Manipulating Space-Time Mapping

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Abstract

Though it is already understood that humans conceptualize the abstract domain of time in more concrete spatial terms in discourse, gesture, and general cognition, variations in the ways people do this in different cultures suggest a strong learned component. The specific metaphorical mapping of time onto space tends to be very consistent within a culture, but can vary from culture to culture. This study investigates the possible flexibility of these mappings as well as the human potential to recruit new mappings for novel tasks. The findings suggest that people can be primed to change their mapping and spontaneously recruit the new mapping for a separate task, lending support to the idea that the mappings we create to deal with time are culturally influenced, and not likely to be innate constructs.

Keywords: Time; Space; Metaphor; Mapping; Embodied Cognition

Article Outline

1. Introduction

It is well established in cognitive research that people use spatial metaphors in understanding and reasoning about time (Clark 1973). Time is an abstract domain, and as such we do not perceive it directly (Evans 2003). We cannot see, touch, smell, or taste time. Humans resolve the abstract nature of time via metaphor. Specifically, we conceptualize time in spatial terms. We *metaphorically map* the abstract domain of time onto the more concrete domain of space. These mappings tend to be very stable within a culture, but they do vary across cultures. This invites a number of important questions. *Are these mappings flexible? Do they develop in early childhood, and then remain essentially unchanged? Or are they potentially plastic?*

[Note: For the purposes of the proposed study, it is important to make a distinction between deictic time and sequential (non-deictic) time. Briefly, deictic time requires contextual information or a fixed reference point to understand. For example, *yesterday* is not the same day today as it was five years ago. Understanding yesterday requires knowledge of now. Sequential time is fixed. A specific historical date, for example, is the same date regardless of when you are talking about it. I make this distinction to point out that this study concerns itself exclusively with metaphorical mappings of sequential time.]

Because spatial mappings of sequential time do vary across, but not typically within, cultures, we can infer a strong cultural component. It seems clear that these mappings are at least strongly influenced by culture, and possibly the written language of a culture.

For example, Native English speakers tend to map sequential time in a more or less linear fashion along a horizontal axis, with earlier events to the left of later events. In other words, they employ a *left-to-right* mapping (Tversky et al. 1991). This is consistent with the written English language.

By contrast, research by Boroditsky has indicated that some groups of native Mandarin Chinese speakers (who employ a vertical top to bottom system of written language) map time along a vertical axis corresponding to their language (2001, 2007). Studies such as these suggest that there is no universal canonical way to achieve a sequential mapping, and in demonstrating its flexibility in development, suggest that it may be susceptible to other external manipulation, such as experimental manipulation.

Preliminary findings in three recent studies further suggest the potential manipulability of this mapping (Boroditsky 2007, Casasanto 2005, Cooperrider 2007), but these findings were not the focus of their respective studies and were not pursued. The findings suggest that participants who are raised with a particular mapping, but are forced to complete tasks requiring an alternate mapping, might temporarily recruit this alternate mapping in subsequent unrelated discourse about linear temporal events.

In this study, we present evidence that, at least in Native English speakers, the spatial mapping of sequential time is flexible, and that people exposed to alternate mappings can be primed to recruit these mappings for other tasks.

2. Experiment

The basic model for the experiment was a standard independent variable-dependent measure design. Participants were given one of two priming stimuli (timelines) designed to test the flexibility of their mapping. The flexibility was measured afterward using a card sorting task (dependent measure). A short trial was run before the experimental conditions to establish the validity of the dependent measure.

2.1 Methods

2.1.1 Participants

Fifty participants performed three conditions of the experiment.[i] All participants were UCSD undergraduates. All were native English speakers according to a language background questionnaire. All gave informed consent and received participation credit through the website Experimetrix. Twenty participants performed experimental condition #1, twenty performed experimental condition #2, and ten were used in the preliminary assessment of the dependent measure task.

2.1.2 Materials

Two timelines graphically depicting an abridged history of the universe, identical except for the orientation of the information on the timeline, were used. Timeline A

(Figure 1) presented the information in a traditional left-to-right orientation, with the birth of the universe at the far left and present day at the far right. Timeline B (Figure 2) presented the same dates, imagery, and internal metric, but in a right-to-left orientation.

Figure 1. Timeline A.

Figure 2. Timeline B.

Eight card sets depicting a unique temporal sequence were used. Each card set was made up of four cards which, placed in order, depict a linear, non-reversible temporal event. The card sets were as follows:

- *Beard*—Images of a man growing a beard. (Figure 3)
- *Banana*—Images of a banana being peeled and eaten.
- *Plant*—Images of a plant sprouting and growing.
- *Fire*—Images of a fire starting and burning. (Figure 4)
- *Decay*—Images of a banana in successive stages of decomposition.
- *Fungus*—Images of a mushroom growing.
- *Dirt*—Images of a person pouring dirt from their hands.
- *Jar*—Images of a jar being emptied of water.

Figure 3. Beard card set.

Figure 4. Fire card set.

Each card set had a clear, correct order, with little room for misinterpretation. The cards were all unlabeled, the names above being how the experimenter refers to each set.

A hi-definition video camera was used to record each experimental session. Data from each session was recorded on a data collection sheet.

2.1.3 Procedure

Prior to each participant session, the eight card sets were randomized using the online random number generator random.org. The cards within each set were randomized in the same fashion.

In the *Card Sort Assessment Task (CSAT)*, each of the ten subjects mentioned above was asked to sit at a table. They were then handed the first of the eight card sets and instructed to place the cards in order on the table in front of them. No further instructions were given. When they had completed the task, the first set was removed, and they were given the next card set, and instructed the same as with the first card set. Each subject ordered all eight sets.

In *Experimental Condition #1 (EC1)*, participants were instructed to sit at the table, facing the camera. They were then handed Timeline A, and asked to study it. After two minutes, they were instructed to stop. The experimenter turned the timeline over so that the images could not be seen. The participants were then instructed to recall and explain, using as much detail as they could remember, the history of the universe as illustrated by the timeline.

When they had finished, the timeline was restored so that they could see it again. They were then asked two arithmetic questions based on the data given in the timeline. The timeline was still visible; they were not asked to do this from memory.

Finally, they were instructed to create their own timeline. They were required to come up with at least four major milestones, and position them appropriately according to the metric of the given timeline.

After this, they were told they could take a short break before proceeding with the next part of the experiment. When the experiment resumed, the participants were instructed to sort the eight card sets, one at a time, in exactly the same manner as the CSAT group.

Experimental Condition #2 (EC2) was identical to EC1 in every way except that the participants were given Timeline B in the first stage instead of Timeline A.

All participants were debriefed and given handedness questionnaires following the conclusion of the experiment.

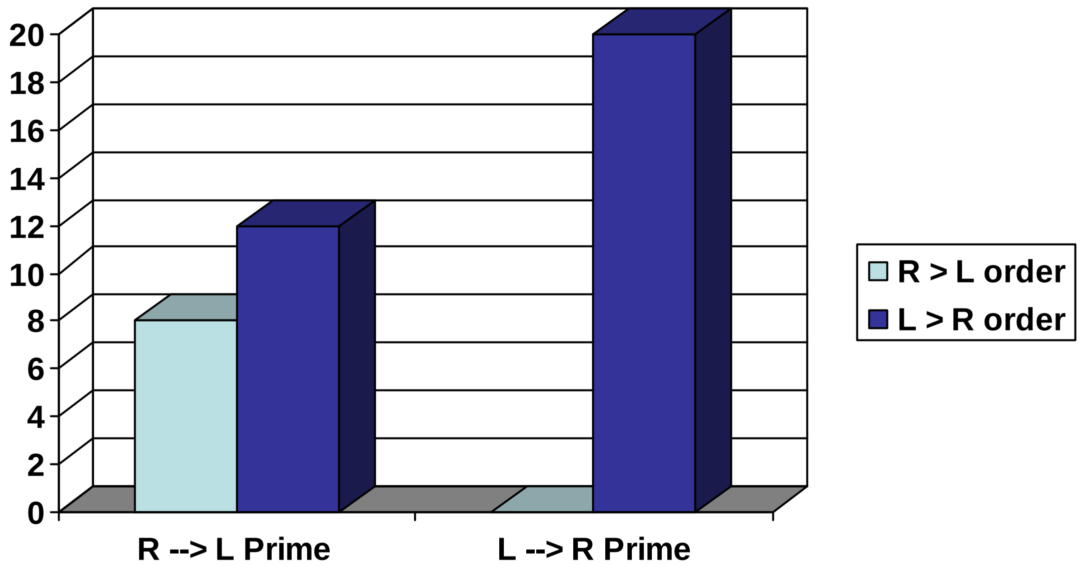
3. Results

The results for all conditions were measured by a simple count of whether a participant sorted more card sets left to right or right to left. In nearly all cases, across all conditions, this was essentially binary (that is, participants did not sort some sets one way, then switch and sort them another way).

The CSAT pre-condition only existed to verify that the dependent measure task was simple and reliable. All ten participants in the CSAT condition sorted the card sets left to right, with very few errors. Only three participants made any errors at all. No participant made errors on more than two sets, and no set was sorted incorrectly by more than two participants.

In EC1, all twenty participants sorted more card sets left to right. In EC2, twelve of the twenty participants sorted more card sets left to right. Eight participants sorted more sets right to left. These results were subjected to Fisher's Exact Test for statistical significance.

The results are significant ($p < 0.001638$), and are shown in the graph below.



p-value: 0.0016

No significant handedness or gender effects were observed.

4. Discussion/Conclusions

The reason for hiding the timeline for the first question of the priming stage (where the participants were required to explain the timeline) was that it was important that the participants mentally reconstructed the timeline, rather than simply referring to it. The point was to force the participants to heavily engage the space in a cognitive fashion. It is also interesting to note that participants in EC2, when gesturing during this recall session, frequently exhibited right-to-left gestures when trying to remember something. By engaging with the space physically, it is likely that they re-enforced the prime in their minds.

The arithmetic questions served the purpose of requiring the participants to engage the space in a different cognitive activity. The timeline was restored because we assumed we could not reasonably expect every participant to remember all of the dates listed in the timeline as well as the image each date corresponded to.

The final task in the priming phase, wherein the participants were required to "create their own timeline," was intended to further immerse the participants in the space of the timeline by requiring them to produce novel milestones and fit them into the metric and chronology of the given timeline.

Nearly all participants in EC2 were able to comprehend the timeline and complete the priming tasks. This in itself exhibits flexibility, but is hardly surprising or worthy of report. Perhaps more surprising and definitely more noteworthy was their performance on the dependent measure (card sort) task.

As we might expect, all EC1 participants employed the typical left-to-right mapping when sorting the cards. However, eight of the twenty EC2 participants, or forty percent, spontaneously recruited the new right-to-left mapping for the card sort task. It would appear, based on these results, that the default time-space mapping is indeed flexible. Furthermore, it would appear that at least some people are open to spontaneously recruiting new mappings for unrelated novel tasks. This suggests that humans do not simply encode their conceptualizations of time at an early age and then never alter them. It re-affirms the conclusion that humans are constantly learning, developing, and adapting to new challenges and ideas.

There is one other item that should be addressed. This was a very limited study with a short, simple prime. Yet despite this, forty percent of those primed in EC2 spontaneously abandoned the mapping they had presumably been using their whole lives in favor of this new mapping to complete the dependent measure task. Though I sincerely doubt this effect lasted much longer than their stay in our laboratory, it raises the intriguing question of just how strong we could make this effect with stronger primes.

5. Future Directions

There are several places to go from here. In future studies with more time and resources, we can vary the strength of the prime and investigate its relationship to the strength of the effect. We can also measure the durability of the effect and investigate its half-life.

As noted earlier, this study limited its focus to manipulating mappings of sequential time. So, we could try to apply these methods to a similar study on deictic time. For example, the Aymara in Chile have exhibited a deictic mapping of time essentially opposite to the mapping employed by native English speakers (Núñez and Sweetser 2006). Very briefly, they have been shown to map the future behind their bodies and the past in front of them. Could we prime participants to recruit this mapping when reasoning about deictic time?

We can investigate how this flexibility can change over the course of human development to gain greater insight into how and when these mappings emerge. Finally, we can look at other cultures, with other default mappings (such as Boroditsky's Mandarin speakers), and determine if the extent of their flexibility is similar.

This is still a largely untapped area of research. There are almost certainly many more ways we can investigate this kind of flexibility in humans, and as we continue to learn more about how humans develop and employ metaphor, we contribute not only to our own discipline, but also to a wide range of other human disciplines such as psychology, philosophy, and neuroscience.

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[i] Three participants who arrived for the experiment were excluded and are not counted in this number for the following reasons. One participant could not, after repeated attempts to explain, understand the instructions well enough to complete the task. One participant left early in the first stage of the task, which she claimed was due to anxiety over having left her backpack in another building. She declined my invitation to reschedule. One participant was excluded due to my strong subjective impression that he was under the influence of cannabis.

No participant was excluded on the grounds that they misinterpreted the timeline or performed any task "incorrectly." Such participants were considered to represent normal variation, and their results are reflected in the data.