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The implicit and explicit embodiment of time

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ABSTRACT

The present research concerns the idea of an "embodied concept" and asks whether a concept as such is fundamentally grounded in implicit sensorimotor representations or is better understood as the product of explicit analytic processes. Our investigation focuses on the relation between spatial and temporal concepts. Systematic constraints and patterns found in space (e.g. the physical environment, the mechanical properties of our bodies and the organization of our perceptual systems) seem to influence how we gesture, talk, and think about temporal relations. A novel method designed to explore how different spatial reference frames ground distinct temporal concepts was used in which participants guessed the spatial locations of picture tiles in one of two boxes. The task was designed to resemble a parapsychology demonstration. Unknown to participants, the tiles depicted either PAST/FUTURE or EARLIER/LATER temporal relations. Results demonstrate that responses were assisted by the relative spatial locations of the boxes in a manner concordant with the structure of a particular temporal concept and suggest that implicit processes act on representations accessible to explicit analysis. Participants became aware of temporal structure when stimuli were placed *in front* and *behind* (Experiment 1) but not when placed to the *left* and *right* (Experiment 2). Furthermore, participants responded systematically to PAST/FUTURE but not EARLIER/LATER stimulus items.
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1. Introduction

1.1. Embodied concepts and the grounding problem

How are the meanings of words linked to each other and the outside world? One method for investigating the *grounding problem* might involve choosing an abstract concept found universally across cultures and examining common structural patterns at the level of semantics. Consider the very abstract concept *time* for example. Time is often thought about and talked about in terms of space (Boroditsky, 2000; Boroditsky and Ramscar, 2002; Casasanto and Boroditsky, 2008; Clark, 1973; Evans, 2003; Gentner et al., 2002; Kranjec, 2006; Matlock et al., 2005; McGlone and Harding, 1998; Núñez et al., 2006; Tenbrink, 2007; Torralbo et al., 2006). For example, languages code the related temporal concepts of past, present and future in terms of spatial locations relative to an observer-centered or deictic reference frame. With rare exceptions (see Núñez and Sweetser, 2006)[1] languages conceptualize the past as "behind", the future as "in front of" and the present as co-locational with the space around the body (Clark, 1973; Evans, 2003; Lakoff and Johnson, 1980, 1999).

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[1] To clarify, the Aymara language also employs a deictic reference frame even though the past is mapped as in front and the future is mapped as behind.

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Why is such language so common? Some researchers argue that these linguistic conventions are not arbitrary but suggest rather that temporal concepts are *embodied*. The general argument goes something like this: numerous constraints imposed by human physiology, perception, and action are reflected in the way time is construed using spatial language. These relations between physical constraints and linguistic patterns are further argued to be non-trivial, such that they reflect a "psychological reality" that goes deeper than mere associations in language. This position culminates with the notion that temporal thought itself is deeply grounded in spatial representation. Some experimental work has supported this general perspective (Boroditsky, 2000; Boroditsky and Ramscar, 2002; Casasanto and Boroditsky, 2008; Kranjec, 2006; Kranjec et al., 2010; Núñez et al., 2006; Núñez and Sweetser, 2006; Teuscher et al., 2008; Torralbo et al., 2006).

Thus, although still very controversial—some cognitive psychologists argue that semantic relations between abstract concepts and concrete spatial morphemes can be fully understood using a disembodied approach (e.g. McGlone, 1996; Murphy, 1996)—embodied views of cognition and conceptual representation are important because they offer possible solutions to the long-standing problem of how abstract meaning is grounded in the world. Along these lines, some cognitive scientists have taken embodied views of cognition to drive machine-based language learning and processing models (Goldstone et al., 2005; Roy, 2005). Cognitive neuroscience has also embraced embodied approaches. Sensorimotor theories of language assert a close correspondence between neural areas subserving word meaning, perception, and action (see Barsalou et al., 2003 for a review). But although correlations between modality-specific neural areas and corresponding concepts have been demonstrated, it has not yet been established that a relevant sensorimotor area is critical or *necessary* for grounding a particular meaning or concept.

This brings us to the current research. The problem of grounding meaning is intimately related to the problem of consciousness. To ask, "What is meaning?" is also to ask, "What makes a mental state meaningful?" For the purposes of the current topic, we would like to understand more clearly the extent to which an "embodied concept" is ultimately grounded in implicit/unconscious sensorimotor representations as is often implied (e.g. Lakoff and Johnson, 1999) or if it is more akin to the products of analytic processes such as proposed within Mandler's (2004) developmental framework. Conceptual Metaphor Theory and Mandler's developmental approach are similar. Both propose that image schemas provide a critical level of representational structure for organizing abstract thought. While Mandler argues that image schemas provide the foundation for concepts that can be explicitly accessed, the Lakovian framework takes things further down. Lakoff proposes that abstract thought finds its fundamental grounding in the very sensorimotor representations that make perception and action possible. The question posed by the current research concerns the representational continuity of our conceptual system. It is a question premised on two aspects of memory. First, implicit memory is not accessible to consciousness as it is not encoded explicitly in the first place. Second, although explicit representations can become *procedure-like*, they remain potentially accessible to conscious analysis. If these premises are correct, then the Lakovian framework needs further elaboration as to how, and under what conditions, our understanding of relations between time and space may become explicit.

To begin addressing these issues, a novel experimental task is introduced to (1) demonstrate that an abstract concept (i.e. time) finds structure in the body and the environment rather than simply in the semantic relations among particular lexical items, and (2) explore the extent to which the psychological construct that Lakoff and Johnson (1999) call the *cognitive unconscious* is, in fact, an attribute of a distinct implicit representational system.

2. The experiments

2.1. Conceptual distinctions and design motivations

In order to appreciate the design of the experiments, it is necessary to first describe the distinction between two related temporal concepts (past/future vs. earlier/later) as well as illustrate the distinct frame of reference, or image-schematic, models they appear to be predicated upon. From his seminal analysis, Clark (1973) identified two principal spatial schemas used to structure temporal concepts in English, the *Moving-Time* and *Moving-Ego* models. Both of Clark's models can be unambiguously classified as *deictic* in respect to the frame of reference each invokes. In general, deictic spatial frames of reference determine an object's location relative to body axes (e.g. the body's asymmetrical front–back axis) and/or an individual's direction of gaze. The Moving-Time and Moving-Ego models are both classified as deictic models because both map *past/future* events as physical objects located in space relative to an ego-centered reference frame. For both models, future events are represented as objects located in front of the observer, past events as behind the observer and the present moment (or "now") as co-locational with the observer (see Fig. 1).

Embodied theories of cognition argue that conceptual structure emerges from typical patterns of experience (Evans, 2003; Núñez, 1999). For example, when taking a walk, one is typically looking forward in the direction of ego-centered forward motion. In general then, there is an experiential correlation between future encounters (including planning for those encounters) and what is ahead of us. Conversely, as one walks past things located along a path, objects passed in space come to be located behind one's field of vision, and become accessible only through memory, occupying a temporal past. Temporal relations defined as such are necessarily fixed to one's own perspective. As a result, the defined positions for such temporal relations change relative to the location of the observer "in" time.

Contrast the frame of reference relations in the past/future concept with those inherent to an *earlier/later* concept. Compared to the past/future concept, earlier/later relations are fixed only to one another. For example, the storming of the

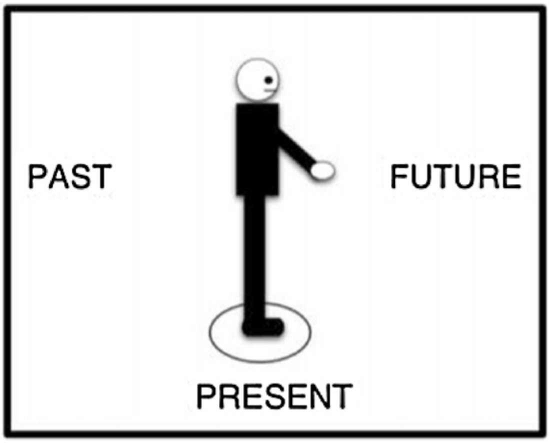
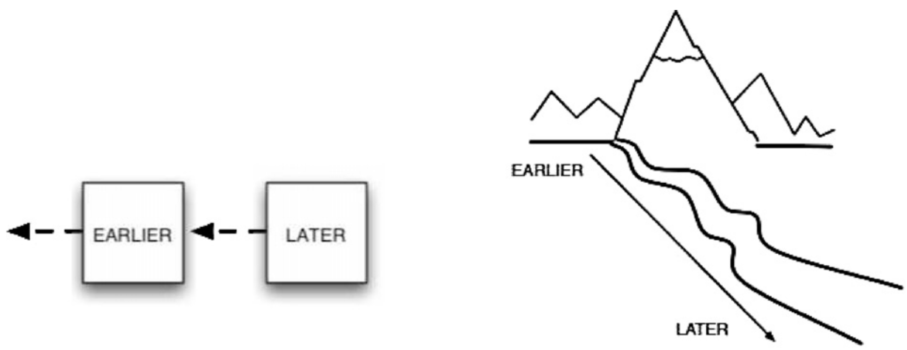


Fig. 1. A schema depicting how a deictic temporal frame of reference can ground the past/future concept. In most languages the future is mapped as *in front* and the past as *behind*. With deictic schemas, forward temporal motion can be in the direction of the future (the Moving-Ego model) or the past (the Moving-Time model).

Bastille (1789) occurred earlier than the Tsar's abdication (1917) with the inherent temporal relation between these events fixed relative to one another. This earlier/later relation is true whether two events are represented as a part of the past or future. A deictic point of reference is irrelevant in describing this particular temporal relation, and the kinds of spatial mappings used to represent earlier/later relations reflect this frame of reference distinction. Spatial construals of earlier/later relations can take the form of either (1) linked objects following a common path where events *in front* of other events are earlier times and events *in back* of other events are later times or (2) an abstracted path or trajectory where locations closer to *the beginning* of the path represent earlier times and locations closer to *the end* of the path represent later times. Both models can be classified as *non-deictic* (see Fig. 2). (Regarding temporal reference frames, see also, Moore, K.E., Shinohara, K., Tenbrink, T., in the current volume.)

While demonstrating that significant relations between spatial and temporal cognition exist, much of the recent experimental research on temporal representation has failed to make adequate distinctions among temporal concepts and their corresponding schema or reference frame. Also, because experimental methods for investigating these issues are in relatively short supply, drawing firm conclusions from the available data is still difficult. For example, one popular method used to investigate the spatial organization of temporal concepts makes use of the *ambiguous question* "Next Wednesday's meeting has been moved forward 2 days. What day is the meeting now that it has been rescheduled?" (McGlone and Harding, 1998; Boroditsky and Ramscar, 2002; Matlock et al., 2005; Núñez et al., 2006; Kranjec, 2006). Typically, when English-speaking adults are asked this question, "Monday" and "Friday" answers are observed in approximately equal proportions. The answer to the question about Wednesday's meeting is ambiguous because it depends on how the word *forward* is interpreted in the context of one's mental representation of the timeline. By priming participants to think about



(A) Linked schema (B) Path schema

Fig. 2. Examples of two non-deictic temporal schemas capable of grounding the earlier/later concept. (A) In spatial schemas that structure time in terms of linked 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. (B) Path-like spatial schemas define temporal relations relative to locations along an abstracted trajectory. Note that according to link schemas forward motion is in the direction of earlier times, whereas with path schemas forward motion is in the direction of later times. (A) Linked schema. (B) Path schema.

spatial relations according to the structure of a particular spatial schema (e.g. by using animations, static illustrations or tasks that require real or imagined personal movement through space) one can predict whether Monday or Friday answers will more typically be given in response to the ambiguous question about Wednesday's meeting. However, depending on one's frame of reference, forward motion in time can represent movement to *earlier* times, *later* times, the *past* or the *future*. ''Monday'' answers to the ambiguous question have been attributed both to deictic Moving-Time and non-deictic, link-like schemas, whereas ''Friday'' answers have been explained using deictic Moving-Ego and non-deictic, path-like schemas (Boroditsky, 2000; Boroditsky and Ramscar, 2002; Kranjec, 2006; Matlock et al., 2005; Núñez et al., 2006). Thus, the ambiguous question about Wednesday's meeting does not necessarily make clear distinctions between frames of reference *or* different temporal concepts like earlier/later and past/future. This is the case because days by themselves can be conceptualized as parts of a linked sequence, as locations along a calendar's timeline or path, or as times relative to a deictic reference point (see Fig. 3). For this reason, the ambiguous question may not distinguish between different temporal concepts as they relate to a particular reference frame. Perhaps an even more relevant limitation of the ambiguous question in the context of the current study is its ''one-off'' nature. Although the spatial schemas thought to be guiding responses are assumed to operate below awareness, when using this method a participant is no longer considered nave after answering a single question that takes mere seconds to read and respond to. Anecdotally, participants often do become aware of the question's ambiguity immediately upon providing an answer.

The design of the present study was in part intended to pick up where the ambiguous question leaves off. Both experiments described in sections 2.2 and 2.3 were designed with the question of awareness in mind. Whereas past studies investigating similar topics have made an effort to conceal the overall intent of the task to ensure that participants lacked awareness of its ambiguous nature (e.g. Boroditsky, 2000; Gentner et al., 2002), we were interested in the extent to which a person might become aware of embodied meaning over the course of the experiment although we also took measures to disguise the purpose of the study at the start.

While the idea of an embodied past/future concept (where the *future is in front of us* and the *past is behind us*) is supported by some empirical work, it has never been investigated experimentally using a direct approach, i.e. with a design that uses the actual space *in front of* and *behind* the participant to test for differences in responding to stimuli representing past and future events. This might simply owe to the fact that, for obvious reasons, it is so much easier for people to respond to visual stimuli when presented *in front* compared to *behind*. So, when setting out to design the proper experiment, the researcher is confronted by a profound asymmetry that makes control an issue. We addressed this issue by ''hiding'' all of our stimuli; thus making stimuli located *in front* of participants as perceptually unavailable as stimuli located *behind*. And though observational and quasi-experimental studies have demonstrated that people consistently (1) gesture towards locations in

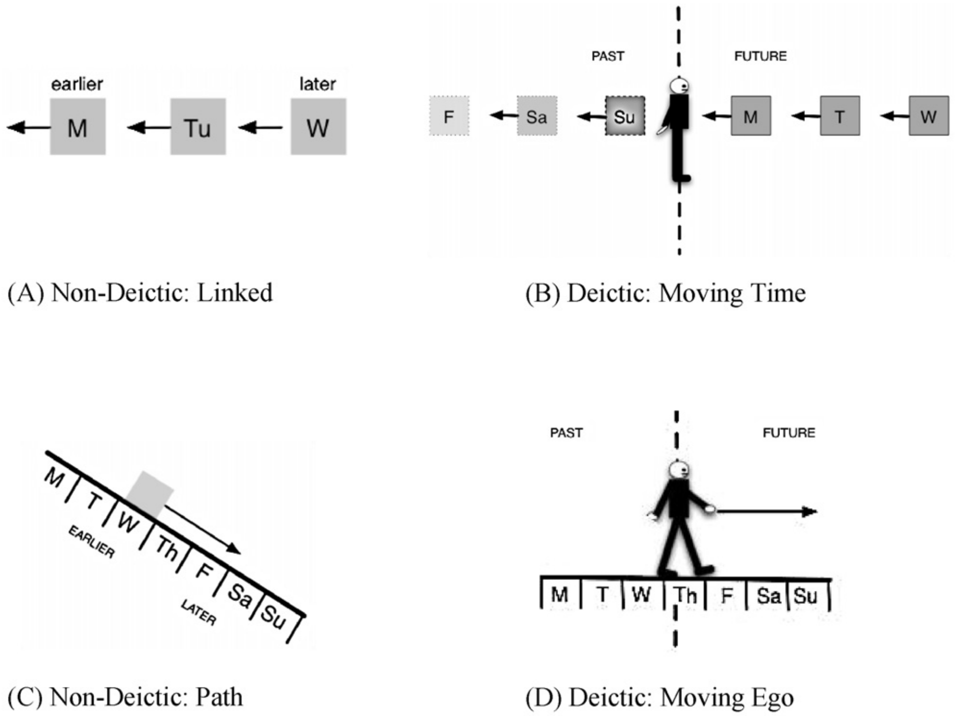


Fig. 3. In experiments using the ambiguous question *''Next Wednesday's meeting has been moved forward 2 days. What day is the meeting now that it has been rescheduled?''* both (A) Non-deictic (Linked) and (B) Deictic (Moving Time) schemas can support Monday answers. Friday answers are supported by both, (C) Non-deictic (Path) and (D) Deictic (Moving Ego) schemas. (A) Non-Deictic: Linked. (B) Deictic: Moving Time. (C) Non-Deictic: Path. (D) Deictic: Moving Ego.

front of and *behind* their bodies when talking about past/future relations, and (2) gesture along a horizontal axis from *left to right* when describing sequential, earlier/later relations (Núñez and Sweetser, 2006; Cooperrider and Núñez, 2007) to our knowledge there are no existing experimental paradigms which address the embodied nature of gestures that depict temporal relations.

In the current study, pictures that represented events or objects from the *future* and *past* were hidden in boxes placed in *front of* and *behind* participants. But the temporal nature of these stimuli was never made salient. Participants were merely instructed to guess the locations of pictures. We predicted that participants would be more likely to make pointing gestures in space that were structurally concordant with the temporal meanings of the stimuli, even though these meanings were not explicitly relevant to our task. The extent to which participants would become aware of the task structure was considered an open question. If embodied temporal concepts are robustly grounded in implicit sensorimotor representations then one would expect some, if not most, participants to point in a manner consistent with the structure of the stimuli and all without developing an awareness of why. Alternatively, if embodied temporal concepts are grounded in schemas accessible to awareness, then participants who point consistently are more likely to become aware of why they are doing so.

2.2. Experiment 1

2.2.1. Methods

2.2.1.1. Participants. Twenty-seven Brooklyn College undergraduate students (13 male; 14 female) participated for partial course credit in Introductory Psychology classes. After testing, participants gave us their email addresses so we could inform them of the purpose of the experiment at a later date. Only after Experiments 1 and 2 (section 2.3) were complete did we send an email to both groups of participants explaining the purpose and results of the experiments.

2.2.1.2. Procedure. In order to distract participants from the purpose and structure of the experiment at the onset of testing, the overall design was intended to resemble that of a ‘‘parapsychology task’’ (see description of instructions below). Although this aspect of the study may seem somewhat idiosyncratic, it was determined *a priori* to be a potentially useful tool for influencing participants to guess on early trials. At the onset of the study, it was critical that participants at least experienced their response as a ‘‘guess.’’ Whether or not the desired phenomenological state was induced by an authentic belief in the existence of psychic powers or, rather, resulted from a more mundane incredulity was deemed less relevant. As with other methodologies that investigate implicit knowledge and learning (e.g. blindsight or artificial grammar studies) it is important that participants, at least initially, experienced their behavior as unstructured (Dienes and Scott, 2005). During the first trials, the instructions to ‘‘guess’’ should still be present in memory, and the structure of the stimuli (to be described in Table 1) is far from obvious. Broadly speaking, the experimental question of interest concerns how participants will come to make sense of this superficially absurd situation.

Each participant was tested separately. Upon entering the lab, participants were seated in the middle of a small ($9' \times 16'$) main room and given preparatory instructions. Prior to beginning the task, participants were shown what they were told were two random examples of the kinds of picture tiles that would be used in the present experiment. They were told that these specific examples were from a previous study and would not be used in the current experiment. For example, participants would be shown ‘‘banana’’ and ‘‘unicorn’’ picture tiles—stimulus items unrelated to the research question—so that they could more easily imagine the stimuli actually used in the experiment (which they would never see). The picture tiles were small rectangles (approximately $1.5'' \times 2''$) made of thick cardboard with color images of objects pasted on one side. After showing participants the examples, the experimenter then informed them that the current experiment would use

Table 1
Stimulus tiles used in Experiments 1 and 2. There are 32 stimuli/trials total. 8 Past/8 Future; 8 Earlier/8 Later.

PAST (P) FUTURE (F) pairs	EARLIER (E) LATER (L) pairs
1P. Model T Ford	1E. Acorn Seed
1F. Toyota Concept Car	1L. Oak Tree
2P. Noah’s Ark	2E. Airplane Taking Off
2F. 4 Horsemen of the Apocalypse	2L. Airplane Landing
3P. Columbus Arriving in America.	3E. Apple
3F. Astronaut Walking on Mars	3L. Apple Core
4P. ‘‘JFK for President’’ Bumper Sticker	4E. Baby Boy
4F. ‘‘Hillary for President’’ Bumper Sticker	4L. Old Man
5P. Horse And Buggy	5E. Caterpillar
5F. Flying Car	5L. Butterfly
6P. Robin Hood	6E. Lump of Clay
6F. Robot Police Officer	6L. Clay Pot
7P. Brooklyn Dodgers Baseball Stadium	7E. A First Birthday Party
7F. Brooklyn Nets Arena	7L. A College Graduation Ceremony
8P. World Trade Center	8E. Raw Egg
8F. Freedom Tower	8L. Fried Egg

Fig. 4. Schematic diagram of the testing situation in Experiment 1. The boxes were not labeled in the experiment.

thirty-two such tiles but with different pictures. The experimenter then left the room and entered a smaller ($6' \times 6'$) adjoining room. From the adjacent room—with the experimenter out of sight but within earshot—picture tiles were loudly mixed in a separate plastic container and then poured, in approximately even proportions, into two opaque cardboard boxes ($1'' \times 8.5'' \times 2.5''$). The experimenter then reentered the main room, placing one of the opaque boxes in front of the participant and the other behind as illustrated in Fig. 4. The boxes were placed at an equal distance in front of and behind the seated participant (7′6″ in each direction).

It was also made clear that the researcher carrying out the experiment did not know the location of particular tiles. Sitting to the side, but slightly behind and out of sight of the participant (in order to prevent unconscious cuing) the experimenter then read the following instructions aloud:

> One at a time, I will read from a list of the tiles used in this experiment. Your task is simply to point at the box (either in front or behind you) where, according to your best guess or intuition, you think a particular tile is located. Try to imagine the thing and make a picture of it in your mind before pointing. OK? Just guess.

After receiving the instructions, participants heard short descriptions of the picture tiles purported to be contained in the two boxes. One item was described per trial (total of 32 item/trials).

2.2.1.3. Stimulus design. The tile descriptions were designed to portray things representing either (1) deictic PAST/FUTURE relations (e.g. ‘‘World Trade Center’’ or ‘‘Freedom Tower’’) or (2) non-deictic EARLIER/LATER relations (e.g. ‘‘caterpillar’’ or ‘‘butterfly’’). The two types of stimuli are distinguishable from each another in one important way. Deictic items, whether they denote PAST or FUTURE things, retain their temporal status even when presented separately. That is, the ‘‘World Trade Center’’ is located in the past independent of its relation to the ‘‘Freedom Tower’’. This is because the temporal status of the ‘‘World Trade Center’’ is dependent on an observer’s temporal location, i.e. the present time. Non-deictic EARLIER/LATER items on the other hand, describe things with temporal relations that are entirely dependent on each other. Consider, for example, the EARLIER/LATER pair *caterpillar–butterfly*. When we say a ‘‘caterpillar’’ comes earlier than a ‘‘butterfly’’ the temporal status of ‘‘caterpillar’’ is dependent on the temporal relation *between* a ‘‘caterpillar’’ and a ‘‘butterfly’’. The single item ‘‘caterpillar’’ itself does not afford the designation of earlier (because caterpillars come later than eggs). When ‘‘caterpillar’’ is presented in isolation, the event of ‘‘transformation’’ implied when caterpillar is paired with ‘‘butterfly’’ is lost in the split. This is true for all the EARLIER/LATER pairs regardless of whether they represent spontaneous transformations (*caterpillar–butterfly*) or events requiring an intervening human action (*raw egg–fried egg*). Also, unlike deictic PAST/FUTURE relations, in ascribing EARLIER/LATER relations to things in a sequence, *the location of an observer in time is irrelevant*. Caterpillars are earlier than butterflies in the past and in the future. In this way, the difference between PAST/FUTURE and EARLIER/LATER relations can be reduced to a fundamental frame of reference distinction: deictic vs. non-deictic. In general, each of the above distinctions between PAST/FUTURE and EARLIER/LATER relations hold true for all stimuli in Table 1.

2.2.1.4. Stimulus presentation. See Table 1 for a complete listing of the testing stimuli. In the left hand column one can see the pairs of PAST/FUTURE items, and in the right hand column, pairs of EARLIER/LATER items. The two items of each pair were presented separately. Item sequence (the list of stimulus tiles) was pseudorandom and counterbalanced. This was done such that item types (PAST/FUTURE or EARLIER/LATER items) were each presented equally as often in each of the 32 possible sequence locations and that particular items were not regularly presented in proximity to one another. Also, if one item in a pair (e.g. ‘‘butterfly’’) was presented in the first 16 trials (1–16) the second item in the pair (e.g. ‘‘caterpillar’’) was presented somewhere in last 16 trials (17–32). This meant that an equal number of a particular item type (PAST/FUTURE or EARLIER/LATER) was presented in each half as well. Lastly, each component of a pair was as likely to appear during the first or last 16 trials of the experiment. So, for example, for half of the participants, ‘‘butterfly’’ (the LATER component) was presented during trials 1–16 and therefore ‘‘caterpillar’’ (the EARLIER component) was presented during trials 17–32, while for the other half of participants, this order was reversed.

2.2.1.5. Response recording and coding. The experimenter recorded the direction of pointing for each item. No feedback was provided. In line with the deictic (and metaphoric) structure of the past/future concept, participants were expected to point more often at the box "in front" to indicate the location of FUTURE things and "behind" when asked about the location of PAST things. No initial difference between "in front" and "behind" responses for EARLIER things compared to LATER things was expected, as non-deictic concepts are not directly grounded in observer-centered reference frames. Whereas the past/future concept is anchored to front–back relations relative to the body, the earlier/later concept, as discussed in section 2.2.1.3, is anchored to a relation between the events themselves. Because items were presented separately, relations between EARLIER/LATER items should not have been immediately apparent. However, the possibility that participants would show some increased performance on EARLIER/LATER items during the second half of the experiment (presentations 17–32) was considered. We speculated that participants could, in principle, use the first presentation of the item pair to ground the second.

For PAST/FUTURE items a schema-consistent response was counted when participants pointed at the box *in front* for FUTURE items (e.g. "Freedom Tower") and at the box *behind* for PAST items (e.g. "World Trade Center"). For EARLIER/LATER items, a schema-consistent response was counted when participants pointed at the box *in front* for EARLIER items (e.g. "caterpillar") and at the box *behind* for LATER items (e.g. "butterfly"). Note that the basis for scoring responses to EARLIER/LATER items can be construed as meaningful because before/after relations (which are semantically related to front–back) are used almost exclusively to describe EARLIER/LATER temporal relations. However, reasoning in the opposite direction is also sensible. For example, EARLIER things could also be conceived as being more a part of the PAST (and therefore *behind* the observer). In the context of the present study, such indistinctness for EARLIER/LATER items is a reflection of the concept's non-deictic structure.

Because the temporal relations between EARLIER/LATER stimuli are non-deictic, when these items are presented separately their temporal relations are severed, and in the process, the temporal meanings of individual items are made less salient or stripped altogether (e.g. what is the temporal status of "apple"?). We assumed that these items might serve a welcome additional role as distractors in the study.

2.2.1.6. Post-task interviews. After the final item was presented and the last response was recorded, participants were told that the experiment was over and interviewing began. Interviews were structured around a script. Questions were posed in a conversational manner to make participants comfortable. Care was taken to avoid suggestive questions. The questions contained in the script did not allude to "time" in any way but rather, were directed towards answering four general questions. Of most interest was (1) *whether* or not the participant used any system or strategy for pointing at one box rather than another as a means to group together different kinds of items. This led to several follow up questions. If any organization strategy was used (2) *what* was it, and (3) *when* in the experiment was this particular strategy adopted? Also of interest was the general question of (4) *how* participants interpreted the purpose of the experiment. (That is, did they have any theories about what the experiment was designed to investigate?) We used a relatively liberal gauge to assess participants' awareness of temporal structure after testing. If a participant mentioned the word "time" and/or made any general reference to temporal concepts using spatiotemporal terms (e.g. *old* things are *behind me*) at any point during the interview, this participant was later coded as *AWARE*. If a participant did not make any such reference, this participant was coded as *NAüVE*. This is not to say that NAüVE participants did not use their own strategies. Interviews proceeded in the same manner regardless of whether a participant reported using a temporal strategy or not.

2.2.2. Results for experiment 1

2.2.2.1. Responding by item type. An ANOVA comparing item type (PAST/FUTURE; EARLIER/LATER) was conducted on the number of schema-consistent responses made by each participant. The result was statistically significant [$F(1, 53) = 8.134$, $p < .01$] indicating that more consistent responses were made for the PAST/FUTURE (61.3%) than EARLIER/LATER items (48.4%). Chi-square analyses comparing the responses to chance (50%) showed that participants responded at above chance levels for PAST/FUTURE items [$\chi^2(1) = 10.89$, $p < .01$] but not for EARLIER/LATER items [$\chi^2(1) = 0.26$]. We can therefore conclude that participants responded differently to the PAST/FUTURE items, and that they did so in a way consistent with the main hypothesis of the experiment (i.e. the general pattern of responding was concordant with the spatial structure of the deictic temporal concept but at chance levels for the non-deictic one) (see Fig. 5).

2.2.2.2. Responding by item type over time. Because the experiment was intended to investigate the interaction of implicit and explicit processes over the course of the task, we looked at the pattern of responding diachronically. Fig. 6 depicts the same group data as in Fig. 5 but represented in a time series. (For clarity, the trials are displayed using a line graph even though the trials were discrete.) Blocks represent two consecutive trials. The data represented is further divided by item-type (PAST/FUTURE or EARLIER/LATER). Thus, there are two data points, representing averages for four responses, in each block. For example, in Block 1, one data point represents the mean percentage of correct responding across all participants to the first and second presentations of PAST/FUTURE items in a session (in black), and the other data point represents the first and second presentations of EARLIER/LATER items (in gray). Examining the pattern of responding within sessions, schema-consistent responses appeared to be well above chance only for PAST/FUTURE items presented at the beginning of each session (Block 1 represents the first 2 presentations for each trial type) and at the end of each session (Block 8 represents

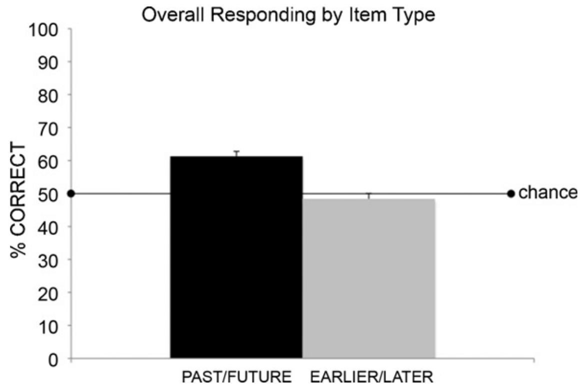


Fig. 5. Responding by item type.

the last two presentations). We analyze the individual blocks in the next section in which we consider the differences between the AWARE and the NAüVE participants.

2.2.2.3. Responding over time: AWARE vs. NAüVE participants. Post-task interviews revealed that 9 participants invoked temporal concepts when justifying their pointing (henceforth the ‘‘AWARE’’ group). The other 18 participants did not report using time at all (henceforth the ‘‘NAüVE’’ group). An ANOVA bore this out. Overall, AWARE participants made more schema-consistent responses for PAST/FUTURE items (78.0% schema-consistent) compared to EARLIER/LATER items [46.0% schema-consistent; $F(1, 16) = 25.13$, $p < .001$]. Individually, no AWARE participants consistently used a temporally relevant categorization strategy for EARLIER/LATER items (i.e. participants did not point *in front* for LATER items and *behind* for EARLIER or *vice versa*.) This was still the case when EARLIER/LATER items presented in the second half of the experiment were analyzed separately. NAüVE participants' responding remained close to chance levels (50%) for both item types over the course of the session. According to chi square tests performed on individual participants' responses, no NAüVE participants' proportion of correct responses on PAST/FUTURE items was above that expected by a 50/50 chance model, while all but three AWARE participants did show above chance levels of correct responding (see Fig. 7).

Reflecting the overall pattern of results, *t*-tests indicated that (1) the AWARE participants responded on PAST/FUTURE items at above chance levels at the beginning of a session: (Blocks 1-3: $t(8) = 2.83$, 2.53, and 5.29 respectively, all *p* values $<.05$) and (2) near the end (Blocks 6-8: $t(8) = 8.00$, 2.53, and 5.29 respectively, all *p* values $<.05$), but (3) at chance levels over the intermediary period (Blocks 4 and 5; $t(8) = 0.56$, 1.16, all *p* values $>.25$). Although the ANOVA testing for a quadratic trend was not significant, the suggestion of a *U*-shaped response curve raises a very interesting question: Why should participants perform above chance at the beginning and end of the task, and do relatively worse during the intermediary period? To address this issue, we turn to their responses during post-task interviews.

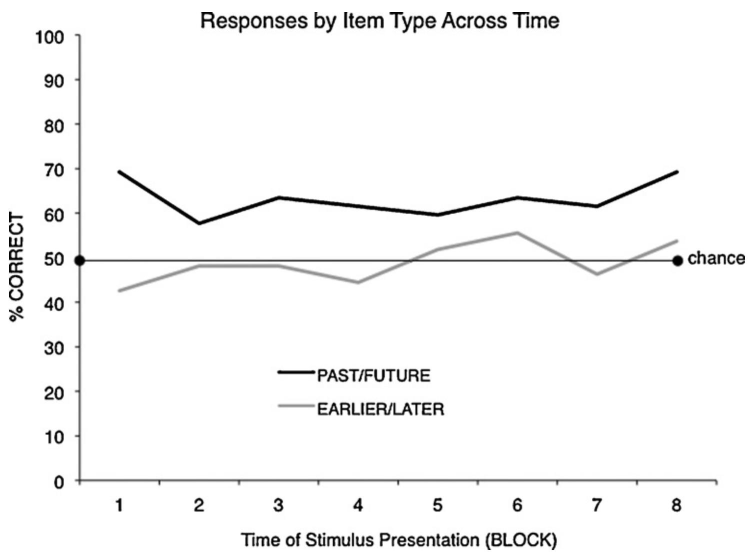


Fig. 6. Percentage of schema consistent responses to PAST/FUTURE and EARLIER/LATER items for all participants in Experiment 1. Blocks represent 2 consecutive trials. PAST/EARLIER = BACK POINTS; FUTURE/LATER = FORWARD POINTS.

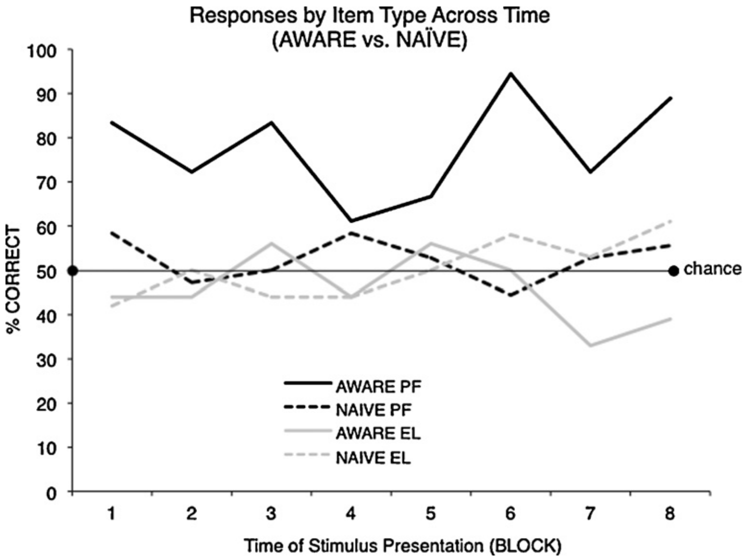


Fig. 7. Percentage of "schema-consistent" responses to PAST/FUTURE (PF) and EARLIER/LATER (EL) items for AWARE vs. NAüVE participants in Experiment 1.

During interviews AWARE participants reported that temporal structure was used to guide pointing no earlier than after the first 3 presentations (i.e. after Block 1; the mean presentation number reported by participants = 3.9). Although one cannot entirely rely on the accuracy of self-reports in any experiment, it seems very likely that "AWARE" participants were in fact not aware of either the experiment's purpose, or their own motives for responding consistently to particular stimuli during the first few trials. The likelihood that these participants were not aware of the critical elements of the experiment's structure at the start of testing is further supported by the generally "absurd" nature of the task, i.e. the effort made to present the study as a "guessing game" or parapsychology task. In general, participants have very little explicit information to make sense of the situation when they begin responding. The results suggest that implicit, unconscious processes may be guiding behavior for these participants at the very start.

At this point though, we still cannot be certain that the relative spatial orientation of the boxes played a critical role in anchoring the semantic relations among PAST/FUTURE items. Perhaps the observed pattern of responding was the product of more conventional "disembodied" semantic relations having little to do with the structurally analogous spatial relations shared between the English time concept and the experimental situation. This is to suggest that the locations of the boxes and the participants' analysis of their own deictically framed pointing responses played a minimal role in bringing the semantic structure of the stimuli to the level of awareness. One could argue that exposure to the stimuli alone over the course of the experiment may have provided participants with enough semantic information to enable awareness of the underlying temporal relations to emerge; i.e. the semantic relations among lexical items are primarily driving awareness of temporal meaning. (Of course, awareness of the temporal relations alone would not automatically guide consistent responses such as pointing forward for future events and backwards to past events in Experiment 1. Also, no participants systematically pointed "behind" for future items.) In order to determine if the relative positions of the boxes was in fact critical in establishing temporal relations among the test items, in Experiment 2 the boxes were moved. Our aim was to address more closely a rather difficult question, i.e. "whether concepts gain their meaning from their connections to each other, or from their connections to the outside world" (Goldstone et al., 2005:287).

2.3. Experiment 2

2.3.1. Introduction

Did the particular locations of the boxes relative to the participants play a critical role in whether or not they became aware of the experimental situation? To investigate this question, we changed the spatial orientation of boxes so that rather than being placed in front and behind participants, boxes were placed to their left and right. If embodied views of cognition are correct then different deictically construed spatial axes should "afford" different levels of structural support for the past/future concept. As we discussed in section 2.2, embodied reference frames derive their fundamental relational anchors from (1) the structure of the physical environment, (2) common patterns in perception and importantly, and (3) the gross structure of the body itself. People are physically asymmetrical when viewed from front to back (the front being privileged perceptually) and symmetrical when viewed from left to right (e.g. eyes and ears on either side). Structural asymmetry has functional consequences for how we move about and experience the world temporally (Clark, 1973). Embodied theories predict that experienced physiological asymmetries as such should influence how asymmetrical deictic temporal concepts (like the past/future concept) are structured. Therefore, the asymmetrical front–back axis should serve better to ground the past/future concept as compared to the symmetrical left–right axis. However, if a body-centered front–back reference frame does not play a significant role in structuring systematic responding in the task, then changing the locations of the boxes should not influence participants' overall performance. To test these contrasting hypotheses, Experiment 2 replicated the procedure used in Experiment 1, with the locations of the boxes relative to the participants changed. In Experiment 2, the boxes were placed both in front and positioned to the immediate left and right of participants (Fig. 7). With the exception of relative box location, the procedure and test items (the list of tiles) were identical to those used in Experiment 1. If the spatial arrangement of the boxes is irrelevant for the purpose of organizing the stimuli—in line with a ''disembodied hypothesis''—then in Experiment 2 we should expect the same percentage of schema-consistent answers and a similar proportion of AWARE participants as observed in Experiment 1.

2.3.2. Methods

2.3.2.1. Participants. Twenty-seven Brooklyn College undergraduates (15 male; 12 female) participated for course credit. (These participants were different than those who participated in Experiment 1.)

2.3.2.2. Procedure. In Experiment 2 the procedure was identical to that of Experiment 1 except that in Experiment 2 the boxes were placed on a table in front of participants as depicted in Fig. 8. The instructions were slightly different as compared to Experiment 1 merely to reflect the new spatial orientation of the boxes. Because handedness could be a potential issue when gesturing along the left–right axis, in Experiment 2 we instructed all participants to use both hands when making their responses:

> One at a time, I will read from a list of the tiles used in this experiment. Your task is simply to point at the box (either to your left, with your left hand or to your right, with your right hand) where, according to your best guess or intuition, you think a particular tile is located. Try to imagine the thing and make a picture of it in your mind before pointing. OK? Just guess.

2.3.2.3. Stimuli. The stimuli used in Experiment 2 were identical to those used in Experiment 1, as were the pseudorandomized lists used to present test items.

2.3.2.4. Response recording and coding. As in Experiment 1, the experimenter recorded responses. For PAST/FUTURE items, a schema-consistent response was scored if participants pointed at the *left box* for a PAST item and the *right box* for a FUTURE item. For EARLIER/LATER items, a schema-consistent response was scored if participants pointed at the *left box* for an EARLIER item and the *right box* for a LATER item. This coding scheme seemed entirely reasonable, as it is concordant with numerous cultural conventions including, (1) reading and writing direction in English and the majority of other languages in the West, (2) event structure in comic strips and other graphic depictions of actions, (3) calendar structure, (4) timelines, (5) the gestures we make (Núñez and Sweetser, 2006; Cooperrider and Núñez, 2007) and (6) sign languages (Engberg-Pedersen, 1993). In Western cultures, when temporal relations are constrained to representation along the left–right axis, earlier or past events are typically represented on the left and later or future events are represented on the right. Experimental tasks have demonstrated that speakers of Western languages commonly structure both earlier/later and past/future temporal relations from left to right (Santiago et al., 2007; Torralbo et al., 2006; Tversky et al., 1991). The left–right axis is arguably the most *culturally* relevant axis for organizing time despite not being the most salient axis from an embodied perspective. For example, although what is located behind us in space often correlates with what we have experienced in the past, ''real world'' events do not typically unfold from left to right.

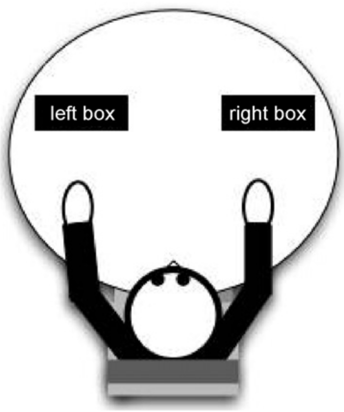


Fig. 8. Schematic diagram of the testing situation for Experiment 2. The boxes were not labeled in the experiment.

A "disembodied" hypothesis predicts that if participants are presented with the same stimuli used in Experiment 1 but under left–right conditions, they should organize stimuli along temporal lines very much like participants did in Experiment 1. The objects and events are the same as those used in Experiment 1 and the left–right axis actually provides a very salient axis for organizing events in respect to cultural conventions. The disembodied hypothesis also predicts that in Experiment 2, an equal number of participants should become aware of the temporal structure of the stimuli. Again, the stimuli are identical to those used in Experiment 1 and, in the context of the task, the spatial relations used to structure time in thought and language should be less important than the non-spatial, conceptual semantics relating the stimuli to one another.

2.3.3. Results for Experiment 2

The general predictions of the disembodied hypothesis were not substantiated. The results indicate that responding for *both* PAST/FUTURE items and EARLIER/LATER items was not significantly different from chance levels (i.e. for PAST/FUTURE items 51.8% were schema-consistent; and for EARLIER/LATER items 54.7% were schema-consistent.) Further analyses examining the data across blocks showed no coherent pattern of performance; participants consistently responded at chance throughout the duration of the experiment. As compared to the pattern of results observed in Experiment 1, the left–right spatial location of the two boxes in Experiment 2 did not suggest a coherent framework for dividing the stimuli along lines demarcated by the structure of temporal concepts and the pattern of responses reflected this.

Even more importantly, interviews conducted after testing revealed that none of the participants became aware of the experimental stimuli's temporal structure. That is, in Experiment 2 no participants could be classified as AWARE as none mentioned *time* or referenced any related temporal concept when describing factors that might have motivated the purpose of the experiment or influenced their own behavior over the course of the session. *The semantic relations between the lexical items themselves were not sufficient to make participants aware of the temporal nature of the stimuli.*

3. General discussion and conclusion

Over Experiments 1 and 2 several features of the results merit emphasis. We note first AWARE participants' response pattern suggestive of a *U*-shaped curve in Experiment 1. This provides some indication that responses made in the beginning of the task were guided by different processes than those made later. The decrease in performance occurs shortly *after* the point these participants report having adopted the relevant strategy for schema-consistent responses. We assume that all participants were nave at the beginning of the experiment and that the temporal relations were unlikely to be salient in and of themselves after one or two trials. It is probable that an implicit process was influencing these participants' responses. Only after having analyzed their own responses (pointing in front for future events and behind for past ones) did the AWARE participants begin to adopt an explicit strategy; one that initially interfered with their consistency. (As it is the case upon responding to the Wednesday meeting question, awareness *that* the question is ambiguous may often be immediate, but it takes both time and effort to determine *why*.) However, after their performance declined it became even more consistent compared to initial trials. At Block 6, immediately following the sharp dip to chance levels of responding, accuracy jumps to its highest point at over 94%. This general relation between implicit and explicit processes, where explicit analysis appears to interfere with a previously learned implicit task, is a basic finding in the literature on implicit–explicit interactions (e.g. Reber, 1989). This kind of response pattern is also found in developmental research where a process or ability is first assumed to be under control of implicit or reflexive processes, and later comes under explicit control only after an intermediary period of decreased ability or performance (e.g. Zelazo, 2004).

However, it should be stressed that an implicit *process* does not imply implicit representational *structure* or content. Explicit concepts can prime other explicit concepts without awareness. That the meaningful content of the past/future concept ultimately did rise to the level of awareness for primed participants is important though. It is our position that these explicit meanings were at some point in their acquisition based on an analysis of actions and events, and later, like forms of motor learning, appear to become more implicit with frequent use. The rationale for this position is based on two principles of memory. First, that implicit memory is not accessible to consciousness because it was not encoded explicitly in the first place and second, that explicit representations remain potentially accessible to consciousness at some level of analysis even after becoming more procedure-like. Such a model has been invoked in the context of semantic representation by others as well. For example, Talmy (1988) discusses the accessibility of meaningful schemas for morphemes such as "across." On hearing "across" used in normal discourse, this morpheme may not provide the same degree of conscious access to its schematic referent as it would when it was first learned, when presented in isolation, or repeated frequently. In his view, the particulars of the schema itself are potentially accessible to consciousness, especially when there is "semantic conflict" or ambiguity involved.

Something similar could be happening when we think about the future as *in front* of us and the past as *behind*. While spatial terms are frequently used in a temporal context, little attention may generally be paid to any cross-domain relation, even though when asked about such statements in isolation, or in an ambiguous context, we can access the meaning behind such a relation. We propose that this is because we may code many of these relations explicitly at some point in development when they are being learned or being used. Note, this is not to say that the child consciously recognizes and "remaps" space–time relations *in language*. Rather, as we will discuss below, it is our position that the meaning underlying such relations could potentially be learned prior to acquiring language in the form of image schemas.

A related question that arises from these experiments concerns the role that gesturing may have played in bringing temporal concepts to awareness. Assuming that temporal relations are unlikely to be salient cues in one or two trials, the principal factor that could have raised the structure of the task to consciousness is participants' analyses of their own responses. Note that previous research has focused on the spontaneous use of gesture during conversations; gestures that are presumably not consciously enacted. However, given the context, it is reasonable to think then that in Experiment 1 the representation of the future as *in front* becomes explicit only after participants detect that they are responding to future events by pointing *in front*. This dynamic analysis of behavior, in concordance with the structure of the task and the participants' representation of time, may have contributed to their awareness. This raises the interesting question of why AWARE participants became aware. Although further research is needed, two general explanations are possible. First, it may be that chance played some role. Coincidentally making the ''correct'' gesture at the beginning of the experiment may have helped some participants to become aware, either because making a concordant response facilitated early analysis or because some motor quality of the gesture itself helped bring the relation into awareness. Alternatively, individual differences could have been important; it may be that some participants were simply more sensitive to space-time associations to begin with. It should also be noted that some NAüVE participants reported using idiosyncratic sorting strategies (e.g. pointing in front for ''good'' items and behind for ''bad'' ones). Further research is needed to explain these individual differences.

The differences in response patterns between Experiments 1 and 2 speak to the roles that specific spatial axes play in supporting specific reference frames. In Experiment 2, the boxes were placed such that they were not directly analogous with the particular deictic structure of the past/future concept in English. Even though the individual stimulus items were identical to those in Experiment 1, there were no differences in responding to item types and therefore no patterns of schema-consistent responding over the course of sessions in Experiment 2. In fact, not a single participant became aware of the temporal relations among test items. This suggests that the specific front–back spatial structure used in the design of Experiment 1, motivated by both embodied theories of cognition and the linguistic structure of the past/future concept in English, was critical for producing the pattern of results observed.[2]

While we interpret this result as suggesting the failure of the left–right axis (in ''space'') to support the structure of the past/future concept, it is an interpretation with a caveat. As described in section 2.1, the deictic front–back axis provides the kind of perceptual-motor asymmetry (viz. experiences traveling through space and time as front-facing organisms) that correlates with the structure of the past/future concept in English. Compared to the ''asymmetrical'' front–back axis, the ''symmetrical'' left–right axis is *per se* less suited for the purpose of making distinctions between different temporal concepts. However, another factor that may account for the results in Experiment 2 concerns language. Although cultural artifacts like calendars and comics regularly structure temporal relations from left to right, we do not use symmetrical left–right language to code asymmetrical temporal relations. That is, we do not typically say things like, ''Move the meeting two days to the right''. Even though spatial morphemes remained unspoken during the task, participants in the left–right condition did not have access to the potential cues provided by spatial language to aid conceptual organization and, for this reason, the temporal structure of the stimuli may have been less salient in Experiment 2.

Clark (1973) suggested that much like the physicist considers time in terms of a ''one-dimensional continuum with asymmetrical properties'' (p. 49), children, learning to talk about time, begin to do so using one-dimensional and asymmetrical spatial-relational prepositions. Clark argued that children learn to use the specific spatial prepositions that best capture temporal experience by analyzing the correspondence between both domains and suggested how particular ecological constraints could support this process. He proposed several ecological parameters that together define a three-dimensional coordinate system. Constrained by an arrangement of anatomical axes (e.g. the front–back asymmetry of the human body) environmentally defined planes (e.g. the ground and horizon) and force gradients (e.g. gravity) the child learning about space, time and language was in a position to assign binary values to a network of spatial, temporal and linguistic vectors while establishing a primitive ground for the making of a semantic system.

Mandler (2004) addresses the subject of early foundations of knowledge in a manner compatible with such a framework. She proposes however, that infants analyze the spatiotemporal structure of their world prior to the acquisition of language. For Mandler, the products of these primitive analyses are formatted into image schemas, the foundational structures for early meanings. Although they are often portrayed as iconic figures or schematized diagrams, image schemas are more like dynamic representations of generalized patterns of actions and percepts. Simply put, image schemas ''re-describe [the] spatial and movement structure of perceptual displays'' (Mandler, 2004:79).

Mandler's proposed analytic process allows one to make explicit the correspondences between time and space. Precisely when this analysis takes place is generally unknown and warrants further investigation, but research indicates that these spatial analyses take place early in development. Piaget (1927) observed that young children conflate space and time when making judgments about simple events, noting that children are biased by the extent of spatial displacement when making judgments about the duration of an event. This suggests that early representations of event knowledge incorporate both spatial and temporal features, but not necessarily that image schemas are doing the work.

McDonough et al. (2003) found that meanings commonly thought to be associated with image schemas such as containment, support, and degree of fit are formed early in development. They showed that infants can categorize spatial relations across several perceptually dissimilar objects (objects that vary in size, texture, color and shape) by 9-months of

[2] One could justifiably object that in Experiment 2 the main finding of interest was actually a negative result. But that no participants became aware of the temporal nature of the stimuli is particularly interesting because it suggests that the spatial location of the boxes in Experiment 1 was critical for making these semantic relations salient. Negative results can be particularly interesting when investigating consciousness or ''inattentional blindness'' in vision studies (see Simons and Rensink, 2003). Sometimes what a participant *doesn't* notice is of primary interest.

age. Given that it was well known that infants can form object categories based on similarities among forms or features, this result was surprising in that it was the first indication that preverbal infants could form relational categories across widely varying objects. How could generalization along these lines be possible at such a young age? An image schema would serve this purpose nicely, although how and when such categories aid in a formal understanding of time awaits more research.

The notion that, ‘‘We simply think and act more or less automatically along certain lines’’ (Lakoff and Johnson, 1980) is close to an axiom in Conceptual Metaphor Theory. And although this idea—that we are generally not aware of the abstract or schematic content that grounds meaning in our conceptual system—may be true, the extent to which we have access to this level of meaning remains an open question. By no means is it a simple one. On the one hand, it should be obvious that representational *structure* at the most highly abstract levels of cognition is not available to awareness. To paraphrase Mandler (2008) how concepts are represented in the mind is not available to consciousness because if it were, we would not be having the substantial discussions we are having in the field. On the other hand, the kinds of abstract relational *content* that both Lakoff and Mandler argue is represented at the level of image schema can, in fact, be analyzed consciously. If this were not true, Conceptual Metaphor Theory would not exist itself. Moreover, conscious analyses of such abstract relations are performed regularly. An insult like, ‘‘Your mama’s so dumb, she put a ruler on the side of the bed to see how long she slept’’ works because time–space metaphors can be taken apart and played with (Pinker, 2006). In this example, time is not only mapped onto space self-consciously, but the relation itself is made explicit under the most casual of settings. In accordance with this example, the results of the current study suggest to us that implicit processes (like priming), observed in past research in this area, act on representations with accessible content. So although the process of priming is implicit, the representational content that is related through this process is explicit; i.e. explicit in the sense that its representational format is not impenetrable to analysis.

In respect to the two main goals of the current study stated in section 1, several conclusions can be drawn. Our primary goal was to provide evidence that abstract concepts find structure in the body and the environment, and not merely the semantic relations among particular lexical items. The contrast between the positive results in the front–back condition in Experiment 1 and the negative results in the left–right condition in Experiment 2 demonstrate the importance of embodied spatial reference frames in organizing the English speakers’ concept of past and future. The second issue we raised concerned the extent to which Lakoff and Johnson’s (1999) *cognitive unconscious* is, in fact, an attribute of a distinct implicit representational system. It is our position that conceptual meanings must be grounded on representations with content; i.e. representational content accessible to conscious analysis. While image schemas are suitable for this purpose, it is unclear how sensorimotor representations impenetrable to conscious analysis could ground meaning. In this regard, the present findings are more in line with Mandler than Lakoff. This does not mean implicit processes do not play any role in grounding abstract concepts. In fact, our results suggest that unconscious processes associated with spatial representations and motor behavior may indeed play a significant role in bringing the meaningful content of abstract concepts to awareness. The results of the present study demonstrate a shift from unconscious, but meaningful, behavior to explicit comprehension. Further research is still needed to address the specific roles that spatial representations, gesture, and language play; both in grounding abstract concepts and calling them to awareness. Although the current study is a starting point, the links between unconscious and conscious knowledge as they pertain to the representation of meaning are rarely investigated experimentally and still poorly understood.

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