moving perspective in one situation, such as waiting for a bus, and the ego-moving perspective in another situation such as walking to a particular destination. Unlike the ZTPI, which measures traits related the perception of time, the two temporal orientations do not profess to be measures that are consistent with personality and identity, rather they are more appropriately described to be fluid and dynamic outcomes of a particular context. Since the two temporal orientations and the ZTPI are measures of separate phenomena, it is permissible that they do not appear to be

directly related to one another.

A limitation of the present study is that the manipulations may have been inadvertently influenced by order effects. The priming sentences could have been removed and the images themselves could have been modified and used as primes. Since space is the foundational schema and time its conceptual counterpart, the transference may have been more direct if the manipulation had been approached in this manner. The eight ambiguous temporal questions could have been presented after and evidence of a successful or unsuccessful manipulation could have been derived based upon answers to those questions.

Thus far, research has depicted and tested perceptions of time in a one directional manner and depth has been largely ignored from examination of time-space relationships. In the study by Santiago and colleagues (2007), it was noted that there appears to be a distinct association between the past as left oriented and the future as oriented to the right. From this view point, time appears to move in a horizontal manner; from the left progressively to the right, which implies that time is of a two-dimensional nature from the observer's perspective. This establishes that there is some evidence for a distinct representation of the past and future in the Western psyche. However, the effects of past and future may not translate as well to depth because people are more likely to think of the past and future as being left or right as opposed to forward and backward.

In the previous studies, responses to the ambiguous question regarding next Wednesdays meeting may be due to an already existing bias toward time, independent of the lunch line, airport and horse racing contexts. In the majority of the studies, along with

this one, the participants responded in congruence with the ego-moving perspective seemingly by default. This could also be a result of the underlying culturally founded Western notion of individualism. Individualistic cultures encourage its members to focus on their own desires and to achieve success through means of independence and self-reliance. The self is of primary importance as opposed to the values and goals of the family, society or any other group. This cultural conditioning makes members of our society more focused on their own perspective as a reference point. Americans may be more likely to think of themselves as moving through time in general as opposed to passively waiting for time to reach them due to the assumption that egotistical concerns are primarily imbued within the western psyche. Future research should address the possibility that culture may influence temporal reasoning.

Future studies should extend their examination of space by considering how depth plays a key role in the space-time complex. In the current literature, depictions of time are too linear and overlook the reality that space is not limited to a two dimensional spectrum. In addition, future measures need to further investigate the extent and implications of the space-time complex. Presently, the literature documents that there is a cognitive conceptual relationship between the two domains, but future measures need to address how far this relationship goes and identify the implications of such a conceptually dependent relationship. Also, the full extent of the role motion plays in time perception needs to be addressed. What role does speed play in time perception? Does moving very fast versus moving very slowly effect how one perceives the passage of time? Specifically, the phenomenon of fictive motion suggests that thinking about

moving is enough to influence perceptions of time. However, efforts need to be made to address the relationship between speed and fictive motion. What are the implications for thinking about moving at great speeds versus slow ones? Addressing these considerations will help to contribute to a greater understanding of the nature of our time perception.

Spatial depth cues were tested to see if they have any relationship toward temporal reasoning. Based upon these results, it appears that some depth cues may serve as more effective primes for certain conditions. As stated in the results, a bias toward atmospheric disturbance was significantly more prominent in the time-moving condition and a bias toward linear perspective was significantly more prominent in the ego-moving condition. The relationship between these conditions and cues needs to be further investigated to determine the extent of their bias. More research needs to be conducted to determine the extent of this relationship. Future research could investigate if there are other cues that have the same sort of relationship regardless of the manipulation. This finding demonstrates that depth cues elicit perceptions of time that are separate and distinct from linear representations of time.





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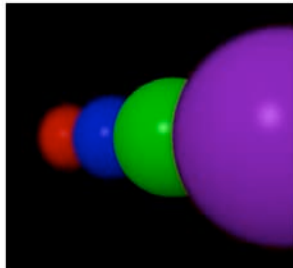


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### Appendix A

<b>Time-Moving Primes</b>	
<b>Key Words</b>	<b>Example Primes</b>
Ahead- Behind	Christmas is <b>ahead</b> of New Years. New Years is <b>behind</b> Christmas. Summer is <b>ahead</b> of fall. Fall is <b>behind</b> summer.
Precede- Follow	Day <b>precedes</b> night. Night <b>follows</b> day. Today <b>precedes</b> tomorrow. Tomorrow <b>follows</b> today.
Before-After	Childhood comes <b>before</b> adulthood. Adulthood comes <b>after</b> childhood. Valentine's Day is <b>before</b> Thanksgiving. Thanksgiving is <b>after</b> Valentine's Day.
Forward- Backward	In the springtime, clocks are moved <b>forward</b> by an hour. In the fall, clocks are moved <b>backward</b> by an hour.  The fundraiser was moved <b>forward</b> to Wednesday. As a result, the auction originally scheduled for Wednesday had to be moved <b>backward</b> .

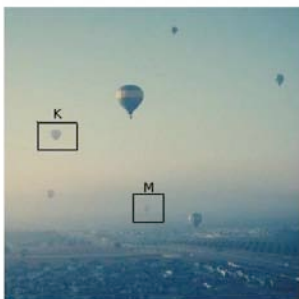
<b>Ego-Moving Primes</b>	
<b>Key Words</b>	<b>Example Primes</b>
Ahead- Behind	<p>Now that she has grown up and her troubled youth is <b>behind</b> her, she is excited about all of the wonderful years <b>ahead</b> of her.</p> <p>We have moved through the summer and the heat is finally <b>behind</b> us. We can embrace the cooler autumn temperatures that are <b>ahead</b>.</p>
Precede- Follow	<p>Your achievement of a high school diploma <b>precedes</b> your achievement of a bachelor's degree. Your achievement of a bachelor's degree <b>follows</b> your achievement of a high school diploma.</p> <p>Some students work their way through the summer that <b>precedes</b> the fall semester. The fall semester <b>follows</b> summer.</p>
Before-After	<p>You were a child <b>before</b> you were an adult. You were an adult <b>after</b> you grew up from being a child.</p> <p>Children go trick-or-treating <b>before</b> they open their Christmas presents. They open their Christmas presents <b>after</b> they go trick-or-treating.</p>
Forward- Backward	<p>In the springtime, people move their clocks <b>forward</b> by an hour. In the fall, people move their clocks <b>backward</b> by an hour.</p> <p>After losing his job and girlfriend, the drug addict felt his substance abuse issues were causing his life to fall <b>backward</b>. He decided it was time to go to rehab to free himself from his addiction and move <b>forward</b> with his life.</p>

## Appendix B

Example Depth Cue Pictures and Questions	
Occlusion Depth Cue	
<p>These hot air balloons are racing. Which balloon is ahead and which is behind?</p>  <p>1 The blue/green/yellow balloon is ahead, the red is behind. 3 The red/green/yellow balloon is ahead, the blue is behind.</p>	<p>Imagine that these balls are rolling. Which ball precedes the others and which follows?</p>  <p>1 The green ball precedes, and the red follows. 3 The red ball precedes, and the green follows.</p>
Relative Size Depth Cue	
<p>Imagine that these balls are rolling in motion. Are they moving forward or backward?</p>  <p>1 The balls are moving forward. 3 The balls are moving backward.</p>	<p>These hot air balloons are racing. Which balloon precedes the others, and which follow?</p>  <p>1 The white balloon precedes the red balloon. The red balloon follows it. 3 The red balloon precedes the white balloon. The white follows it.</p>

### Atmospheric Disturbance Depth Cue

These hot air balloons are racing. Which balloon is likely to finish before the other balloons and which is going to finish after the other balloons?



- 1 Balloon K is going to finish before M. M will finish after K.  
 3 Balloon M is going to finish before K. Balloon K will finish after M.

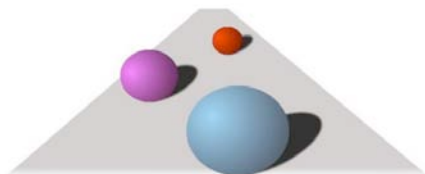
These hot air balloons are racing. Which balloon is ahead and which is behind?



- 1 The yellow is ahead, the gray is behind.  
 3 The gray is ahead, the yellow is behind.

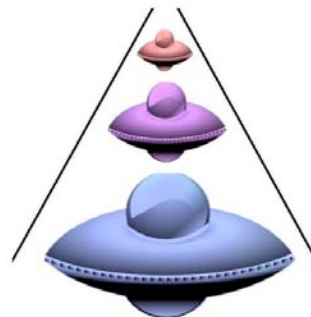
### Linear Perspective

Imagine that these balls are rolling. Which ball precedes in front of the others, and which follows the other balls?



- 1 The blue ball precedes in front of the red ball. The red ball follows the blue ball.  
 3 The red ball precedes in front of the blue ball. The blue ball follows the red ball.

These space ships are racing. Which is ahead and which is behind the other ships?



- 1 The blue is ahead, the red is behind.  
 3 The red is ahead, the blue is behind.

### Appendix C

Example Ambiguous Temporal Questions
<p>Next Wednesday's meeting has been moved <b>forward</b> two days. What day is the meeting now that it has been rescheduled?</p> <p>1 Friday (<i>ego-moving response</i>)</p> <p>3 Monday (<i>time-moving response</i>)</p>
<p>A man has made dinner reservations a month in advance for Friday the 14th. However, his date has requested that they reschedule and change the reservation for the <b>following</b> week. On which day is their new dinner reservation now scheduled?</p> <p>1 Friday the 7th (<i>time-moving response</i>)</p> <p>3 Friday the 21st (<i>ego-moving Response</i>)</p>
<p>Yesterday was three days <b>after</b> Saturday. What is day today?</p> <p>1 Wednesday (<i>ego-moving response</i>)</p> <p>3 Tuesday (<i>time-moving response</i>)</p>
<p>A family was planning to go on vacation in June. However, they decided to instead take their vacation on the <b>preceding</b> month. What month will the family now be on vacation?</p> <p>1 May (<i>time-moving response</i>)</p> <p>3 July (<i>ego-moving Response</i>)</p>

## **Appendix D**

### **Zimbardo Time Perspective Inventory**

Read each item and, as honestly as you can, answer the question:

"How characteristic or true is this of you?"

Check the appropriate box using the scale:  
1 = Very Untrue -> 3= Neutral -> 5= Very True

1. I believe that getting together with one's friends to party is one of life's important pleasures.
2. Familiar childhood sights, sounds, smells often bring back a flood of wonderful memories.
3. Fate determines much in my life.
4. I often think of what I should have done differently in my life.
5. My decisions are mostly influenced by people and things around me.
6. I believe that a person's day should be planned ahead each morning.
7. It gives me pleasure to think about my past.
8. I do things impulsively.
9. If things don't get done on time, I don't worry about it.
10. When I want to achieve something, I set goals and consider specific means for reaching those goals.
11. On balance, there is much more good to recall than bad in my past.
12. When listening to my favorite music, I often lose all track of time.
13. Meeting tomorrow's deadlines and doing other necessary work comes before



tonight's play.

14. Since whatever will be will be, it doesn't really matter what I do.

15. I enjoy stories about how things used to be in the "good old times."

16. Painful past experiences keep being replayed in my mind.

17. I try to live my life as fully as possible, one day at a time.

18. It upsets me to be late for appointments.

19. Ideally, I would live each day as if it were my last.

20. Happy memories of good times spring readily to mind.

21. I meet my obligations to friends and authorities on time.

22. I've taken my share of abuse and rejection in the past.

23. I make decisions on the spur of the moment.

24. I take each day as it is rather than try to plan it out.

25. The past has too many unpleasant memories that I prefer not to think about.

26. It is important to put excitement in my life

27. I've made mistakes in the past that I wish I could undo.

28. I feel that it's more important to enjoy what you're doing than to get work done on time.

29. I get nostalgic about my childhood.

30. Before making a decision, I weigh the costs against the benefits.

31. Taking risks keeps my life from becoming boring.

32. It is more important for me to enjoy life's journey than to focus only on the destination.

33. Things rarely work out as I expected.
34. It's hard for me to forget unpleasant images of my youth.
35. It takes joy out of the process and flow of my activities, if I have to think about goals, outcomes, and products.
36. Even when I am enjoying the present, I am drawn back to comparisons with similar past experiences.
37. You can't really plan for the future because things change so much.
38. My life path is controlled by forces I cannot influence.
39. It doesn't make sense to worry about the future, since there is nothing that I can do about it anyway.
40. I complete projects on time by making steady progress.
41. I find myself tuning out when family members talk about the way things used to be.
42. I take risks to put excitement in my life.
43. I make lists of things to do.
44. I often follow my heart more than my head.
45. I am able to resist temptations when I know that there is work to be done.
46. I find myself getting swept up in the excitement of the moment.
47. Life today is too complicated; I would prefer the simpler life of the past.
48. I prefer friends who are spontaneous rather than predictable.
49. I like family rituals and traditions that are regularly repeated.
50. I think about the bad things that have happened to me in the past.

- 51. I keep working at difficult, uninteresting tasks if they will help me get ahead.
- 52. Spending what I earn on pleasures today is better than saving for tomorrow's security.
- 53. Often luck pays off better than hard work.
- 54. I think about the good things that I have missed out on in my life.
- 55. I like my close relationships to be passionate.
- 56. There will always be time to catch up on my work.