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# Remembrances of Times East: Absolute Spatial Representations of Time in an Australian Aboriginal Community

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## Abstract

How do people think about time? Here we describe representations of time in Pormpuraaw, a remote Australian Aboriginal community. Pormpuraawans' representations of time differ strikingly from all others documented to date. Previously, people have been shown to represent time spatially from left to right or right to left, or from front to back or back to front. All of these representations are with respect to the body. Pormpuraawans instead arrange time according to cardinal directions: east to west. That is, time flows from left to right when one is facing south, from right to left when one is facing north, toward the body when one is facing east, and away from the body when one is facing west. These findings reveal a qualitatively different set of representations of time, with time organized in a coordinate frame that is independent from others reported previously. The results demonstrate that conceptions of even such fundamental domains as time can differ dramatically across cultures.

## Keywords

time, space, frames of reference, Australian Aboriginal, cross-cultural differences, space-time mapping

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Time is a topic of central interest in the English-speaking world. The word *time* is the most frequent noun in the English language, and other temporal words, such as *day* and *year*, also rank in the top 10 (Brysbaert & New, 2009; Kucera & Francis, 1967). Time is ubiquitous yet ephemeral. It forms the very fabric of human experience, and yet it is unperceivable: We cannot see, touch, or smell time. So how do we mentally represent and organize this fundamental domain of experience?

To represent time, people around the world rely on space. We spatialize time in cultural artifacts such as graphs, timelines, orthography, clocks, sundials, hourglasses, and calendars and rely heavily on spatial words (e.g., *forward*, *back*, *long*, *short*) to talk about the order and duration of events (Clark, 1973; Traugott, 1978; Tversky, Kugelmass, & Winter, 1991). Our private mental representations of time also appear to be based in space (Boroditsky, 2000; Boroditsky & Ramscar, 2002; Casasanto & Boroditsky, 2008; Fuhrman & Boroditsky, 2010; Gevers, Reynvoet, & Fias, 2003; Núñez & Sweetser, 2006; Santiago, Lupiáñez, Pérez, & Funes, 2007; Torralbo, Santiago, & Lupiáñez, 2006).

In the study reported here, we investigated the spatial representations of time in the remote Australian Aboriginal community of Pormpuraaw, located on the west coast of Cape York Peninsula, Australia. We were interested in how Pormpuraawans think about time because of the way they represent space. Unlike English, the Pormpuraawan languages do not make extensive use of relative spatial terms like *left* and *right*; instead, speakers of these languages rely on absolute direction terms (e.g., "north," "south," "east," and "west"), saying things like "move your cup over to the north-northwest a little bit" or "the boy standing to the south of Mary is my brother" (Gaby, 2006; Kilham, Pamulkan, Pootchemunka, & Wolmby, 1986; Smith & Johnson, 2000; Sommer, 1991). Members of such linguistic communities must always stay oriented, just in order to be able to speak the language properly. In Kuuk Thaayorre (one of the languages included in this study), to say hello, one says, "Where are you going?" and an appropriate response would be, "a long way to the south-southwest." Thus, if you do not know which way is which, you literally cannot get past hello. Previous work has documented that speakers of such languages do indeed stay oriented, show

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precision in spontaneous co-speech gesture, and exhibit remarkable skill in dead reckoning (Haviland, 1993; Levinson, 1996, 2003; Levinson & Wilkins, 2006; Majid, Bowerman, Kita, Haun, & Levinson, 2004). How might members of such speech communities think about time?

We tested Pormpuraawans and Americans on two temporal-ordering tasks. The tasks were based on standard tests of temporal reasoning used in IQ tests administered to millions of people around the world (Wechsler, 1981). Americans tested on such tasks organize time from left to right (Fuhrman & Boroditsky, 2010; Tversky et al., 1991). In addition, people have been shown to represent time from right to left, front to back, or back to front (e.g., Boroditsky, 2000; Boroditsky & Ramscar, 2002; Fuhrman & Boroditsky, 2010; Núñez & Sweetser, 2006; Santiago et al., 2007; Torralbo et al., 2006; Tversky et al., 1991), and other representations are also possible. All of the patterns reported to date lay out time in body-relative space (e.g., left/right, front/back). The representations of time we discovered with Pormpuraawans are strikingly different from those of American English speakers and from all others documented to date.

## Method

Fourteen Pormpuraawans took part in this study. They were fluent in English as a second language, but all used at least one aboriginal language in day-to-day communication. Several were highly literate in both English and one or more Pormpuraaw languages. (See the Supplemental Material available online for additional details about participants, materials, and procedure.)

Pormpuraawan participants were tested in Pormpuraaw. Two tasks were used: card arrangement and dot drawing. In the card-arrangement task, participants were tested on 6 to 12 sets of cards. Each set of cards depicted a temporal progression (e.g., a man at different ages, as shown in Fig. 1a). On each trial, participants were handed a shuffled set of cards and asked to lay the cards out on the ground so that they were in the correct order. Each participant arranged a given set only once.

Each participant was tested in two sittings, each including half of the card sets. The two sittings were conducted with the participant facing in different cardinal directions, generally 180° or 90° apart (whatever was possible in the field context).

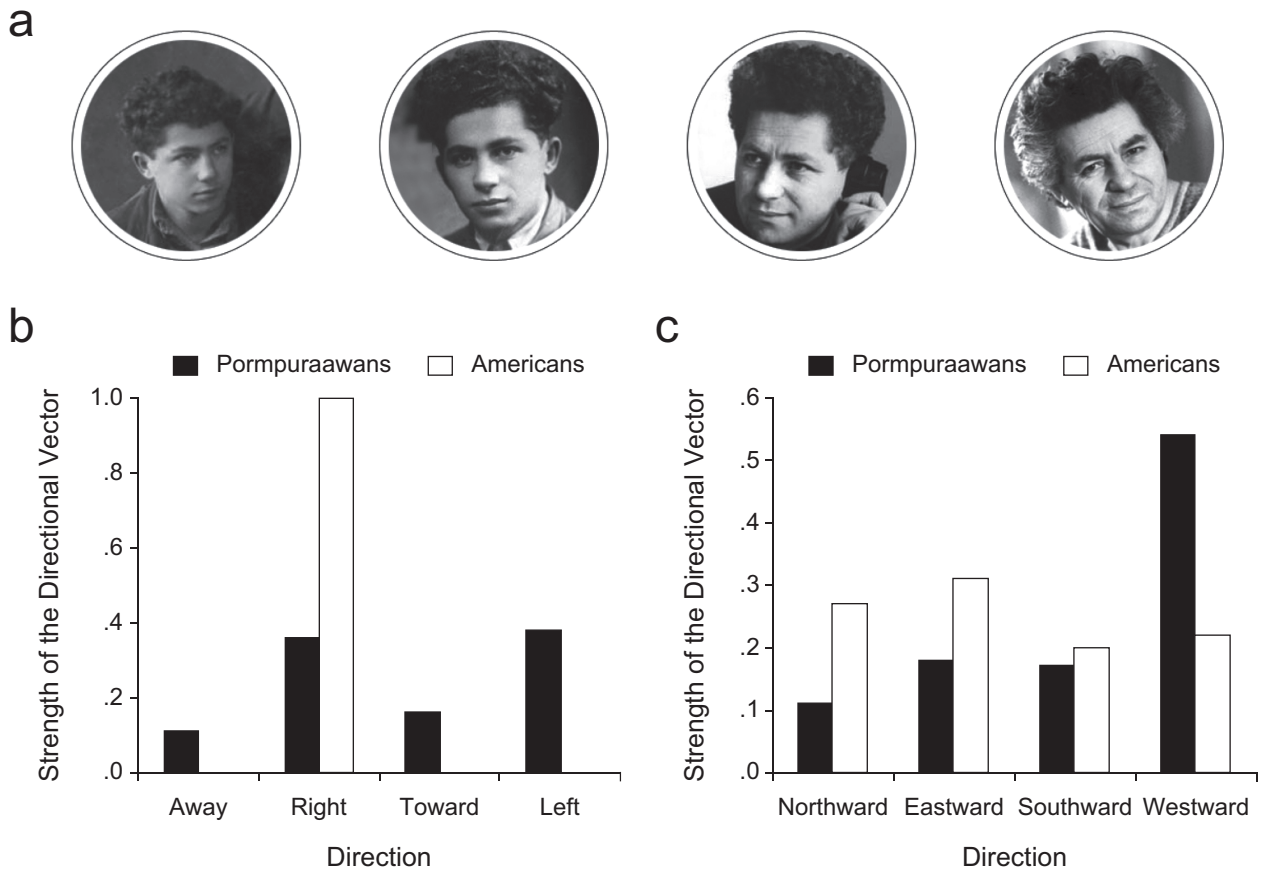


**Fig. 1.** Experimental materials and results. An example of a card set for the card-arrangement task is shown in (a). The photos show Lev Boroditsky at different ages. The graphs show the strength of the directional components of temporal sequences arranged by Pormpuraawans and Americans, plotted in (b) relative coordinates and (c) absolute coordinates. Results from the card-arrangement and dot-drawing tasks are combined; numbers reflect by-participants averages.

In some cases, the two sittings were conducted on different days. When this was not possible, the sittings followed each other immediately. After the participant arranged half of the card sets, the experimenter explained that it was necessary to get a different angle for the camera and asked the participant to sit in a different place before continuing with the task. This explanation allowed the experimenter to turn the participant halfway through the task in a way that minimized social awkwardness. Participants interpreted the task as a test of their temporal reasoning and were unaware that the particular spatial orientations they were producing were the measure of interest.

The dot-drawing task followed the same design, but instead of arranging picture cards, participants placed dots corresponding to temporal periods on the ground. For example, the experimenter placed a dot in front of the participants and said, "If this here is today, where would you put yesterday? And where would you put tomorrow?" Participants indicated their answer by drawing dots in the sand or by placing stones or round plastic chips on the ground. The temporal periods tested included days of the week (Tuesday, Wednesday, Thursday) and times of the day (morning, noon, evening), as well as deictic 1-day intervals (yesterday, today, tomorrow), weeks (last week, this week, next week), and long durations (olden days, nowadays, far in the future).

Fourteen American English speakers, members of the Stanford University community, were tested on the same tasks used in Pormpuraaw. Each American participant was yoked to a Pormpuraaw participant such that the exact facing directions, picture sets, and dot-drawing sequences that had been used for each Pormpuraaw participant were duplicated precisely with an American counterpart. This ensured that presentation sequences and facing directions were exactly matched for the two populations.

## Results

Results are plotted in Figures 1b and 1c. Details of the data-coding procedures and additional analyses can be found in the Supplemental Material. As documented previously in these tasks (Fuhrman & Boroditsky, 2010; Tversky et al., 1991), Americans laid out time as proceeding rightward, with earlier time points on the left and later ones on the right (100% for both tasks). The Pormpuraawans laid out time in a strikingly different way. Overall, Pormpuraawan arrangements had a significantly smaller rightward component than did American arrangements, $t(13) = -8.74$, $p < .0001$, by participants; $t(16) = -11.5$, $p < .0001$, by items; $d = -3.3$.[1] Pormpuraawan arrangements were about equally rightward and leftward, and also about equally coming toward the body and going away from the body[2] (see Fig. 1b).

However, despite the impression given by Figure 1b, Pormpuraawans did not lack a preferred direction for organizing time, nor did their arrangements lack order. Rather, they organized time in an entirely different coordinate frame than the Americans did. Figure 1c shows the same data as in Figure 1b, but plotted in absolute coordinates. In this form, the Pormpuraaw data reveal a striking pattern. The strongest directional component in the Pormpuraawan arrangements was east to west (.47 for the card-arrangement task and .60 for the dot-drawing task). The east-to-west vector was more than twice as large as that of any other cardinal direction in the Pormpuraawan arrangements, and was significantly larger than the east-to-west vector in the American arrangements, $t(13) = 4.14$, $p < .0001$, by participants; $t(16) = 5.60$, $p < .0001$, by items; $d = 1.25$.

The east-to-west vector in Pormpuraawan arrangements was larger than that for any other cardinal direction—by-participants tests: $t(13)$s = 3.17, 3.25, and 3.81 for comparisons with the west-to-east, north-to-south, and south-to-north vectors, respectively, $p$s $< .01$; by-items tests: $t(16)$s = 7.39, 5.99, and 7.64 for comparisons with the west-to-east, north-to-south, and south-to-north vectors, respectively, $p$s $< .0001$; $d$s = 1.44, 1.51, and 1.83. In American arrangements, the east-to-west vector was not larger than that for other cardinal directions—by-participants tests: $t(13)$s = 1.21, 0.24, and 0.43 for comparisons with the west-to-east, north-to-south, and south-to-north vectors, respectively, n.s.; by-items tests: $t(16)$s = 1.67, 0.65, and 1.56 for comparisons with the west-to-east, north-to-south, and south-to-north vectors, respectively, n.s.

Finally, we calculated the percentage of participants who changed the dominant relative orientation of the cards (e.g., left to right or right to left with respect to their body) when their sitting direction was rotated. Dominant relative orientation was defined as the most frequent orientation a participant produced in a given sitting. A majority (58.3%) of the Pormpuraawans switched the dominant relative orientation of the cards between sittings, and no Americans (0%) did so, $\chi^2(1, N = 24) = 7.26$, $p < .05$, Yates-corrected; $d = 1.18$.

## Discussion

Unlike the Americans, who laid out time from left to right regardless of their cardinal facing direction, the Pormpuraawans spontaneously took their facing direction into account when making their arrangements. When facing south, they were likely to lay out time from left to right; when facing north, they were likely to lay out time from right to left; when facing east they were likely to lay out time as coming toward them; and when facing west, they were likely to lay out time as moving away from them. This was true even though the participants were never told which way they were facing.

After the temporal-arrangement tasks, we tested participants' ability to point north, south, east, and west. We coded responses as correct if they were within a 60° range (i.e., ±30° relative to the correct cardinal direction). All of the Pormpuraawans' responses were correct on this criterion; moreover, all were within a 20° range (i.e., ±10° relative to the correct cardinal direction). Of the Americans, 36% pointed correctly, 36% were 45° to 90° off compass, and the remaining 28%

either had no idea or failed to produce a consistent set of directions. The Pormpuraawans' superior knowledge of spatial orientation is consistent with patterns of spatial reference in the local languages. Although some Americans knew their cardinal directions, they did not make use of this knowledge in their representations of time. Further, the majority of Americans simply could not have laid out time in absolute coordinates even if they had wanted to, because they lacked the basic spatial knowledge necessary to do so. The Pormpuraawans not only knew their absolute orientation, but also spontaneously used this absolute spatial knowledge to construct their representations of time.

The east-to-west orientation of time in Pormpuraaw does not seem to stem from patterns in temporal language. Pormpuraawans have a rich vocabulary dedicated to describing time, but there is no overlap between absolute spatial reference frames and time in the lexicon; absolute direction terms like "north," "south," "east," and "west" are not used to describe temporal relationships. Likewise, the left-to-right orientation of time for Americans does not stem from patterns in temporal language (e.g., English speakers do not say, "Tuesday is three days left of Friday"), but instead is derived from writing direction (Fuhrman & Boroditsky, 2010; Tversky et al., 1991).

It seems likely that the east-to-west time orientation discovered in Pormpuraaw is related to the motion of the sun. Pormpuraawans do point to positions in the sky to mark the times of day, and informal observation suggests that their spontaneous gestures accompanying temporal descriptions also tend to lay out time on the east-to-west axis, with past events gestured to the east. Similar patterns in gesture have been observed with the Arrernte of Central Australia (D. Wilkins, personal communication, March 5, 2004). The results presented here demonstrate that Pormpuraawans have abstracted away from using the sun's trajectory to mark only the times of day. They have come to use the east-west axis to lay out time at all scales, from transformations that take mere seconds (an apple falling from a tree) to those that take decades (a young boy becoming an old man).

The question of how people represent time is at the center of one of the great mysteries of mind: How are we able to think about things we can never see or touch? Our mental lives go far beyond those things observable through physical experience; we invent sophisticated notions of number and time, theorize about atoms and invisible forces, and worry about love, justice, ideas, goals, and principles. The ability to cognitively transcend the physical is one of the very hallmarks of human intelligence. How are we able to do it?

One possibility is that representations of the abstract are constructed through analogical extensions from more experience-based domains (Clark, 1973; Lakoff & Johnson, 1980). That is, in order to construct mental representations of abstract or intangible entities, people may co-opt the representations they have developed for more tangible and concrete domains. If this is the case, then people who construct different basic representations (e.g., of space) should also think differently about more abstract or intangible entities (e.g., time). The findings presented in this article are consistent with this hypothesis (though clearly the nature of the causal relationship between spatial and temporal thinking remains to be determined in this case): Pormpuraawans rely predominantly on cardinal directions for representations of space, and they do the same for time. This correspondence offers the tantalizing suggestion that cross-cultural differences in basic spatial representations may have far-reaching consequences for other knowledge domains in the cognitive system.

## Conclusions

Results reported in this article demonstrate a cross-cultural difference in thought that is more than a matter of style or preference. Pormpuraawans think about time in ways that other groups cannot (because they lack the necessary spatial knowledge). The Pormpuraawan cardinal-direction organization for time contrasts sharply with all other representations of time reported to date. More generally, these findings show that conceptions of even such fundamental domains as time can differ dramatically across cultures.

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### Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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### Supplemental Material

Additional supporting information may be found at http://pss.sagepub.com/content/by/supplemental-data

### Notes

1. The degrees of freedom in the by-participants paired *t* tests reflect the number of participants (14 in each group). For the by-items analysis, they reflect the number of items used (12 for the card-arrangement task and 5 for the dot-drawing task, 17 combined). All analyses revealed significant differences whether performed paired or unpaired, one-tailed or two-tailed, for the two tasks separately or for the two tasks combined. For brevity, we report statistics for the two tasks combined and Cohen's *d* for the by-participants analysis in all cases. We note that although the sample size is not large (14 participants in each group), the differences between the two groups are large and stable: Not a single American participant produced the Pormpuraaw pattern.

2. When arranging cards, Pormpuraawans preferred transverse arrangements (left-right or right-left) to sagittal arrangements (toward or away), but there was not a preferred direction within either of these axes. It is likely that people preferred the transverse axis in this task because the card arrangements were simply too long to comfortably lay out on the sagittal axis (a full linear arrangement extended 25 in.). In the dot-drawing task, in which participants could comfortably make sagittal arrangements, equal numbers of transverse and sagittal arrangements were found in the Pormpuraaw data. This suggests that the transverse-axis bias in the card-arrangement task was created by the pragmatic constraints of the task: The fact that humans have a greater comfortable reaching distance on the transverse axis than on the sagittal axis appears to have made transverse arrangements more likely in the card-arrangement task.

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