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Prescribed spatial prepositions influence how we think about time

Alexander Kranjec, Eileen R. Cardillo, Gwenda L. Schmidt, and Anjan Chatterjee

Neurology Department and the Center for Cognitive Neuroscience, University of Pennsylvania

Abstract

Prepositions combine with nouns flexibly when describing concrete locative relations (e.g. *at/on/in* the school) but are rigidly prescribed when paired with abstract concepts (e.g. *at risk; on* Wednesday; *in* trouble). In the former case they do linguistic work based on their discrete semantic qualities, and in the latter they appear to serve a primarily grammatical function. We used the abstract concept of *time* as a test case to see if specific grammatically prescribed prepositions retain semantic content. Using ambiguous questions designed to interrogate one's meaningful representation of temporal relations, we found that the semantics of prescribed prepositions modulate how we think about time. Although, prescribed preposition use is unlikely to be based on a core representational organization shared between space and time, results demonstrate that the semantics of particular locative prepositions do constrain how we think about paired temporal concepts.

Keywords

Prepositions; Semantics and Grammar; Space and Time; Language and Thought

1. Introduction

1.1. Prescribed prepositions: Grammatical or meaningful?

Do patterns of obligatory preposition use reflect grammatical conventions or semantic relations? And if these prescribed spatial prepositions retain their semantics, do they influence thought in more abstract domains? Of course, prepositions *do* have meanings. Locative prepositions describe general categories of spatial relations (Bowerman, 1996; Pinker, 2008; Talmy, 2000). English schematizes, or “carves up,” space in particular ways using the prepositions *at*, *on*, and *in*. *At* describes a zero-dimensional point in space referring to a particular *location*; *on* describes a contact and support relation between an object and a two-dimensional *surface*; and *in* describes a containment relation between an object and a three-dimensional *volume*. (Figure 1A.)

If describing the location of a box in relation to a landmark, one might make statements such as those in Figure 1B. Each preposition in this example conveys distinct information about the location of the box. The schema implied by each preposition supports imagery about the spatial relations between the box and the other objects in the scene.

Corresponding author and present address: Alexander Kranjec, Department of Neurology, University of Pennsylvania, 3 West Gates Building, 3400 Spruce St., Philadelphia, PA. 19104, USA, phone: 001 215 614 0177, fax: 001 215 349 8260.

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Prepositions describe spatial relations flexibly. They can describe both (1) the same spatial relations among different kinds of things and (2) different kinds of spatial relations among the same things. So, combinations of prepositions and concrete nouns are relatively unrestricted; a box can be *in* a school but ants can also be *in* a box and, depending on its actual location, a box can be *at* or *on* or *in* the school.

However, often it is less clear that the particular spatial meaning of a preposition is doing *any* semantic work. See Figure 1C. In many cases preposition choice seems both arbitrary and prescribed. Because prepositions can have meaning, the kind of prescribed preposition use in Figure 1C suggests the end-product of *grammaticalization*. Grammaticalization is a process of conventionalization where, over time, words lose semantic content and take on grammatical characteristics (see Hopper & Traugott, 2003). In some contexts, prepositions can come to be thoroughly bleached of their meaning (Heine, 1993). For instance, if we are told that “a particular grant is *at* risk, the lab should be *on* alert, although our specific project is not *in* trouble,” prepositions serve a functional, grammatical role; the discrete spatial schema denoted by a particular preposition would seem uninvolved in the representation of each construction. And unlike combinations of prepositions and concrete nouns, combinations of prepositions and abstract nouns like those in Figure 1C are entirely restricted, or prescribed. That is, one cannot say the project is *at* or *on* trouble. Superficially arbitrary, but prescribed preposition use suggests that prepositions in these constructions serve a grammatical function (Lehmann, 1982). When a preposition has lost its meaning altogether, its function seems to be determined solely by the conventions of a particular language's grammar.

Another view argues that prescribed preposition choice represents semantic refinement, rather than meaning loss incurred over the process of grammaticalization (Brugman & Lakoff, 1988; Matisoff, 1991; Lakoff & Johnson, 1999). Matisoff (1993) depicts grammaticalization as “the partial effacement of a morpheme's semantic features, the stripping away of some of its precise content so it can be used in an abstracter, grammatical-hardware-like way” and even goes so far as to call it “a subtype of metaphor” (p. 384). For these linguists, prescribed pairs like those in Figure 1C might reflect a metaphorical relation between a preposition and an abstract concept (Brugman & Lakoff, 1988) or at least a principled semantic relation between similar “lexical concepts” (Tyler & Evans, 1993; Evans, in press). Lakoff & Johnson (1999) argue that we conceptualize psychological “STATES as LOCATIONS” using spatial prepositions to organize our knowledge about them in a way that makes thinking about things we cannot directly see or touch possible. Evans (in press) extends this idea, claiming that the particular semantics denoted by the prepositions *at*, *on*, and *in* relate to particular psychological states. He organizes these relations into a vast typology where the relations between *in* and *trouble*, or *at* and *risk*, for example, are based on semantic characteristics shared by a preposition and its paired abstract concept. For Evans, experiencing trouble is like being “enclosed,” whereas experiencing risk is like being “collocated” with an external threat. The details of these models are not important for our investigation. From this general perspective we can generate the hypothesis that prescribed prepositions provide a window into the semantics relating two lexical items, rather than merely highlighting a grammatical rule linking them together.

At present, no experimental work directly assesses the validity of these two perspectives. One view sees prescribed prepositions as lacking semantic content while serving an arbitrary grammatical role. The other sees prescribed prepositions as meaningful units that have come to be paired with related abstract concepts. We used a specific abstract concept—*time*—to test the value of each perspective.

1.2. Time as a Model System

Across languages, prescribed prepositions are used to talk about time (Haspelmath, 1997). See Figure 1D. We say, *at* that second, *on* Thursday, *in* the month of October, but not *on* 3pm, *in* Thanksgiving, *at* November. Such inflexibility in preposition use suggests an end-product of grammaticalisation. But unlike the examples in Figure 1C, for *time* a certain logic is suggested by English usage patterns; we tend to talk about small temporal units (moments or clock times) with *at*, intermediate units (days) with *on*, and the largest ones (months, seasons, years, decades, etc.) with *in*. Noting these patterns, Wierzbicka (1993) suggests that locative preposition usage across different temporal phrases is determined by semantics, reflecting a common spatiotemporal conceptual organization—not merely a set of idiosyncratic grammatical rules.

We wished to learn if prescribed prepositions retain some meaning despite their apparent grammatical function. That is, does the use of a particular spatial preposition meaningfully influence thinking about time? If a meaningful relation between prescribed preposition and time unit pairs is present, it could exist in one of two versions (see Boroditsky, 2000; Kemmerer, 2005). The *strong version* states that a fundamental overlap exists between the domains of space and time, where pairings between prepositions with particular spatial semantics (e.g. 3D containment) and abstract concepts (e.g. large temporal unit) reflect obligatory relations. This version suggests that the schematic spatial representations suggested by different prepositions are *necessary* for thinking about time (Lakoff & Johnson, 1999). The *weak version* suggests that the spatial meaning of a particular preposition might not be necessary for providing structure, but nevertheless influences how we think about associated abstract concepts.

Space-Time relations provide an ideal test bed for exploring these issues. Casasanto (2009) argues that *time is a model system* for testing relations between language and thought. Space-time relations are sensitive to experimental manipulation and provide some of the strongest behavioral evidence for interactions between language and thought (Boroditsky, 2000; Boroditsky & Ramscar 2002; Casasanto & Boroditsky, 2007; Gentner, Imai & Boroditsky, 2002; Matlock, Ramscar & Boroditsky, 2005; McGlone & Harding 1998; Nunez & Sweetser, 2006; Torralbo, Santiago, & Lupiáñez 2006).

In order to determine if spatial prepositions with prescribed grammatical relations to particular abstract concepts influence thought, we used ambiguous questions designed to probe one's meaningful representation of temporal relations.

2. Methods

2.1. Stimuli

The ambiguous query, “Next Wednesday's meeting has been moved forward two days. What day is the meeting now that it has been rescheduled?” has been used previously to investigate how spatial structure influences thinking about time. Generally, English speakers respond to this question with “Monday” and “Friday” in approximately equal proportions. The answer to the question about Wednesday's meeting is ambiguous because one's answer depends on how the word *forward* is interpreted. Forward movement can be interpreted either as movement towards earlier (Monday) or later (Friday) times depending on the mental frame of reference one adopts when answering (Boroditsky, 2000; Boroditsky & Ramscar, 2002; Matlock, Ramscar & Boroditsky, 2005; McGlone & Harding, 1998; Núñez, Motz & Teuscher, 2006).

To see if spatial prepositions influence the way people think about time, we designed six stimulus sentences based on the original ambiguous question. (See Table 1.) Each question served as a complete, self-contained trial for a single participant. There were two sentence types: (1) a *Preposition* condition (Prep) where three ambiguous questions using three distinct scales of temporal units (*hour*, *day*, and *month*) each included the appropriately paired spatial

preposition (*at*, *on*, and *in* respectively) and (2) a *No Preposition* (NoPrep) condition consisting of analogous questions using the same three temporal scales, but without prescribed prepositions.

Whether the scale of a time unit alone would influence the proportion of earlier and later answers was not known. Because the original question used a day scale and is itself premised on disambiguating the precise spatial meaning of *forward*, we thought it possible that inherent differences in how we represent different time scales spatially could influence how participants answered the question, even in the NoPrep condition.

2.2. Predictions

With our six questions, we anticipated three possible effects of prescribed prepositions.

2.2.1. Association: Prep = NoPrep—The first possibility is that the spatial structure of a particular preposition has no meaningful relation to its associated temporal concept. If the semantic relation between a particular preposition and its associated temporal concept merely reflects a rule-like convention, then we would expect to see an equal proportion of earlier and later responses made within the same time unit across both Prep and NoPrep conditions. In the most straightforward null result, proportions of earlier and later responses would approximate 50/50 across Prep and NoPrep in all three temporal unit conditions. However, we could also observe distinct trends across different temporal units with no significant differences between Prep and NoPrep conditions (e.g., more earlier responses for MONTH questions and more later responses for DAY questions in both Prep and NoPrep conditions). Both outcomes would suggest that prescribed prepositions are not conveying meaning when we think about time, but simply associate with biases inherent in the scale of the temporal unit under consideration.

2.2.2. Amplification: Prep > NoPrep—Spatial and temporal concepts could share a common representational organization. Furthermore, spatial representations may be *necessary* for thinking about time (Lakoff & Johnson, 1999). If particular conventionalized pairings reflect a core ontological and psychological relation between spatial and temporal domains, proportions of earlier and later responses within a time scale should trend in the same direction across Prep and NoPrep conditions [similar to the second prediction in Section 2.2.1] but with response biases in the NoPrep condition being *amplified* in the Prep condition. Such amplification would occur because the refined semantics provided by a preposition's spatial schema should highlight the core structure shared between it and a homologous temporal concept.

2.2.3. Modulation: Prep ≠ NoPrep—Finally, the way we think about time in terms of space could be *ad hoc* and flexible. Although spatial meanings may be useful for thinking about time, the fundamental semantic representations underlying spatial and temporal concepts may be structurally independent (Boroditsky, 2000; 2001; Boroditsky & Ramscar, 2002; Kemmerer, 2005). If the pairing of particular prepositions with particular temporal concepts does not reflect a core correspondence between spatial and temporal meanings, but the spatial meaning of a preposition modulates how we think about its corresponding temporal concept, we should see different response patterns across Prep and NoPrep conditions. These directional differences would not be predicted by directional response biases produced by different temporal units in the NoPrep condition.

2.3. Participants & Procedure

183 native English-speakers from the University of Pennsylvania community participated. The 58 male and 125 female participants had a mean age of 23.3 years. All participants gave informed consent in accordance with the institutional review board guidelines.

One of the six possible questions was randomly assigned to each participant. Each read their single question before or after participating in unrelated behavioral studies. Answers were written in a designated blank space below the question. Three participants made incorrect responses (e.g. moved the meeting more or less than two temporal units) so their data was discarded. We thus included data from 180 participants with 30 unique participants responding to each sentence.

3. Results

Results and analyses are summarized in Figure 2.

Overall, particular prepositions (*at* and *in*) biased participants to move the meeting in opposite directions (earlier or later, respectively). The dimensional characteristics of different prepositions appear to bias thinking about time. That is, the effects were not just a matter of space biasing time more generally. It is also unclear how grammatical or pragmatic differences *per se* could lead participants to interpret these sentences in such qualitatively different ways. In respect to our predictions in Section 2.2, the pattern of results suggest that spatial prepositions are *modulating* temporal thought.

4. Discussion

We found strong evidence that prescribed prepositions retain semantic content and modulate how we think about time. However, we found no compelling evidence that the pairing of time units with particular prepositions reflects an ontologically deep or psychologically obligatory relation between spatial and temporal representations. Our result is sensible given that variation occurs in these pairings across different languages. Furthermore, if a fundamental schematic structure shared between spatial and temporal uses of prepositions was necessary for thinking about time, then the effects should have been amplified in the Prep condition, which they were not.

Results are consistent with the *weak version* of the proposed relation between spatial and temporal representation discussed in Section 1.2. stating that (1) spatial and temporal representations are distinct, (2) spatial schemas are not necessary for, but (3) can influence temporal thought. On these assumptions, spatial schemas (i.e. timelines) evoked by particular prepositions could have modulated thinking about time in one of two ways. First, the increasing dimensional complexity of the prepositions *at*, *on* and *in* from zero dimensions to three could have increased the ambiguity of the timeline. Alternatively, particular prepositions could have served to disambiguate the question and bias the direction of movement. Each possibility is discussed below.

Prescribed prepositions could retain meaning and influence thought, but still serve to increase the ambiguity of the sentence probes. Because timelines are generally represented as one-dimensional and unidirectional, linear motion could have become less constrained as particular prepositions evoked increasing levels of spatial dimensionality. So while the zero-dimensional preposition *at* specifies a point on a timeline, the three-dimensional preposition *in* creates a volume with two additional spatial axes. If movement is less constrained, responses could become more variable. This variability would have resulted in closer to equal proportions of earlier and later responses with increasing dimensional complexity in the Prep condition. Clearly, this pattern of results was not observed.

Rather, the differential dimensional complexity of *at*, *on* and *in* appears to have decreased ambiguity in a specific manner. We propose that the zero-dimensional preposition *at* biased thought towards small points of time; two-dimensional *on*, intermediate lengths of time; and three-dimensional *in*, large volumes of time. On a timeline, a position closer to the beginning

represents a smaller extension of time, while a position closer to the end represents a larger one. (E.g., compared to Monday, *more* of the week has elapsed by Friday.) These beginning and end locations also represent earlier and later times, respectively. If spatial language encourages participants to invoke a timeline extending from smaller (and earlier) times to larger (and later) times, then prepositions of varying dimensional complexity might bias participants' towards the corresponding segment of this mental representation (see Schwarz & Eiselt, 2009). Questions containing the zero-dimensional preposition *at* should result in a greater number of earlier responses, and questions with the three-dimensional preposition *in* should result in a greater number of later responses. Questions with the two-dimensional preposition *on* should produce an intermediate pattern of results. Moreover, whereas the one dimensional *at* specifies the starting point of an event (i.e. the meeting), the multidimensional *on* and *in* bias the representation of an event in its entirety (as a *figure* object) in respect to a relatively larger extension of time (as the *ground*). When biased towards the starting point of a timeline with *at*, one may be more likely to continue movement in the direction of earlier times. When one is biased to represent the entirety of an event in respect to a larger expanding timeline with *on* and *in*, one may be more likely to move that event in the direction of later times. Thus, if prepositions serve to disambiguate temporal relations in general, 2D *on* sentences should behave more like 3D *in* sentences compared to 0D *at* sentences.

The difference scores plotted in Figure 3 illustrate the value of this interpretation; a preposition's level of dimensional complexity served to disambiguate the stimulus questions in a manner consistent with the structure of a mental timeline extending from smaller (and earlier) times to larger (and later) times. Dimensional complexity predicted both the strength and direction of bias in the three forms of Prep condition sentences.

5. Conclusion

Although we make no claims about other domains of thought, our observations regarding links between space and time as mediated by locative prepositions suggest the possibility that semantic relations could exist between prescribed prepositions and other classes of abstract concepts. Probing the specific nature of such potential relations, and the rules governing their use, provides rich territory for future research.

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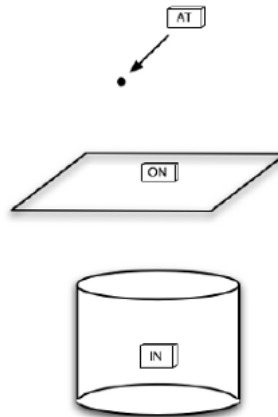
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A. Spatial-dimensional characteristics and schematic representations

At: location (0D point)

On: contact/support (2D surface)

In: containment (3D volume)



B. Concrete uses

At the entrance

On the floor

In the school

C. Abstract uses

At risk

On alert

In trouble

D. Temporal uses

At noon.

On Wednesday

In June

Figure 1. At, On and In

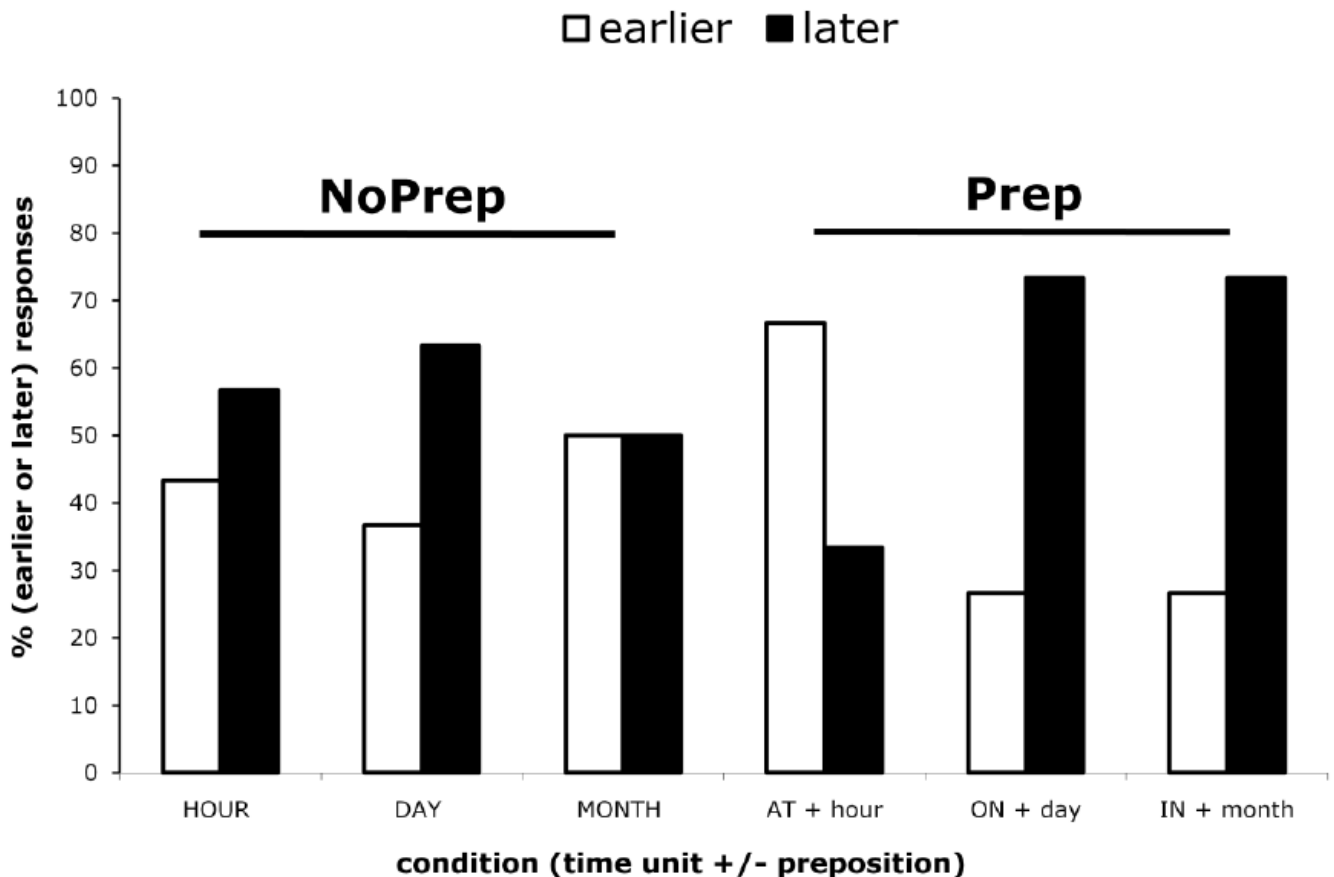


Figure 2. Proportions of earlier and later responses to the ambiguous meeting question for all conditions

In the **NoPrep** condition, proportions of earlier and later responses were not significantly different than the 50/50 model predicted by chance for all time scales [HOUR, $\chi^2(1, N=60) = 0.53$, $p = 0.47$; DAY, $\chi^2(1, N=60) = 2.13$, $p = 0.14$; MONTH, $\chi^2(1, N=60) = 0.00$, $p = 1.00$] nor were they significantly different from one another. That is, differences in the time scale alone did not produce significant directional biases in how participants answered these ambiguous questions. In the **Prep** condition, all proportions of earlier and later responding were significantly or marginally different from the 50/50 model predicted by chance, [AT + hour, $\chi^2(1, N=60) = 3.33$, $p = 0.07$; ON + day, $\chi^2(1, N=60) = 6.53$, $p = 0.01$; IN + month, $\chi^2(1, N=60) = 6.53$, $p = 0.01$] suggesting that spatial prepositions do influence how we think about time. More critically, proportions of responding for the same time scale across Prep and NoPrep conditions varied, providing the most direct evidence implicating prepositions for the biases we observed [AT + hour vs. HOUR, $\chi^2(1, N=60) = 6.65$, $p = 0.01$; IN + month vs. MONTH, $\chi^2(1, N=60) = 6.53$, $p = 0.01$]. The difference between DAY and ON + day was not significant. However, because of the significantly high proportion of later responses in the Prep (ON + day) condition and the nonsignificant result in the NoPrep (DAY) condition, there may be an effect here as well, but one that is difficult to detect because of a small (but nonsignificant) “later bias” observed in the NoPrep sentences.

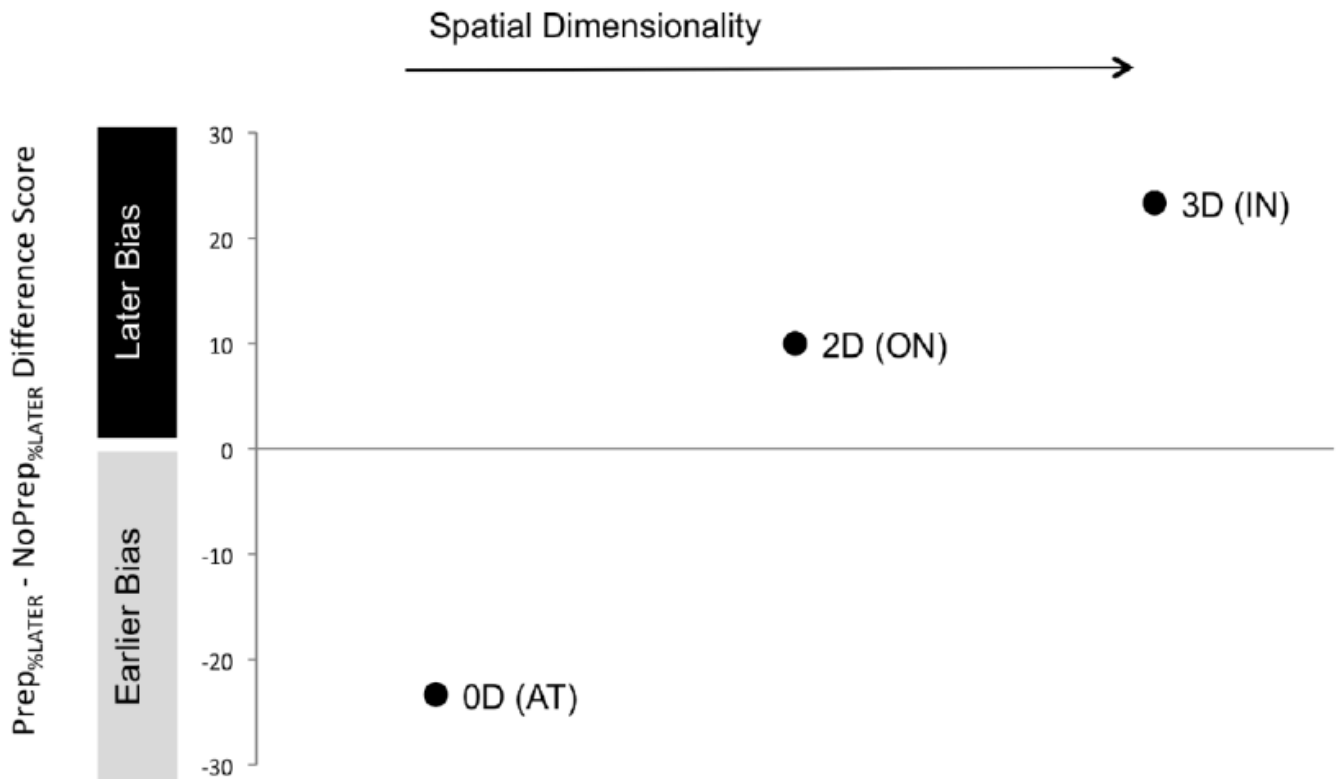


Figure 3. Difference scores at each time scale

Scores were calculated by subtracting the percentage of later responses in the NoPrep condition from the percentage of later responses in the Prep condition ($\text{Prep}_{\%LATER} - \text{NoPrep}_{\%LATER}$). Negative scores indicate a bias towards earlier responses to the ambiguous question as a result of preposition inclusion; positive scores indicate a bias towards later responses. The effects for 0D *at* and 3D *on* sentences were equal and opposite while the effect for 2D *on* sentences was intermediate.

Table 1**Stimuli****Preposition (Prep)**

The meeting **at** noon has been moved forward 2 hours. **At** what hour is the meeting now that it has been rescheduled?

The meeting **on** Wednesday has been moved forward 2 days. **On** what day is the meeting now that it has been rescheduled?

The meeting **in** June has been moved forward 2 months. **In** what month is the meeting now that it has been rescheduled?

No preposition (NoPrep)

The noon meeting has been moved forward 2 hours. What hour is the meeting now that it has been rescheduled?

The Wednesday meeting has been moved forward 2 days. What day is the meeting now that it has been rescheduled?

The June meeting has been moved forward 2 months. What month is the meeting now that it has been rescheduled?