Extending Spatial Frames of Reference to Temporal Concepts

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Abstract

Tripartite systems are currently common to several theories concerned with distinguishing different spatial frames of reference (Levinson, 1996, 2003; Levelt, 1996; Tversky, 1996). The notion that such a 3-part spatial model (e.g. intrinsic, deictic, extrinsic) can be extended to temporal models is at least theoretically plausible (Levinson, 2003). The current study reviews three basic spatial frame of reference types. Then, the results of recent empirical work investigating temporal metaphor is reviewed and applied to a theoretical temporal frame of reference model. Lastly, the concept of an extrinsic temporal frame of reference is introduced and supported by several experiments.

Introduction

Space is often divided into three frames of reference (see Levinson, 1996, 2003; Levelt, 1996; Tversky, 1996). The notion of frame of reference in the context of spatial cognition refers to the "distinctions between underlying coordinate systems" (Levinson, 2003 p. 24) people use when thinking and talking about space. In general, frame of reference models can be understood as attempts to disambiguate and refine issues raised by the many disciplines in cognitive science where perspective and figure/ground relations are important. Generally, these models divide frame types by the main reference point used to establish unambiguous relations: (a) of inherent object features or *intrinsic* relations; (b) according to viewer or ego-centered *deictic* frames; or (c) in respect to environmental or *extrinsic* reference axes.

Time is often understood in terms of space. Lakoff and Johnson (1999) have suggested that our entire system of conceptualization is built upon a limited number of *source domains* that emerge directly from experience. They argue that abstract domains of thought, whether one examines modes diverse as moral reasoning or temporal cognition, are generally understood and elaborated upon in terms of a more concrete source domain, like physical well-being or spatial cognition, respectively. Recent work in *conceptual metaphor theory* has begun to investigate the structure of mappings between concrete experiential domains, like space, and abstract concepts, like time.

According to conceptual metaphor theory, more abstract domains that lack direct perceptual support, like time, are *target domains* and understood metaphorically in terms of experientially concrete source domains, like space (see also Gentner, 1983; 2001). Metaphorical mappings are assumed to "preserve the cognitive topology (the image-schema structure) of the source domain, in a way consistent with the inherent structure of the target domain" (Lakoff 1993, p. 215). In the case of time, the source domain consists of cognitive representations of basic spatial relations that emerge through the subject's experience navigating through, observing motion in, and orienting oneself within, space. Thus the extension of spatial frame of reference models to temporal concepts might illuminate similarities in the structure of spatial and temporal cognition.

Spatial Frames of Reference[1]

Intrinsic

The intrinsic frame of reference is an "object-centered" coordinate system where directional valences are based on the inherent formal properties or features of the object that is being used to ground a scene. In English, "sidedness" is often a saliency issue generally determined by an object's function and the manner in which one acts upon it. So, the front of a chair is the side aligned with our own front when in use (Fig. 1a). The front of a television is the side we watch. And the front of a car is the end facing the direction of its motion trajectory. If an object has no inherent front or back that can be determined by physical features, motion alone can provide a front and back. In the case of a cube sliding down a hill for example, the front of the cube is regularly assumed to be the side facing downhill.

Deictic

For the purposes of the present discussion the deictic frame of reference can be understood as ego-centered or grounded in a particular "viewpoint." Deictic coordinate systems tend to be based on the reference planes derived from bodily

[1] Although terminology is a topic of some dispute in this area of research, for the present paper I have to chosen to evade excessive hand wringing on the matter. For example, "deictic" is being used although I could have chosen the term "egocentric" to define the sort of "viewer-centered" perspective described in this paper. Yet Levinson's (2003) term "relative" would have been inappropriate because his relative frame represents in some sense an attempt to reconcile ambiguities arising in 3-D space that are probably irrelevant in 1-D time. I have decided to use the term "extrinsic" because I interpret it to be a sufficiently general abstraction of the similarly conceived "allocentric" or "environment" centered frames that focus on the "ground" to establish reference. Another term that could have been used, "absolute," I thought carried too much philosophical baggage in the context of time.

axes. The human body can be divided along three major planes. These divisions provide the anchor for left/right, top/bottom and front/back coordinates. As compared to the axis that gives left/right coordinates, front/back and top/bottom axes are asymmetrical (and hence will be more amenable to extension to temporal concepts). Deictic frames of reference determine an object's location relative to these axes and frequently an individual's direction of gaze (in canonical examples) (Fig. 1b).

Extrinsic

Extrinsic frames of reference anchor coordinates to fixed bearings like cardinal directions (e.g. north/south/east/west) and environmental gradients (e.g. uphill/downhill, wind direction, gravity). Extrinsic frames are fixed, and therefore independent in respect to the intrinsic properties of objects or the perspective of the viewer or ego. Thus, in Figure 1c the ball is south of the chair regardless of the position of the observer or the inherent orientation of the chair. Extrinsic coordinates are not necessarily environmentally based. They can be culturally determined (e.g. reading direction).

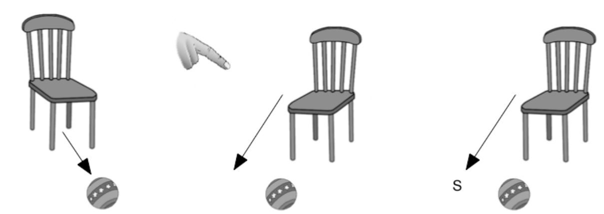

Figure 1. Spatial Frames of Reference. (a) Intrinsic: "The ball is in front of the chair." (b) Deictic: "The ball is to the right of the chair." (c) Extrinsic: "The ball is south of the chair"

Integrating Spatial and Temporal Models

Although never fully integrated into a coherent model, notions relevant to distinct intrinsic, deictic and extrinsic frames of reference have been discussed to some extent in research investigating the structure of temporal concepts. Thus far, no systematic attempt to extend a tripartite spatial frame of reference model to time has adequately described the common features of spatial frameworks and temporal concepts. Although Bender, Bernardo & Beller (2005) set out to extend a tripartite spatial frame of reference to temporal concepts, the authors failed to make the critical distinction between past/future and earlier/later relations. In the parlance of philosophy, this is the basic distinction between "A properties" of time which are in constant flux relative to our experience of change and "B properties" which represent static sequences. For example, my 50^{th} birthday may currently reside in the future relative to my place in the present, but that status will eventually change as I grow older, until this particular day comes to occupy my past on February 18, 2022. In contrast, it is understood that the storming of the Bastille (1789) occurred earlier than the Tsar's abdication (1917) and that the temporal relation between these events is fixed. This fundamental bipartite division of the time concept would seem the basic starting point for any model hoping to extend spatial perspective to time. Indeed, recent work in cognitive linguistics and conceptual metaphor theory suggests that the distinction between lexical concepts like past/future and early/later is more than "language deep" and grounded in more basic cognitive processes that derive structure from simple schemas which reflect this perspective-based division.

In the following sections I will review how this two-part division emerges from current research on temporal metaphor. I'll demonstrate how deictic and intrinsic frames can be mapped onto several preexisting temporal models emerging from this research. Then, in order to argue for the possibility of extending a tripartite spatial frame of reference model to time, I will introduce the idea of an extrinsic temporal concept and discuss new empirical evidence suggesting the "psychological reality" of an extrinsic temporal frame of reference.

Temporal Framework Models

Deictic

Researchers investigating temporal metaphors in English have traditionally focused on two distinct ego-centered metaphors, both of which can without difficulty be classified as deictic in terms of frame of reference (Clark, 1973; Lakoff & Johnson, 1999; Gentner, 2001). These two distinct schemas, the Moving-Time (MT) and Moving-Ego (ME) metaphors, both map future events in front of the observer, the present moment (or "now") as co-locational with the observer, and past events behind the observer.

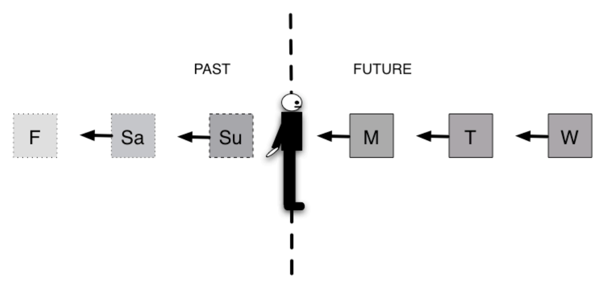

Figure 4. Deictic Temporal Framework: The Moving-Time model. Note that although the ego is used to define past/future relations, forward motion is in the direction of earlier times. Times are represented as objects in space.

In regard to spatial structure, MT and ME metaphors are figure-ground reversals of one another. With MT metaphors, the ego is stationary as future events approach from in front; in ME metaphors the ego moves forward in the direction of stationary events "located" in the future. As the ego and event come to occupy the same space, the event is conceptualized as present. When the event occupies the space behind the ego, it is in the past (Figs. 4 and 5). The difference between these mappings is apparent in sentences using spatial language for time like, "The deadline is almost here" (MT) and "We are approaching our first wedding anniversary" (ME).

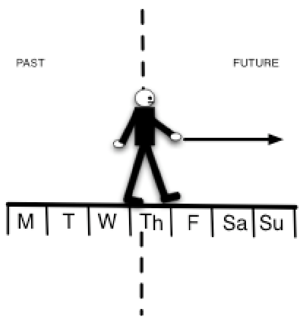

Figure 5. Deictic Temporal Framework: The Moving-Ego model. Note that although the ego is used to define past/future relations, forward motion is in the direction of later times. Times are represented as locations in space.

As part of a broad program of research, Boroditsky and her colleagues (Boroditsky, 2000; Gentner, Imai & Boroditsky 2002; Boroditsky & Ramscar, 2002) have set out to demonstrate the psychological reality of such structural metaphors. The basic finding of these studies—that actual or imagined motion through space can influence the way people think about events in time—reveals interesting relations between spatial and temporal concepts. Consider the question, "Next Wednesday's meeting has been moved forward 2 days. What day is the meeting now that it has been rescheduled?" The question is ambiguous because it can be answered either Monday or Friday depending on the temporal metaphor one uses. If a person adopts a MT metaphor, where the ego is stationary as events in the future move towards the observer, forward motion moves the meeting to an earlier time along the motion trajectory of sequenced events, in a direction towards the position of the stationary observer (leading to a Monday response). On the other hand, if one takes the perspective of a ME metaphor, forward motion is directed away from the ego, moving the meeting to a later time (leading to a Friday response). When asked the ambiguous question with no experimental manipulation Boroditsky (2000) reports that people will answer Monday or Friday with approximately equal proportions.[2] However, if participants are primed to imagine or experience motion through space in a manner concordant with the spatial structure of either the MT or ME metaphors (e.g. pulling a chair towards oneself while standing stationary vs. riding in an office chair along a straight path) then answers to the ambiguous question tend to match the primed perspective. What this suggests is that our experience of space actually influences the way we think about time. Boroditsky's studies suggest that a deictic coordinate system, based on the reference planes derived from bodily axes, can serve to structure temporal concepts.

Intrinsic

However, are the Moving-Time and Moving-Ego metaphors necessary for conceptualizing temporal relations in spatial terms? If one considers sentences like, "Wednesday follows Tuesday and Monday precedes Tuesday" it would seem not. Such expressions do not require a deictic center to establish a point of reference but rather derive sequential relations from intrinsic features. The asymmetrical, unidirectional nature of causal relations makes representing discrete events in terms of a beginning (a front) and an end (a back) quite ordinary. In spatial metaphors that structure time in terms of objects moving through space, the intrinsic fronts of events (objects in space) are defined relative to their direction of motion. Events in front of other events are earlier times and events in back of other events are later times (Fig. 6). Note that an intrinsic temporal model only maps earlier/later relations and is distinct from deictic models that can specify past, present and future temporal relations with respect to an ego.

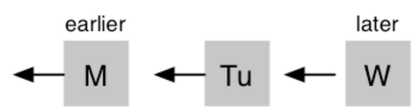

Figure 6. Intrinsic Temporal Framework. Note that forward motion is in the direction of earlier times.

In two recent papers, Núñez and his colleagues (Núñez & Sweetser, 2006; Núñez, Motz & Teuscher, in press) lucidly make a similar distinction between intrinsic and deictic temporal models, choosing to label them, *Time-Reference-Point* metaphors (*Time-RP*) and *Ego-Reference-Point* metaphors (*Ego-RP*) respectively. The major difference between the two metaphors they describe is that in Time-RP metaphors "there is no compulsory specification of 'Now' " (Núñez et al., in press).

In priming studies using an animated sequence of cubes moving across a screen horizontally (counterbalanced for direction) the authors find that spatial priming, without any reference to the ego, influenced participant's answers to the ambiguous temporal question about Wednesday's meeting. That is, after priming with moving sequences of cubes designed to highlight the intrinsic structure of non-ego referenced sequential temporal relations, participants more often moved Wednesday's meeting to Monday, an earlier time. The result is consistent with the structure of the intrinsic temporal model (see Fig. 6) where forward motion is in the direction of earlier times. The authors conclude:

[2] When asked the ambiguous question without priming, using the materials for the current study's Experiments 1-3, 46.2% of participants answered Monday and 53.8% Friday ($N = 26$).

The results of our experiments suggest that when people give a "Monday" answer to the "Next Wednesday's meeting …" question, they are not drawing the essential inferential organization from "an entity moving toward *me*," as it is usually suggested, but from the intrinsic front/back relationship of the spatial sequence itself (i.e., anteriority/posteriority). The Time-RP metaphor, in which "moving forward" is "moving earlier," thus provides a more precise and parsimonious account of "Monday" answers than the one found in the literature (Núñez et al., in press).

Extrinsic

Newton, in the *Principia Mathematica*, writes "Time, of itself, and from it's own nature, flows equably without relation to anything external" (from Evans, 2003 p.142). Perhaps, in the context of modern physics, this conceptualization of time seems rather old-fashioned. However, the notion that time itself is a backdrop, or something understood to move forward, independent of particular events embedded within it, is a very common one.[3] The extrinsic frame of reference is invoked with expressions like "across time, the effect of variable X is minimal" or "time flows on forever" where both examples involve motion yet neither requires a deictic reference point. An extrinsic temporal frame of reference can be distinguished from intrinsic temporal frames as well.

Consider a single car moving from one end (A) of a one-way street to the other end (B). When the car is at location (A) it is at an earlier time relative to its time at location (B). Location (B) can be said to be in front of location (A) relative to the path of motion taken by the car. The car brings attention to its abstracted trajectory, but the path itself, or the ground—which in an extrinsic temporal frame serves to establish relations between earlier and later events—*is* the reference object. According to this schema, time really *is* motion, where forward motion is in the direction of later times (Fig. 7). Note that this relation between forward motion and locations later in time is opposite to that in intrinsic temporal frames where forward motion is correlated with earlier times.

Like the Moving-Ego metaphor, times represented in an extrinsic frame are represented as locations in space. However, the presence of a reference object that can take the position of discrete locations along a path is not a necessary feature of an extrinsic temporal framework. As long as a path of motion is defined relative to some stable ground, extrinsic temporal models can have meaningful structure (Fig. 8).

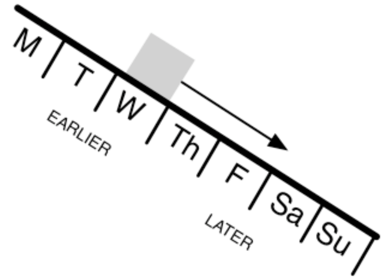

Figure 7. Extrinsic Temporal Framework. Note that forward motion is in the direction of later times.

Importantly, there is evidence that temporal 'cardinal directions' like reading direction can serve to provide extrinsic temporal structure to a spatial array (Tversky, Kugelmass & Winter, 1991; Dehaene, Bossimi & Giraux, 1993; Chan & Bergen, 2005).

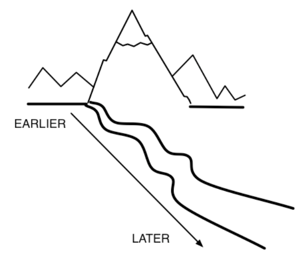

Figure 8. Extrinsic Temporal Framework. Note that forward motion is in the direction of later times.

Priming Studies

In order to examine the extent to which extrinsically framed models influence temporal thought, 3 priming experiments were conducted.

Experiment 1

In Experiment 1, participants viewed a color animation that showed a blue square moving horizontally (in either direction) over a rectangular bar spanning the display screen. The rectangular bar depicted the gray scale (Fig. 9). The animation was looped and participants were permitted to watch until they got bored. Afterwards, they were asked several questions including (1) "What color was the square?" and (2) "Which side of the floor did the square get to first: the dark side or the light side?" This was followed by the target question, "Next Wednesday's meeting has been moved forward two days. What day is the meeting now that it has been rescheduled?"

There was no reference to an ego in Experiment 1. If participants are using an extrinsic frame to answer the question about Wednesday's meeting, then the meeting should be moved to Friday, a later time. This was indeed the result. 75% of participants answered Friday (later) and

[3] Evans (2003) calls this aspect of the time concept the "matrix sense."

only 25% answered Monday (earlier), $\chi^2(1, N=16) = 4.00$, p = 0.046. There was no effect for direction.

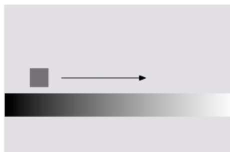

Figure 9. One box extrinsic prime. (The arrow was not present during the experiment.)

Experiment 2

For Experiment 2 a paper and pencil test was used. Participants received a 2-page survey. On the first page was a scene depicting a mountain range and river. Adopting the general method of Boroditsky & Ramscar (2002) participants were directed to follow the instructions written on the first page and then complete the question on the second page (Fig. 10). The second page contained the ambiguous question about Wednesday's meeting.

In what direction would the water flow in the picture?________
Imagine how the water would flow.
Draw a straight arrow indicating the general path of motion.

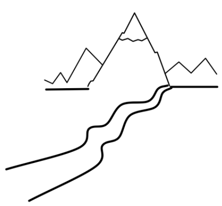

Figure 10. Mountain extrinsic prime.

As with the previous experiment, there is no reference to the ego in Experiment 2. However, this study has the added benefit of controlling for deictic explanations. Since almost all participants imagined the water moving "down" (96.4%) towards the bottom of the paper, if participants were adopting a deictic frame in order to answer the target question, the Moving-Time metaphor would be the most coherent model to adopt. *Thus we could predict alternative results for deictic and extrinsic frames.* If participants are using a deictic frame to answer the ambiguous question about Wednesday's meeting, they should provide more answers of Monday. If adopting an extrinsic frame, Friday answers should be more abundant.

Again the results were as predicted. Participants used an extrinsic frame of reference. 71% of participants answered Friday (later) and 29% answered Monday (earlier), $\chi^2(1, N=28) = 5.14$, p = 0.02.

Experiment 3

Experiment 3 uses a spatial prime intended to elicit an intrinsic temporal frame in responses to the ambiguous question (i.e. more "Monday" responses). It is very similar in design to studies discussed above (Núñez et al., in press). As in Experiment 1 of the current study, participants were permitted to watch a looped color animation depicting a simple motion scene until they became bored. In Experiment 3, five differently colored squares moved across a computer screen in either direction. The green square in the middle had a black "X" (Fig. 11).

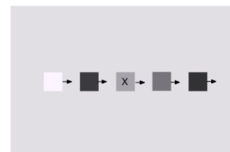

Figure 11. Five box intrinsic prime. (The arrows were not present during the experiment.)

After priming, participants answered several simple questions including, (1) "What color square was the X in?" and (2) "What color square was in the front? What color square was in the back?" These questions were followed by the target question about Wednesday's meeting.

As predicted, more participants adopted an intrinsic temporal frame after intrinsic spatial priming. 61% of participants answered Monday and 39% answered Friday $\chi^2(1, N=36) = 1.778$, p = 0.182. Although the results in Experiment 3 are not statistically significant, the direction of responding is consistent with the theoretical framework presented in this study (Fig. 12).

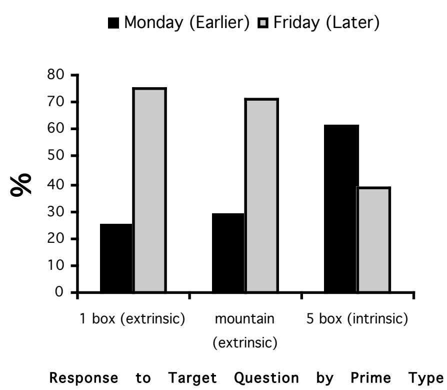

Figure 12. Responses to ambiguous target question in Experiments 1-3.

Conclusions

Whenever possible, it is best to avoid monocausal explanations. Much as the experiments reported in Núñez et al. (in press) demonstrate that "Monday" answers to the ambiguous question about Wednesday's meeting can arise from at least 2 distinct mental representations, the current study provides evidence that "Friday" answers can also be derived from a non-egocentric temporal model. And because an extrinsic temporal model makes predictions opposite to those for an intrinsic model (regarding forward motion in space and before/after relations in time) the evidence from the experiments reported here suggest a temporal model distinct from what Núñez calls "Time-Reference-Point" metaphors.

The current study also orients the results of several empirical studies within the broader context of the spatial frame of reference literature. If a coherent relation exists between spatial and temporal frames of reference, then empirically testable predictions can be made about the degree to which shared reference frames interact.

For example, if spatial and temporal frames are structurally related, would priming a more general spatial frame of reference engage a corresponding temporal frame of reference? (Would looking in a mirror prime a deictic temporal frame; reading a compass, an extrinsic temporal frame?) It may also be possible to predict the particular sense a temporal concept will take, across languages, by examining the orientation of the spatial axis used to provide structure. That is, one would expect past/future relations, where ego-reference is an experiential and conceptual requirement for grounding, to be more often structured along the asymmetric, deictic front/back axis, where ego-motion along a horizontal plane is canonical. However, across languages, the past/future concept is less likely to be mapped along an extrinsic vertical axis, where earlier/later relations could more regularly find grounding in a natural environmental slope gradient, like that provided by gravity.

Although past research in this area has clearly demonstrated that structural relations between spatial and temporal conceptualization exist, most of this work has described space—time relations in terms of asymmetrical metaphorical mappings from a concrete source domain (space) to an abstract target domain (time). If spatial and temporal frames of reference are tightly connected, the notion that a strict asymmetry exists between source and target domains, a principle of sorts in conceptual metaphor theory, is in need of further examination. The framework presented here suggests that, in the case of space and time, both domains share something more fundamental in common; namely the constraints imposed by a more dynamically represented spatiotemporal coordinate system.

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